VIMS 2017

Toronto

6th International Conference on

VISUALLY INDUCED MOTION SENSATIONS

Nov 16-17, 2017
Toronto, Canada

Conference Program

VIMS 2017

UHN Toronto Rehabilitation Institute

Greetings

Welcome from the Committee

The International Conference on Visually Induced Motion Sensations is in its 6th year, and as a bi-annual conference, many things have changed since the first meeting. For instance, new technologies have emerged, some of which have significantly impacted our lifestyle: smartphones, tablets, social media. We rely on visual technologies more than ever and have implemented them in our daily routines. Despite the increase in technological knowledge, our understanding of the potential adverse physiological and psychological effects of these technologies has not grown proportionally, still leaving us with the question of why these effects occur and how they can be prevented. VIMS will serve a key role in helping to find ways in which to optimize the engagement and improve the perceptual aspects with these technologies and mitigating potentially adverse effects.

We decided to widen the scope of this year's VIMS by including presentations from research fields that are relevant to motion sickness, but also have their own empirical tradition: vection, eye-movements, postural control. We believe that the best way to tackle the current challenges is to consider the interplay of various research streams in this field. We have also engaged industry partners, given that their experiences with the increasingly pervasive use and explosive development of these technologies (in health, entertainment, training) can help to prioritize research objectives. We hope that the 6th VIMS conference will reflect this diversity and will facilitate new collaborations for exciting, innovative, and unique research in the future.

Behrang Keshavarz and Jennifer Campos
Toronto Rehabilitation Institute – UHN

Welcome from Toronto Rehab

The Toronto Rehabilitation Institute, part of the University Health Network (UHN), is the world leader in rehabilitation research. Our research focuses not only on optimizing patient care, but also on preventing injuries and promoting independent living while ageing.

To achieve this goal, we use state-of-the-art simulation technologies that allow us to systematically create challenging situations under controllable and safe conditions. Our centerpiece, the Challenging Environment Assessment Laboratory (CEAL), houses a hydraulic, hexapod motion platform that can be mounted with four different laboratories, each with unique capabilities. Two of these labs use immersive Virtual Reality (VR) technologies to measure perception and performance under highly realistic conditions with the goal to improve mobility and safety; StreetLab focuses on safe standing and walking mobility including falls prevention and DriverLab is used to improve the safety of drivers.

Being well aware of the potential side-effects of VR use, we are actively supporting research to find effective solutions. We are therefore particularly excited to host the 6th VIMS Conference in Toronto!

Geoff Fernie, PhD PEng CEng FCAHS
Institute Director, Research
Toronto Rehabilitation Institute – UHN

General Information

Your Host

Toronto Rehabilitation Institute – University Health Network (UHN)
For more information, please visit www.uhn.ca/TorontoRehab, www.idapt.org, or www.mive.ca

Social Events

Welcome Reception: Nov 15 (7:00pm – 9:00pm)
Conference Dinner: Nov 16 (6:45pm – 9:00pm)
Optional tours of Toronto Rehab iDAPT facilities: Nov 16 (4:00pm – 5:30pm) and Nov 17 (5:00pm – 6:30pm)

Location

MaRS Discovery District – Room CR-2
101 College St
Toronto ON M5G 1L7
Canada

WiFi Information

Name: *mars-open-internet*
No password needed

Contact

To get in touch with the local organization committee, send an email to: VIMStoronto2017@gmail.com

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Dr. Behrang Keshavarz

Toronto Rehabilitation Institute, Ryerson University

Dr. Behrang Keshavarz is a Scientist at Toronto Rehab's Challenging Environment and Assessment Laboratory and an Adjunct Professor in the Department of Psychology at Ryerson University, Toronto. Behrang's research focuses on human factors in virtual environments, with particular emphasis on minimizing adverse effects of simulators, such as nausea and disorientation that are related to simulator sickness. He is also involved in research promoting driving safety for younger and older adults, such as developing methods to detect and prevent drowsy driving. In addition, Behrang is exploring the neurocognitive and behavioral aspects of self-motion perception (vection) in virtual environments.

Dr. Jennifer Campos

Toronto Rehabilitation Institute, University of Toronto

Dr. Jennifer Campos is the Chief Scientist of Toronto Rehab's Challenging Environment Assessment Laboratory and an Assistant Professor in the Department of Psychology (University of Toronto). Jenny's research focuses on enhancing safe mobility during walking and driving under realistic and challenging conditions. This includes understanding how age-related, sensory impairments (e.g., vision loss, hearing loss) and cognitive impairments (e.g., dementia) can increase the risk of falls and driving difficulties. She uses virtual reality and simulation technologies to a) carefully recreate typical and challenging real-world conditions to ensure the generalizability of research outcomes to real world applications and b) adapt these technologies for training and rehabilitation interventions.

Ms. Shoshana Teitelman

Toronto Rehabilitation Institute

Shoshana is one of the Administrative Coordinators at Toronto Rehab's Research Department. She supports many scientists, the DriverLab Team, the Home, Community & Institutional Environments Team, as well as special events, conferences, and Toronto Rehab's Research Day.

Conference Volunteer: Ms. Maryam Pandi, McMaster University, Canada

International Advisory Committee

Jelte E. Bos, TNO, Netherlands
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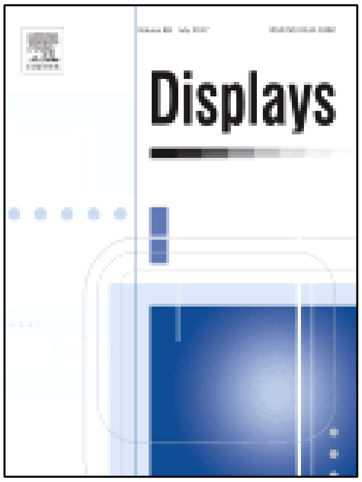
Richard H.Y. So, Hong Kong University of Science and Technology
Hiroyasu Ujike, National Institute of Advanced Industrial Science and Technology, Japan
Hiroshi Watanabe, National Institute of Advanced Industrial Science and Technology, Japan

Call for Papers – Special Issue on Visually Induced Motion Sensations

A special issue of *Displays (Elsevier)* on Visually Induced Motion Sensations is accepting submissions focusing on (but not limited to) the following topics:



Visually Induced Motion Sickness (e.g., Simulator sickness, VR sickness)
Visual discomfort (e.g., visual fatigue, visual stress – asthenopia)
Illusory self-motion (vection)
Optic flow
Display factors and designs
Photosensitive seizures (visually induced epilepsy)
Neurophysiological mechanisms
Pharmaceutical and non-pharmaceutical countermeasures
Virtual Reality and simulators
Serious gaming
Social aspects
Civil and military applications
Regulation and standardization

Submissions and Deadlines

Submissions to this special issue should include new, unpublished, original research or opinion papers. Reviews will not be accepted. All papers must be written in English. All submissions will be reviewed by at least two experts in the field (single-blind review). Papers should be submitted electronically using the EVISE submission system (http://www.evise.com/evise/jrnl/DISPLA). Please make sure that authors select "**SI:VIMS 2017**" when uploading their manuscripts to ensure that all submissions are correctly identified for inclusion into the special issue. Send an email to the Lead Guest Editor for any questions regarding the submission process. All submissions will undergo initial pre-screening by the Guest Editors to ensure they meet the criteria for the Special Issue.

Submission Deadline: February 18, 2018
Review results: May 13, 2018
Revised Versions Due: August 12, 2018
Final Decision: October 14, 2018
Publication: November 18, 2018

Lead Guest Editor

Behrang Keshavarz (behrang.keshavarz@uhn.ca). Toronto Rehabilitation Institute – UHN, Canada; Ryerson University, Canada

Guest Editors

Jennifer Campos (jennifer.campos@uhn.ca). Toronto Rehabilitation Institute – UHN, Canada; University of Toronto, Canada
Stefan Berti (bert@uni-mainz.de). Johannes Gutenberg-University Mainz, Germany

The Program at a Glance

Time	Wednesday, Nov 15	Thursday, Nov 16	Friday, Nov 17
8:00am		Continental Breakfast & Registration	Continental Breakfast
9:00am		Welcome & Opening Remarks **Talk Session 1** – Vection, Sway, and Motion Sickness	**Talk Session 4** – Sensory Aspects: Vestibular
10:00am			
11:00am		**Talk Session 2** – Sensory Aspects: Vision	**Talk Session 5** – Technical Aspects
12:00pm		Lunch Break	Lunch Break
1:00pm		**Talk Session 3** – Visually Induced Motion Sickness: General	**Talk Session 6** – Reality and Virtual Reality
2:00pm			
3:00pm		"The Founders Panel"	"The VR Industry Expert Panel"
4:00pm		Tour of Toronto Rehab iDAPT facilities (optional)	Closing remarks
5:00pm			Tour of Toronto Rehab iDAPT facilities (optional)
6:00pm		Conference Dinner	
7:00pm	Welcome Reception		
8:00pm			
9:00pm			

Legend

Social Events	Talk Sessions	Special Presentations/Discussions	Breaks	iDAPT Tours

Social Events and iDAPT Tours

Welcome Reception (Wed, Nov 15 – 7:00pm to 9:00pm)

Location
The REDS Midtown Tavern – Mezzanine Level
382 Yonge St #6
Toronto ON M5B 1S8

Directions
The REDS Midtown Tavern is located on the north-west corner of the main interseaction of Gerrard St and Yonge St, near the Chelsea Delta Hotel (1 minute walk) and the Holiday Inn Downtown (5 minute walk).

The welcome reception is sponsored by

oculus

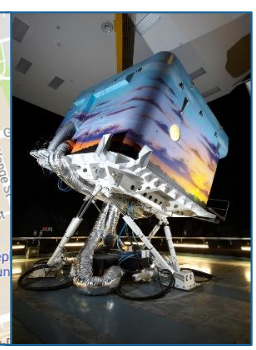
Conference Dinner (Thu, Nov 16 – 6:45pm to 9:00pm)

Location
360 The Restaurant at the CN Tower
301 Front St W, Toronto, ON M5V 2T6

Meeting Point: 6:30pm
In front of the Main Entrance at the CN Tower

Directions
The CN Tower is a 20-25 minute walk away from the Toronto Rehabilitation Institute. A Taxi ride will cost approximately $12-14 CAD.

Tour of Toronto Rehab's iDAPT facilities (Thu, Nov 16 – 4:00pm to 5:30pm and Fri, Nov 17 – 5:00pm to 6:30pm)



Meeting point
550 University Ave
Main Entrance Lobby

Detailed Program

Thursday, Nov 16

Talk Session 1 (9:30am – 10:50am) – Vection, Sway, and Motion Sickness
Session chair: Behrang Keshavarz

9:30am to 9:50am	Why is vection making you sick? Cognitive effects in visually induced motion sickness **Suzanne A.E. Nooij, Paolo Pretto, Heinrich H. Bülthoff**
9:50am to 10:10am	Does vection or do alternations in vection cause VIMS during constant optic flow? **Ouren X. Kuiper, Jelte E. Bos, Cyriel Diels**
10:10am to 10:30am	Perceived vection and postural sway: A behavioural response to virtual reality **Onoise G. Kio, Laurie M. Wilcox, Robert S. Allison**
10:30am to 10:50am	Motion Sickness and Posture **Jelte E. Bos**

Talk Session 2 (11:00am – 12:20pm) – Sensory Aspects: Vision
Session chair: Hirojasu Ujike

11:00am to 11:20am	Eye Movements and Visually Induced Motion Sickness **Richard H. Y. So, Yue Wei, Yixuan Wang, Jason X. Yang**
11:20am to 11:40am	Persistent Optokinetically Induced Nystagmus and Vection with Virtual Reality Goggles. **John French, Dylan Bush, Heidi Mundhenke, John Prutsman**
11:40am to 12:00pm	Adverse Effect of Watching Three-Dimensional Image with Vertical Disparity **Norihiro Sugita, Katsuhiro Sasaki, Makoto Yoshizawa, Tomoyuki Yambe**
12:00pm to 12:20pm	Prefrontal activity recorded by fNIRS while viewing a Trypophobic dot pattern placed on the face **Manami Furuno, Takeo Kato, Shinichi Koyama**

Talk Session 3 (1:30pm – 2:50pm) – Visually Induced Motion Sickness: General
Session chair: Jelte Bos

1:30pm to 1:50pm	Predictors of Visually Induced Motion Sickness Susceptibility **John F. Golding, Behrang Keshavarz**
1:50pm to 2:10pm	Derivation of Indices Reflecting Visually Induced Motion Sickness Using Discriminant Analysis **Shin Tabeta, Shigehito Tanahashi**
2:10pm to 2:30pm	Frequency Responses of Visually Induced Motion Sickness **Yue Wei, Richard H. Y. So, Jinzhao Chen**
2:30pm to 2:50pm	The Sound of Sickness: How Music Valence, Arousal, and Pleasantness Affect Visually Induced Motion Sickness **Katlyn Peck, Frank Russo, Jennifer Campos, Behrang Keshavarz**

The Founders Panel (3:00pm – 4:00pm)

Panelists

Dr. Jelte E. Bos

TNO Netherlands

Prof. Dr. Jelte E. Bos got his M.Sc. degree in physics and Ph.D. degree in medicine at the Vrije Universiteit in Amsterdam, the Netherlands. He was then appointed as assistant professor at the same university, extending his work on the visual to the vestibular system. In 1994 he moved to TNO (a large applied scientific research organization in the Netherlands, founded by law). There he still works on the effects of motion on human health and safety, comfort and performance, which refers to motions induced physically and visually. His particular interest concerns the understanding of self-motion and attitude perception and motion sickness from a neurophysiological and control theoretical point of view. He also holds a chair at the Faculty of Behavioural and Movement Sciences at the Vrije Universiteit in Amsterdam as a professor in vestibular motion and attitude perception. He is a (board) member of several national and international scientific committees and societies, has published over 100 peer reviewed papers as well as over 100 project reports, as can be further seen at http://www.jeltebos.info.

Dr. Richard H.Y. So

Hong Kong University of Science and Technology

Prof. Richard So received his BSc degree in Electronic Engineering and PhD degree in Sound and Vibration (Human Factors) from University of Southampton, England. He started his research into Virtual Reality (VR) when he worked for the 'Super Cockpit Program' from the Wright-Patterson Air Force Base, USA. Prof. So joined the Hong Kong University of Science & Technology as an Assistant Professor, Associate Professor and later Professor of Industrial Engineering and Professor of Bio-medical Engineering. His research interests focus on human spatial vision and binaural spatial hearing. He is a Fellow of the International Ergonomics Association, a Chartered Fellow of the Royal Chartered Institute of Ergonomics and Human Factors and a Fellow of the Hong Kong Chartered Institute of Engineers. He is currently serving as the co-Editor-in-Chief of Displays, Editor of Ergonomics and Scientific Editor of Applied Ergonomics. He is serving on the drafting committee of ISO International Workshop Agreement IWA3 on Image Safety and Commission Internationale de L'eclairage (CIE) Technical Committee TC1-67 and expert panel for ISO working group on dynamic image safety. Prof. So has over 100 referred publications, 2 patents and one Technology Start-up. He is also a pioneer in Experiential Learning & Design Thinking.

Dr. Hiroyasu Ujike

National Institute of Advanced Industrial Science and Technology

Dr. Hiroyasu Ujike obtained his BEng in Mechanical Physics Engineering and DrEng in Visual Psychophysics from Tokyo Institute of Technology, Japan. He also worked as Post Doc on parallactic depth perception with Professor Hiroshi Ono in York University, Toronto. This was his start of research on visual motion and space perception, which has been his major research interest. After he joined the National Institute of Advanced Industrial Science and Technology (AIST), he also got involved in works of standardizations. Major part of the standardizations related with his research interests is on Image Safety; in recent years, he has been investigating visual fatigue caused by stereoscopic 3D images and visually induced motion sickness, which is sometimes referred to as VR sickness for recent spotlighted technology on virtual reality. He was the secretary of ISO International Workshop on Image Safety held in Tokyo in 2004, the leader of ISO/TC 159/SC 4/Study Group on Image Safety, and now the convenor of ISO/TC 159/SC 4/WG 12 on Image Safety, the expert of ISO/TC 159/SC 4/WG 2 on Visual Display Requirements. He is also the Leader of JENC/SC 4/WG 2+12, mirror committee in Japan Ergonomic National Committee for ISO/TC 159.

Friday, Nov 17

Talk Session 4 (9:30am – 10:50am) – Sensory Aspects; Vestibular
Session chair: Jennifer Campos

9:30am to 9:50am	The Influence of Noisy Vestibular Stimulation on Perception in Virtual Reality **Seamas Weech, Nikolaus F. Troje**
9:50am to 10:10am	Generation of Brown-out Vection During Simulated Flight in the Visual Vestibular Balance Device **Anil Raj, Margaret Freyaldenhoven**
10:10am to 10:30am	Studying Cybersickness and Sensory Conflict Theory Using a Motion-Coupled Virtual Reality System **Adrian K.T. Ng, Leith K.Y Chan, Henry Y.K. Lau**
10:30am to 10:50am	Vection Induced by Oscillation and its Relation to the Dynamics of the Vestibular System **Hiroyuki Sumida, Shigehito Tanahashi**

Talk Session 5 (11:00am – 12:20pm) – Technical Aspects
Session chair: Richard So

11:00am to 11:20am	Effects of Visual Global Rotation and Viewing Conditions on VIMS **Hiroyasu Ujike and Hiroshi Watanabe**
11:20am to 11:40am	Vection Perception Across Different Display Types: Good News for Small Labs **Stefan Berti, Behrang Keshavarz, Martina Speck, Bruce Haycock**
11:40am to 12:00pm	Display Size Effects of Visual Induced Motion Sickness on 4K Video Viewing **Naoki Kobayashi, Ayumi Matsuura, Masahiro Ishikawa, Tetsuya Miyashita**
12:00pm to 12:20pm	Consumer Virtual Reality Systems as Research Tools: Challenges And Limitations **Amelia Kinsella, Sarah Beadle, Eric Muth**

Talk Session 6 (1:30pm – 2:50pm) – Reality and Virtual Reality
Session chair: Stefan Berti

1:30pm to 1:50pm	The Importance of Vision in Carsickness, Especially Self-Driving Carsickness **Ouren X. Kuiper, Jelte E. Bos, Cyriel Diels**
1:50pm to 2:10pm	Behavioral Validity and Motion Sickness: Comparing Various Fixed and Moving-Base Simulators to Real-World Driving **Heiko Hecht, Malte Klüver**
2:10pm to 2:30pm	Speed Ratings in a Virtual and Real Driving Environment **Jelte E. Bos, Liselotte van den Berg-Kroon, Ouren X. Kuiper, Mark M.J. Houben**
2:30pm to 2:50pm	Balance Control and Motion Sickness in Real and Virtual Environments **Michael Barnett-Cowan**

The VR Industry Expert Panel (3:00pm – 4:00pm)

Panelists

Ed Callway

AMD Canada

Ed Callway is an Entertainment Architect at AMD. He has been designing analog and digital products for 35 years, beginning with a grad project to display Blissymbolics, and a first career designing ultrasonic medical equipment. ATI/AMD products include the award winning All-in-Wonder graphics + TV tuner series, STB/DTV designs, as well as algorithms for video and display processing. His current work is focused on computers for Virtual Reality and movie effects rendering. He has a B.Eng and M.Eng in Engineering Physics from McMaster University with a biomedical focus, and holds over 25 patents in video technology and computer architecture

Kevin Millar

INVIVO

Kevin is the Vice President, Creative and Medical Science at INVIVO Communications, an interactive medical agency specializing in custom solutions for the healthcare industry. Kevin's remarkable blend of creative and scientific leadership is a natural extension of his Masters of Biomedical Communications degree and his position on the Board of Governors of the Association of Medical Illustrators. In over 18 years at INVIVO, Kevin has overseen the development of hundreds of medical animations, patient videos, medical games and mobile applications that help our clients articulate their messages. Kevin's experience with projects from pitch to completion is invaluable in aligning our services to meet our clients' business needs.

Abstracts

Thursday, November 16 – Talk Session 1

Why is vection making you sick? Cognitive effects in visually induced motion sickness.

Suzanne A. E. Nooij[1], Paolo Pretto[1], Heinrich H. Bülthoff[1]
[1]*Dept. of Human Perception, Cognition and Action, Max Planck Institute for Biological Cybernetics, Tübingen, Germany*

When stationary observers are exposed to yaw rotation of the visual surround, a compelling sense of self-rotation (i.e., vection) develops over time. Prolonged exposure to visual rotation may also result in motion sickness (VIMS). In a previous experiment, we manipulated the strength of vection and found a positive correlation between vection and VIMS. Interestingly, VIMS occurred without changes in vection strength over time, which contradicts with predictions of the widely accepted Sensory Conflict theory. It is therefore unclear what determines the measured relationship. Here, we investigated whether participants' expectation of inertial motion affected VIMS. We hypothesized that VIMS occurs only in conditions where participants are aware that inertial rotation is impossible, and a conflict between perceived rotation and expected stationarity arises. In a first experiment, consisting of two separate sessions, participants watched a rotating scene through a Head Mounted Display, while sitting either on a fixed four-legged chair (inertial rotation impossible) or a chair that allowed inertial rotation. During the 20min. exposure continuous ratings of vection and VIMS were obtained. Although VIMS tended to be higher on the fixed chair, the effect was not significant and possibly masked by habituation: VIMS ratings were significantly lower in the second session, independent of the experimental condition. In addition, we found that the expectation of inertial rotation was not manipulated equally well in all participants. To overcome these issues, we are currently running a follow-up study with new participants. Instead of virtual reality, we are using a physical optokinetic drum where inertial and visual rotation are actually indistinguishable. This is expected to increase the perceived likelihood of inertial rotation, and thus, decrease the conflict between perceived rotation and expected stationarity. We will compare these new results to those of the previous studies and discuss the consequences for motion sickness theories.

Does vection or do alternations in vection cause VIMS during constant optic flow?

Ouren X. Kuiper[1], Jelte E. Bos[1,2], Cyriel Diels[3]
[1]*VU University, Faculty of Behavioural and Movement Sciences, Amsterdam, Netherlands*
[2]*TNO Perceptual and Cognitive Systems, Soesterberg, Netherlands*
[3]*Coventry University, Centre for Mobility and Transport, Coventry, UK*

Vection is a visually induced illusionary sense of self-motion. It has been proposed that vection is a necessity for VIMS, however the exact nature of the relationship is a topic of discussion (Keshavarz et al., 2015). The sensory conflict theory (Reason and Brand, 1975) attributes motion sickness to a conflict between sensed and expected motion. Following this theory, illusory self-motion (vection) being incongruent with vestibular sensory information when stationary can cause motion sickness. A complicating factor, however, is that a state of consistent vection should produce no sensory conflict. This is due to the vestibular system only being responsive to accelerations, which are absent when moving at constant speed. However, even with a constant optic flow, vection is often not constant. In an experimental study, we tried to answer the question whether it is vection, or rather alternations in vection that lead to VIMS. Using a HTC Vive headset subjects (N=18) were exposed to 10 minutes of 3D visual optic flow stimuli suggesting motion in the anterior-to-posterior direction; the stimulus thus showed a radially expanding pattern suggesting constant forward self-motion. Vection was measured continuously over the duration of the experiment, using a hand-held slider. (At one extreme (0%) environment is moving and I stand completely still and at the other (100%) environment is standing completely still and I feel like moving through it'.) The SSQ (Kennedy at al., 1993) and MISC (Bos et al., 2005) were used before and after the trial to assess subjects' VIMS. In addition, before and after the experiment 1-minute balance measurements were recorded. All but one subjects reported strong (>95%) vection at some point. Interestingly, we found no significant correlation between any measure of vection and VIMS. The relation between vection and VIMS might have been modulated by others factors, such as polarity.

Perceived Vection and Postural Sway: A Behavioural Response to Virtual Reality

Onoise G. Kio[1], Yoshitaka Fujii[2], Laurie M. Wilcox[3], Domenic Au[3], Robert S. Allison[1]
[1]Department of Electrical Engineering & Computer Science, Centre for Vision Research, York University, Toronto, Canada
[2]Ibaraki Campus Research Organization, Ritsumeikan University, Osaka, Japan
[3]Department of Psychology, Centre for Vision Research, York University, Toronto, Canada

The quality of stereoscopic 3D content is a major determinant for immersion and user experience in virtual reality (VR). Thus it is important that the effectiveness of stereoscopic 3D content parameters be assessed behaviourally. A typical behavioural response to VR is vection, the visually-induced perception of self-motion elicited by moving scenes. In this work we investigate how participants' vection and postural sway vary with the simulated optical flow speed and the virtual camera's frame rate and exposure time while viewing depictions of movement through a realistic virtual environment. We compare the degree of postural sway obtained from the centre-of-pressure data of a Nintendo Wii Balance Board with subjective vection scores. Results obtained from this study show that average perceived vection increases with increase in frame rate and simulated speed but not with exposure time. We also found that perceived vection in VR does not induce significant postural sway in typical 3D cinema scenarios. We are currently conducting experiments to confirm whether this finding holds for immersive virtual reality scenarios where screen edge and other surround cues are eliminated.

Motion Sickness and Posture

Jelte E. Bos[1,2]
[1]VU University, Faculty of Behavioural and Movement Sciences, Amsterdam, Netherlands
[2]TNO Perceptual and Cognitive Systems, Soesterberg, Netherlands

Motion sickness can be considered a means to optimise the control of self-motion. In that sense it can be assumed that, e.g., postural instability (PI) as a measure of self-motion and motion sickness (MS) are related. So far, however, both positive and negative correlations between PI and MS have been observed, and an explanation is still lacking. A theoretical control-mechanism explicitly relating and explaining body motion (as the main control variable) and sickness (as an error signal), includes an internal model or "neural store" making a prediction of self-motion. The internal model itself is updated continuously based on the error between the predicted and actually sensed self-motion. This assumption implies that the state of the internal model can be optimal for one condition with, e.g., congruent visual and vestibular cues, but not in others with, e.g., incongruent visual and vestibular cues. In case of patients suffering from vertigo there may also be a central cause. As a consequence, the internal model may adapt to deal with the incongruent cues such that the mentioned error and hence the resulting sickness is minimised. The resulting habituation has indeed been observed. With this habituation in terms of sickness, however, an increased PI can be predicted in addition, which has been observed too. The framework therefore is capable of explaining not only a positive, but also a negative correlation between PI and MS, which explanation has been lacking so far.

Eye Movements and Visually Induced Motion Sickness

Richard H. Y. So[1,2], Y. Wei[2,3], Y. X. Wang[2,3], J. X. Yang[2]

[1]HKUST-Shenzhen Research Institute, Shenzhen, China

[2]Department of Industrial Engineering and Logistics Management, Hong Kong University of Science and Technology

[3]Bio-Engineering Program, School of Engineering, Hong Kong University of Science and Technology, Hong Kong

Eye movement has been repeated shown to significant affect levels of Visually Induced Motion Sickness (VIMS) in the presence of provoking visual motion. Since eye movements modulate our perception of visual motion, could the influence of eye movements merely due to this modulating effects on visual motion? Or is it related to the afferent signals from extra-ocular muscle as predicted by Ebenholtz's nystagmus hypothesis? A series of experiments were conducted to isolate the influence of eye movements, velocity of the provoking visual stimuli, effective foveal retinal slip velocity and effective peripheral retinal slip velocity. Initial results indicate that zero eye movement velocity (i.e., eye fixation) rather than zero foveal slip velocity is considered to be a key factor in reducing levels of VIMS. Further experiments were conducted and data suggest that foveal retinal slip velocity has significantly stronger effects on VIMS than peripheral retinal slip velocity.

Persistent Optokinetically Induced Nystagmus and Vection with Virtual Reality Goggles.

John French[1], Dylan Bush[1], Heidi Mundhenke[1], John Prutsman[1]

[1]Aerospace Physiology, Embry-Riddle Aeronautical University, Daytona Beach, Florida, USA

The Optokinetic Nystagmus (OKN) drum has long been a standard means to induce nystagmus and symptoms of motion sickness. With the advent of virtual reality goggles, it was possible to create the same conventional OKN experience using a horizontally moving vertical black and white striped pattern on Oculus Rift VR goggles. The OKN drum and VR OKN were compared in a repeated measures, within group design for symptoms of motion sickness in 12 healthy college students. Motion sickness symptoms were assessed using the conventional Subjective Sickness Questionnaire (SSQ). The SSQ was given once before either OKN, three times during OKN, after 10, 20 and 30 minutes of exposure and then after 10 and 20 minutes of recovery from OKN. A Friedman's repeated measures test was used to determine if comparisons were warranted in which case a Dunn's planned comparison tested which exposures were different at $p<0.05$. Both drum and VR OKN were different from the pre-exposure SSQ after 20 and 30 minutes of exposure. All participants increased the severity of SSQ scores in a stepwise manner during OKN exposure. VR and drum OKN symptoms returned to pre-exposure levels after 30 minutes of recovery. In general, VR OKN had more intense symptoms than the standard drum, particularly for the nausea component. The advantage of VR OKN is that software can be used to create multiple OKN vection experiences such as off-axis tilt, 360-degree exposure and multiple display patterns. VR OKN is also far less costly and far simpler to alter and administer than the standard drum OKN. We think the nystagmus produced by either OKN exposure may have potential for rapidly and reliably inducing nystagmus and motion symptoms which could be helpful for VR game developers or as a diagnostic for mTBI.

Adverse Effect of Watching Three-Dimensional Image with Vertical Disparity

Norihiro Sugita[1], Katsuhiro Sasaki[1], Makoto Yoshizawa[1], Tomoyuki Yambe[1]

[1]Tohoku University, Sendai, Japan

The vertical disparity of both eyes caused by tilting the head in watching 3D TVs or 3D movies is possible to induce visual fatigue or 3D sickness. This adverse effect is considered to relate to the reverse phase eye movement in the vertical direction. To ascertain this hypothesis, we performed an experiment in which 10 healthy subjects were watching a 3D image with the vertical disparity. The result indicates that the vertical eye movement with reverse phase was induced by the vertical disparity, and the viewer's feeling of visual malaise increased as the amount of the eye movement increased. Furthermore, there was a limit to the viewer's ability to correct the vertical disparity. In the case of watching a 3D image including the vertical disparity over this limit, binocular rivalry occurred and more fatigue was induced.

Prefrontal Activity Recorded by fNIRS While Viewing a Trypophobic Dot Pattern Placed on the Face.

Manami Furuno[1], Takeo Kato[2], Shinichi Koyama[3]
[1]*Graduate School of Engineering, Chiba University, Chiba, Japan*
[2]*Department of mechanical Engineering, Keio University, Yokohama, Japan*
[3]*Faculty of Art and Design, University of Tsukuba, Tsukuba, Japan*

A cluster of dots such as lotus seed pods evoke especially strong disgust when it is placed on the skins. The disgust evoked by the cluster of dots has been called Trypophobia, and the disgust has been explained by the dot pattern per se (e.g., Cole and Winkins 2013; Le et al. 2015) and the combination of the dot pattern and the skin (Skaggs, 2014; Kupfer and Le, 2017; Furuno et al. 2017). However, few empirical studies have examined the role of the background image such as skin in the generation of disgust. First, we conducted a psychological experiment to examine whether the orientation of background faces has an influence on the disgust evoked by the dot pattern. The participants were asked to evaluate disgust to an upright, inverted, or phase-scrambled face image with or without a cluster of dots on it. The results suggested that disgust was amplified by the background faces, especially strongly by the upright faces. The results indicated face-inversion effect on the disgust to the dot pattern, suggesting significant role of the background image in the disgust evoked by the cluster of dots. Second, we recorded cerebral blood flow of sixteen regions (channels) of the forehead while viewing the faces using Near-Infrared-Spectroscopy NNIRS). The results showed that although there was no significant main effect of faces and no interaction between faces and presence/absence of dots, there was a significant main effect of presence/absence of dots on channel 8 ($p < .01$). The forehead covers the prefrontal cortex (PFC), and the PFC interconnects with the amygdala (Garcia et al., 1999; Ghashghaei & Barbas, 2002). Thus, the co-activation of PFC and the amygdala may play some roles in the perception of disgust evoked by a cluster of dots placed on the face.

Thursday, November 16 – Talk Session 3

Predictors of Visually Induced Motion Sickness Susceptibility

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The widespread use of new visual technologies produces increasing risk of visually induced motion sickness (VIMS). The aim of this study was to investigate possible predictors for individual susceptibility to VIMS. Three studies were conducted: in a pilot study, survey data from participants with (n=873) and without (n=854) vestibular disorders were analyzed with regards to dizziness due to visual technologies, Motion Sickness Susceptibility (MSSQ), Social & Work Impact Dizziness (SWID), migraine, syncope, age and gender. In a development study, a prototype VIMS susceptibility questionnaire (VIMSSQ) probing usage of 11 types of visual technologies and experience of 5 symptoms (nausea, headache, dizziness, fatigue, eyestrain) as well as the risk variables syncope and migraine was tested on n=54 participants. In the third study, the VIMSSQ was applied in two experimental studies that exposed participants to VIMS-inducing visual stimuli (video of bicycle ride, n=30; horizontally moving black-and-white bars, n=27). VIMS was measured using the Fast Motion Sickness Scale (FMS). Results of the pilot study showed that dizziness due to visual technologies was elevated in vestibular patients (p< 001) and generally predicted by greater MSSQ, SWID, migraine, and syncope scores (all p<.001). In the development study, the total VIMSSQ score was mainly predicted by elevated

MSSQ scores (p<.001). Active avoidance of visual technologies was predicted by the VIMSSQ subscales headache (p<.001) and nausea (p<.01). In the experimental studies, the level of VIMS was predicted by the VIMSSQ-total score (p<.01) for the moving bar stimuli, but failed significance in predicting for the video bicycle ride. Our results suggest that risk factors for some aspects of VIMS include elevated motion sickness susceptibility, elevated dizziness from other sources, migraine, and syncope. Headache seems to play a prominent role in the avoidance of visual technologies. Despite the complexity of VIMS, we propose a short, 6-item questionnaire (VIMSSQ-short) that might be beneficial for the prediction of VIMS susceptibility.

Derivation of Indices Reflecting Visually Induced Motion Sickness Using Discriminant Analysis

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Previous studies have shown that visually induced motion sickness (VIMS) can be assessed via physiological indices of the autonomic nervous system calculated from heart rate variability and blood pressure. However, the response of these physiological indices to VIMS was inconsistent in these studies. Since the variance of the physiological indices of the autonomic nervous system has shown to reflect vasovagal reflex, in this study, we aimed to assess VIMS based on the mean and variance of several physiological indices. In this study, we aimed to derive indices that may be related to VIMS by applying discriminate analysis to several physiological indices. We used a high-luminance liquid crystal display projector to back-project a visual stimulus on a 70-inch screen. Motion sickness was induced by two different stimuli that comprised of first-person viewpoint scenes. One (stimulus A) was based on an original 10-min movie showing two sisters visiting an amusement park, and the other (stimulus B) was a video made of different moving images related to motor and air sports. We enrolled twenty participants in this study (23.4 Â± 1.2 years). The participants continuously indicated the subjective strength of VIMS and underwent an electrocardiographic examination to evaluate the status of the autonomic nervous system during the 20-minute experimental trial. We analyzed the relationship between the presence of motion sickness and various physiological indices of the autonomic nervous system, as LF, HF, LF/HF, SDNN, RMSSD, and SDNN/RMSSD, using discriminant analysis. The explanatory variables were indices of the autonomic nervous system selected using a stepwise approach, and the discriminant variable was the presence of motion sickness. The participants were categorized into a sickness group and a non-sickness group based on the subjective VIMS strength score. The results showed that different indices of the autonomic nervous system were chosen with respect to stimulus A and stimulus B. The discriminant rate was 100% for stimulus A and 90% for stimulus B.

Frequency Responses of Visually Induced Motion Sickness

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Describing the characteristics of a sensory perception process using frequency responses has been a common practice. Once the frequency response is quantified, it allows researchers to utilize a set of well-established signal processing tools to conduct modeling, simulation and system identification. For an oscillating wave, frequency, peak-to-peak amplitude and velocity are related to each other. In other words, to double the frequency, one could increase the velocity keeping the amplitude the same or one could reduce the amplitude and keeping the velocity the same. A series of studies have been conducted to determine the frequency responses of VIMS for different combinations of amplitudes and velocities. Results suggest that keeping amplitude constant or keeping velocity constant will result in two significantly different frequency responses for VIMS. This is disruptively important because a different frequency response will definitely affect the subsequent inference of the knowledge.

The Sound of Sickness: How Music Valence, Arousal, and Pleasantness Affect Visually Induced Motion Sickness

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Visually-induced motion sickness (VIMS) is a common side-effect of interacting with virtual environments and simulators, resulting in discomfort, dizziness, and/or nausea. Recent findings have shown encouraging effects of using pleasant music to reduce VIMS, however additional research is necessary to validate this method. The goal the present study was to further investigate the nature of this effect by analyzing the role of valence, arousal, and subjective pleasantness of music on VIMS. Two studies were conducted during which participants watched a 15-minute video of a bicycle ride filmed from first person perspective that has been show to induce VIMS. In Study 1, 40 participants were randomly assigned to one of four music groups (happy, agitating, peaceful, or sad) and a control group (n = 19) completed the task with no music. Participants were presented with pre-selected, classical music excerpts from their respective groups that varied in valence and arousal while watching the video. VIMS was measured using the Fast Motion Sickness Scale (FMS) and the Simulator Sickness Questionnaire (SSQ). No differences in VIMS ratings were found between any of the groups. However, participants who liked the pre-selected music (regardless of valence and arousal level) reported significantly less VIMS than those who did not like it. Consequently, in Study 2 we aimed to maximize the level of subjective pleasantness by asking 20 participants to select their favorite music, which was then played during the VIMS stimulus exposure. Results demonstrated that VIMS was significantly lower in the group who selected their own pleasant music compared to the pre-selected music group and the no music control group. Our findings support the use of pleasant music as an effective and feasible intervention to reduce VIMS. Potential explanations regarding the mechanism of this effect including distraction and physiological changes are discussed.

Friday, November 17 – Talk Session 4

The Influence of Noisy Vestibular Stimulation on Perception in Virtual Reality

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Sickness and low immersion experienced in virtual reality (VR) inhibit the widespread adoption of VR technology. Both are thought to relate to errors in the process of estimating self-motion from multisensory stimuli. Recoupling multisensory cues can generate more convincing illusory self-motion (vection) and reduce sickness, but current methods rely on expensive or invasive techniques to simulate the expected sensory cues. We present an approach to reducing cue mismatch based on statistical sensory reweighting principles, and outline initial evidence that shows the addition of vestibular "noise" can produce a facilitation of vection and a reduction in sickness in VR. In one study we examined the effect of noisy vestibular stimulation (stochastic galvanic stimulation, or bone-conducted vibration) on the onset latency of circular vection. Both noisy stimulation methods reduced the onset latency of illusory self-motion for roll, pitch, and yaw optic flow stimuli. In a second study we applied bone-conducted vibration in a navigation task in VR and measured simulator sickness. We found that sickness was reduced significantly when the timing of noisy vestibular stimulation was coupled with the occurrence of expected vestibular cues. The results provide evidence that a low-cost, non-invasive vestibular stimulus has the potential to influence vection and simulator sickness. Second, the results reiterate the finding that vection onset latency and sickness in VR are related to multisensory mismatch. This work constitutes the first effort to use noisy vestibular stimulation to improve the user experience in the virtual environment. Future studies are needed to explicate the mechanism through which noisy stimulation affects self-motion perception.

Generation of Brown-out Vection During Simulated Flight in the Visual Vestibular Balance Device

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The Howard tumbling room inspired Visual Vestibular Balance Device (VVBD) is a novel, one of a kind multi-axis human rotational stimulus device. It consists of a fourteen-foot diameter gimbal that holds a twelve-foot diameter rigid spherical visual surround that encapsulates a multi-axis human rotator. The VVBD provides independent velocity and position control for both the rotator and the sphere using custom high torque, direct drive DC motors. The large diameter surround accommodates standing participants while leadscrews mounted to the participant fixture z- and y-axes, allow remote adjustment of the vertical and horizontal position of the participant to place the head or either vestibular organ at the center of the sphere and rotator. In addition, the participant fixture can be pitched independently of the main gimbal that supports the sphere and rotator to provide visual stimuli for supine roll and yaw and standing roll and pitch conditions, in addition to the standing yaw condition used in this study. Participants flew a software flight simulation consisting of a large, vertically-mounted, high resolution computer monitor that displayed both instrument and forward out the window views and completed two, forty to fifty- minute cross country flights. During each trial, the sphere, which has a white background internal surface covered with approximately 300, five-inch black dots distributed in a hyperuniform (apparently random) pattern, rotated about the Earth-vertical yaw axis. At four 90 deg turns in each flight plan, the velocity of the sphere accelerated to and maintained either five or ten deg/sec until completion of a second, opposite direction 90 deg turn. Video oculography, stabilometry, head accelerometry and electroencephalography were recorded as well as flight path cross track error, flight time and subjective motion sickness scores. The VVBD provides unique capabilities for operationally relevant studies of the effects of vection on task performance.

Studying Cybersickness and Sensory Conflict Theory Using a Motion-Coupled Virtual Reality System

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Sensory conflict theory attempts to explain the immediate cause of visually induced motion sickness (VIMS) in virtual reality (VR) systems. The discomfort is based on the mismatch in visual–vestibular interaction. Traditional VR experiences often involve visual stimuli without significant amount of physical motion to compensate the missing vestibular stimuli. This study examined whether virtual visual scene coupled with motion sensation could reduce VIMS symptoms. A motion-coupled VR system with HTC Vive head-mounted display (HMD) was developed and used in the experimentation. The mechanical 3-DOF motion platform provides programmed physical motion which supplements the visual stimulus shown on the HMD. In addition to providing coherent visual and vestibular sensations, the study also tested the effect of an Earth-referenced visual scene that provides a fixed visual horizon. This is similar to a past study of using virtual horizon on a ship motion simulator. Anecdotal report suggested that visual Earth reference is important in establishing postural stability in a sea voyage and simulation, while instability of postural is usually correlated with cybersickness. Hence, a generated Earth-referenced visual scene could in theory reduce the effect of VIMS. In the experiment, participants experienced regular programmed visual and motion yaw rotation while viewing a virtual apartment (0.6Hz ±30°) for 3.5 minutes in each trial. Three conditions: purely visual, motion synchronized with visual, and motion with Earth-referenced visual scenes were tested on how motion and visual stimuli interact. Participants were asked to complete the simulator sickness questionnaire (SSQ) (every trial), the 11-points misery scale (every 60 seconds), and the 11-points joyfulness scale (every 60 seconds). These measurements help to create a cybersickness symptom profile and severity measurement for different conditions. Participants were also asked to stand on a balance board for 60 seconds to measure their centre of pressure after each trial. The result of the experiment could provide further insights into the relationships between the two senses and potential ways of relieving VIMS in VR systems.

Vection Induced by Oscillation and Its Relation to the Dynamics of the Vestibular System

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Palmisano et al. (2000) have found that vection is facilitated by adding random oscillation to a visual stimulus and that the magnitude of facilitation varies according to the frequency of the oscillation. Fernandez and Goldberg (1971, 1976) have found that the dynamics of the vestibular system of monkeys varies according to the frequency of the acceleration stimulus. We hypothesize that facilitation is related to the dynamics of the vestibular system. Hence, in the present study, we examined the effect of oscillation added to a visual stimulus in relation to the dynamics of the vestibular system. A visual stimulus that simulated an ordinary mountain road was rendered in real time. The visual stimulus simulated forward self-motion by adding oscillation with a head mounted display for a period of 90 s. The stimulus conditions comprised of combinations of ten types of frequency (0, 0.0125-0.1, 0.1-0.25, 0.25-0.5, 0.5-1.0, 1.0-2.0, 2.0-4.0, 4.0-8.0, 8.0-16, and 16-32 Hz) and four types of oscillation direction (horizontal & vertical, pitch, yaw, and roll). Forty adults (21.6 Â± 1.50 years) participated in the study were naïve as to the purpose of the experiment, and had normal or corrected-to-normal visual acuity. During the trials, whenever the observers experienced vection, they continuously indicated the change in the strength of vection using a subjective response box to evaluate the perception of severity on a 5-point scale. Then, we used the five parameters obtained from the evaluation during the trials, i.e., the strength, duration, onset, number of intermittent episodes (the number of times the vection broke off) and number of change (the number of times a change in strength was noted) of the vection. When a yaw-direction oscillation (0.0125-0.1, 0.25-0.5, 1-2, 2-4 Hz) was added to the visual stimulus, the strength was greater and the duration was longer than those observed when no oscillation was added to the visual stimulus. These results suggest that vection may be affected by the dynamic characteristics of the vestibular system.

Friday, November 17 – Talk Session 5

Effects of Visual Global Rotation and Viewing Conditions on VIMS

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Purpose: To investigate effects of visual global rotation on VIMS, and also its interaction with viewing conditions, such as fixating a point in moving image, image size in visual field, and spatiotemporal resolution of moving image. Background: Based on the previous literatures, we confirmed the linear relation between SSQ-TS and dropout rate, based on the discussions of Balk et al. (2013). Moreover, some reported experimental data suggests that the possible linear relation between amount of visual global motion and SSQ-TS. Methods: We conducted two experiments, in which eight-minute CG moving images were presented on a 4K LC display (58 inch). SSQ was conducted before and after the presentation. In Experiment 1, we used a combination conditions of two different amount of visual global rotation, fixation or no fixation point, viewing distance of 3H (triple of display height) or 1.5H, and higher resolution (4K, 60p) or lower (SD, 30p). In Experiment 2, the constant amount of visual global rotation was dispersed differently in two conditions. Results: In Experiment 1, SSQ-TS was larger for larger amount of visual global rotation, while the combinations of fixation point, larger viewing distance (3H), and lower resolution (SD, 30p) significantly decreased SSQ-TS. Moreover, those scores were almost constant among the conditions including fixation point, larger viewing distance, and higher resolution and those including fixation point, smaller viewing distance, and lower resolution. In Experiment 2, SSQ-TS was almost constant regardless of different dispersion of visual global rotation. Conclusion: SSQ-TS increased linearly with amount of visual global rotation, at least, within some limited viewing period, while the combination of viewing conditions enhance/reduce SSQ-TS. We speculate linear interaction between the effects of visual global motion and those of various viewing conditions. Based on the speculation, severity of VIMS can be predicted at least some limited ranges of conditions.

Vection Perception Across Different Display Types: Good News for Small Labs

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We tested whether the perception of visually-induced vection is modulated by the display type used for visual stimulation. Alternating black and white moving bars were presented on four different display types in randomized order: (1) large field of view dome projection, (2) combination of three computer screens, (3) single computer screen, (4) large field of view flat projection screen. In addition, the individual level of field dependence was measured, indicating the person’s tendency to rely on external spatial cues. Thirty healthy adults (age range 18-45 years) participated in the study. Each participant was exposed to every display type and rated vection intensity, vection onset time, and vection duration. All four display types successfully generated vection, with strongest vection (i.e., shortest onset time, longest duration, and strongest intensity) obtained for the dome projection. However, the combination of three screens induced vection that was comparable to the dome projection. The other two display types resulted in significantly lower vection ratings. Additionally, field dependency modulated vection: For the dome projection, vection ratings were stronger in field dependent participants. In contrast, no group differences were obtained in the other three display types. Our findings suggest that vection can be effectively induced using rather simple display settings such as a combination of three screens. Furthermore, our results also indicate that personal trait factors can affect vection perception and that field dependence might be a promising area for future vection research.

Display Size Effects of Visual Induced Motion Sickness on 4K Video Viewing

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Visual induced motion sickness (VIMS) is one of the most effective factors of visual discomfort on wide screen such as 4K display. We investigate difference of display size of VIMS on 4K display in same field of view (FOV), i.e. 1.5H. The experimental result shows that large display caused stronger discomfort than small display in spite of same FOV: 1.5 H.

Consumer Virtual Reality Systems as Research Tools: Challenges and Limitations

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The purpose of this experiment was to examine whether two consumer grade head-mounted displays (HMDs) could be used for a live camera-to-display research platform. The low-cost nature of consumer grade HMDs makes their use in research attractive. However, these systems may not be flexible enough to meet the demands of controlled experimental research. This work compared reported simulator sickness from two consumer grade HMDs configured to display the image captured from a live camera. Twenty participants (8 male) completed five trials of an object location task while wearing either an Oculus Rift or an HTC Vive displaying a live feed from an attached GoPro camera. Self-reported sickness symptoms were collected using the Simulator Sickness Questionnaire (SSQ) and the Motion Sickness Assessment Questionnaire (MSAQ). Subjects who wore the Rift had higher peak SSQ (M=71.8, SD=57.9) and MSAQ (M=51.0, SD=31.3) scores than subjects who wore the Vive (M=64.0, SD=56.9; M=47.9, SD=33), but these differences were not statistically significant. Nine subjects (six from the Rift and three from the Vive) were not able to complete the full experiment. When compared to SSQ data from a previous HMD setup, these systems (M = 67.9, SD = 56.0) were more sickening than previous results (M = 24.8, SD = 25.4; $t(24.3) = 3.2$, $p = .004$). Both systems were sickening to participants when displaying the live camera feed. Sickness scores for the Rift and the Vive were higher than previously observed scores from the same task. The proprietary nature of each system limited our control over

what was displayed to subjects. Overall, these systems do not appear to be a viable option for this research paradigm (camera to display). While these systems are desirable for entertainment purposes, scientists should be cautious of their technical limitations when using them as research tools.

Friday, November 17 – Talk Session 6

The Importance of Vision in Carsickness, Especially Self-Driving Carsickness

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Motion sickness exists in a wide variety of forms. While motion sickness can occur with eyes closed, generally visual perception plays a role through a visual-vestibular conflict. Carsickness is a form of motion sickness resulting from a mismatch between actual and anticipated sensory signals (Griffin & Newman, 2004, Bos et al., 2008), generally with a visual component. A well-known example is that reading a book (visual scene suggesting no motion) is incongruent with vestibular and proprioceptive signals suggesting motion. While purely visual stimuli can be a detrimental factor to comfort, e.g. when vision suggests motion while actually stationary (VIMS during VR), vision can also be problematic when it suggests no self-motion is occurring while other senses are suggesting motion (e.g. during reading in a vehicle). We performed a study aimed to evaluate the impact of the positioning of in-vehicle displays, and subsequent available peripheral vision, on carsickness of passengers. We hypothesized that increased peripheral vision during display use would reduce carsickness. Seated in the front passenger seat participants (N=18) were driven a 15-minute long slalom on two occasions while performing a continuous visual search-task. The display was positioned either at 1) eye-height in front of the windscreen, allowing peripheral view on the outside world, and 2) the height of the glove compartment, allowing only limited view on the outside world. Using a display at windscreen height offering increased peripheral vision resulted in significantly less carsickness compared to a display at glove compartment height. Occupants of automated vehicles, especially when using a display, are at higher risk of becoming carsick than drivers of conventional vehicles. Therefore, understanding of motion sickness' underlying mechanisms becomes more paramount for application of human factors in this domain as self-driving vehicles become more commonplace (Diels & Bos, 2016).

Behavioral Validity and Motion Sickness: Comparing Various Fixed and Moving-Base Simulators to Real-World Driving

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Next generation automotive hardware and user interfaces are increasingly pre-tested in driving simulators. What are the potential limitations of such simulations? We determined the relative and absolute validity of five different driving simulators, based upon a dual-task paradigm that involved driving and communicating with the on-board infotainment system. The tasks were chosen according to the guidelines of the Alliance of Automobile Manufacturers (2006). We compared performance in the simulators to on-road driving, and hypothesized that not only simulator characteristics, but also user characteristics, such as simulator sickness, gender, or age, influence behavioral validity. We demonstrated the usefulness of all simulators on a relative and partially on an absolute level. Moving-base simulators were superior to fixed-base simulators, but not dramatically so. Simulator sickness was associated with impaired performance regardless of simulator type. Interestingly, age and gender modulated performance in fixed-base simulators, whereas they did not explain any variance in moving-base simulators or real-world driving.

Speed Ratings in a Virtual and Real Driving Environment

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In simulators, visual motion generally requires larger amplitudes than the physical motion in order to be rated as coherent. This discrepancy is documented rather well and has been attributed to a reduced naturalism of the visual in these virtual environments (Correia et al, Experimental Brain Research 232:637-646, 2014). Less well documented is how velocity, or specially speed, is rated in virtual as well as real environments. We therefore exposed 18 subjects, seated as passengers in the front of a car on a straight road to four experimental conditions: (1) while looking to the real world ahead, (2) looking to a live view ahead presented by video goggles, (3) blindfolded, and (4) viewing pre-recorded video's presented by video-goggles while standing still. Field-of-view was made equal in all conditions. Velocities tested ranged between 20 and 60 km/h. On average, speed was estimated 5 km/h less than actual, while we did not find a statistically significant difference between the four conditions. This finding seems inconsistent with the large differences between visual and vestibular motions rated as coherent by Correia et al. (2014). It may yet be explained by: (1) the limited field of view used in this experiment, and (2) the assumption that speed ratings are dominated by (conscious) cognitive processes, while visual-vestibular coherence (or mere perceptual) ratings are dominated by (unconscious) neurophysiological processes. Moreover, vection, i.e., perceived self-motion induced by mere visual motion may play a crucial role in the perception of visual-vestibular coherence, and not in rating speed. Irrespective of the role of vection, the current data do stress the importance of making a distinction between highly cognitive ratings such as estimating speed in terms of km/h, and perceptual ratings determining the coherence between visual and vestibular motion cues in simulators.

Balance Control and Motion Sickness in Real and Virtual Environments

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Virtual reality (VR) is an interactive computer interface that immerses the user in a synthetic three-dimensional environment giving the user the illusion of being in that virtual setting. VR has rapidly grown in its accessibility to the general public due to lower cost hardware and improved computer graphics. While head mounted display VR technology has potential for innovation beyond entertainment, its adoption is restricted by reports of feeling unwell in many users. Exactly why some people are more prone to feeling unwell in VR than others has not been established, however, previous research suggests that individual differences in balance control may be related to an increased likelihood for people to self-report feeling unwell during activities where this happens most (e.g., riding in a car, watching large field of view movies, playing virtual reality games). Amongst the common theories attempting to explain motion sickness and cyber sickness in VR, is the sensory conflict theory, which states that a conflict between the vestibular and vision system causes these uncomfortable symptoms. By invitation from the Ontario Science Centre our lab was able to collect data during March Break 2017 from 120 participants from ages 5-55 for measures of 1) past susceptibility of motion sickness, 2) balance control, 3) ratings of cyber sickness for two Oculus CV1 VR experiences rated by Oculus users as "comfortable" or "intense", as well as 4) saliva samples to assess whether individual differences in these measures can be explained by genetic polymorphisms. Candidate genes include BDNF, APOE, COMT and KIBRA, which have been found to be polymorphic in the general population and to be related to performance on neurological tasks. The results of this experiment will be discussed to provide further insight into the nature of individual differences and susceptibility to sickness in VR.

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