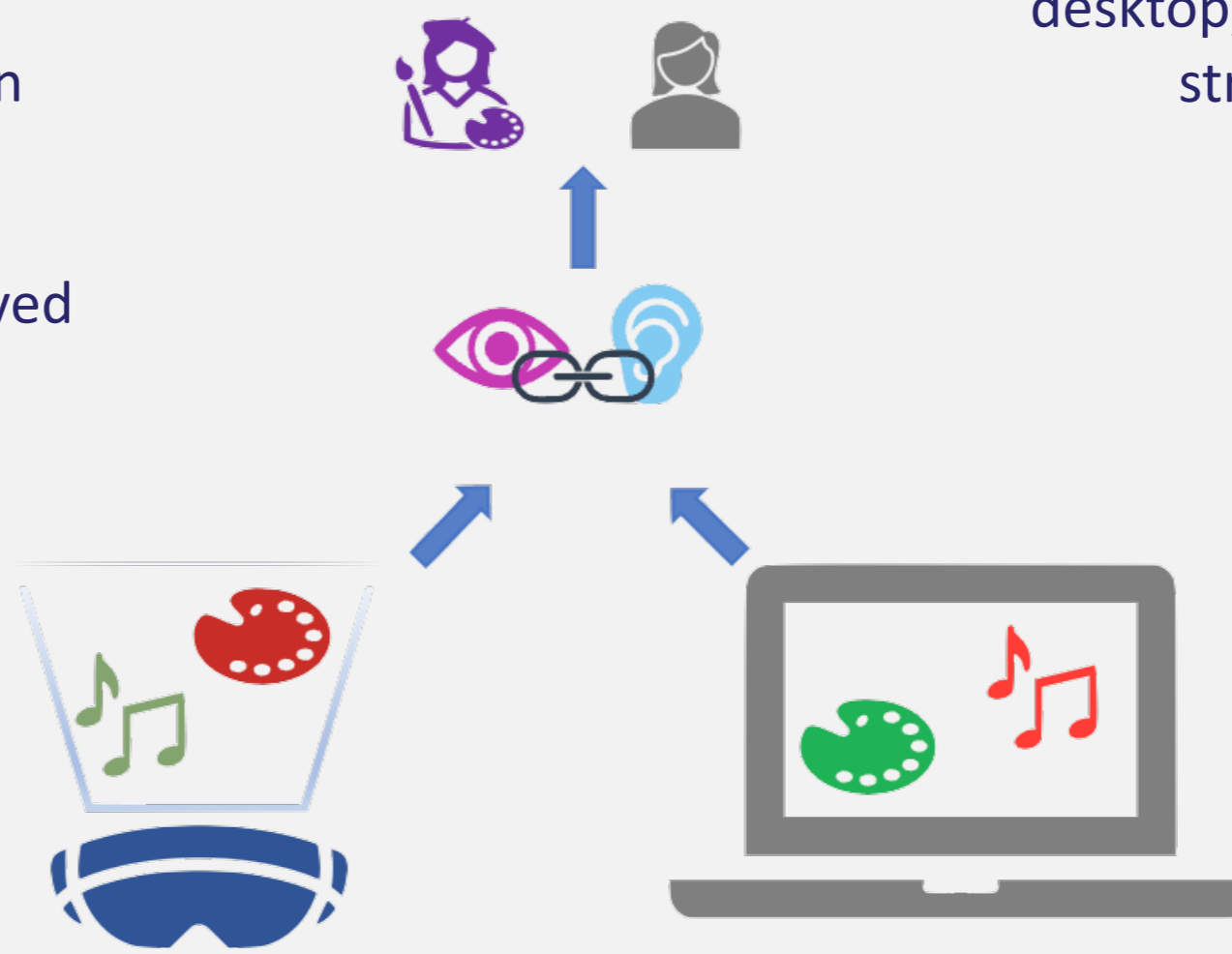# Can VR Help Understand Auditory-Visual Associations and Synaesthesia Through Immersive Battery Tests?

Many different types of tests have been used to understand associations between the auditory and visual senses and the condition called Synaesthesia [1][2][3][4][5]. While these tests have been satisfactory in furthering our understanding of sense association. Using new technologies like Virtual Reality, can we develop and adapt these auditory-visual and synaesthesia tests using more immersive environments, give us an understanding on how we association between our senses? Can synthesizing Synaesthetic perception using VR help users gain the creative benefits that has been shown in people with Synaesthesia?

Auditory-Visual Associations

Many tests have been created to test associations between auditory and visual stimuli, generating different results, in terms of different types of audio stimuli and the congruent associations in the visual sense such as colour, size, shape, direction etc.

- The Synaesthesia Battery test, has been validated and can indicate if a person has synaesthesia or not [1].
- The Implicit Association test (IAT) can be used when studying both implicit and explicit associations between different items [2][3].
- The Test of Genuineness has been used and improved on the decades, with the TOG-R test by Asher et al providing a more precise scoring system and also including auditory-visual tests [4].
- NeCoSyn is based on the TOG test and the Swedish Natural Colour System, and it can provide individual profiles of colour synaesthesia in the dimensions of hue, chroma and blackness [5].

Similar Stroop Test Research with Virtual Reality

Auditory-Visual cross modal association research is lacking within the more immersive environment of VR. Some studies in similar research areas have shown that VR can be used to improve results on real life tests.

- In [6], stress perception was compared in VR and on a regular desktop, using a Stroop word-colour test. Results showed stressful tasks were perceived less stressful in the VR environment.
  - Using a Stroop word-colour test to understand optimal arousal level for an individual to improve performance, the optimal arousal level was identified, and it was found that moderate levels of arousal can lead to improved performance [7].
  - A follow up study to [6], the authors created an open-source VR Stroop test, and found a 30-40% improvement in some metrics compared to traditional Stroop tests [8].

Possible Benefits of Using VR Over Standard Testing

With access to VR/AR/XR technologies, researchers have a new platform which can be used to gain valuable insights on research questions across different fields. In HCI, and more importantly, with understanding associations between our auditory and visual senses, VR can help inform how we design interfaces and intelligent interactions with technologies that are more adaptive and inclusive.

- A more immersive environment can provide more detail to the user that can give them a more meaningful experience to inform their choices.
- When testing for Synaesthetic perception, providing an environment that can replicate the real-world experience might help in more accurately detecting it and also see if creative benefits of real world synaesthetes can be seen in users of the VR environment.

Impact on the UN SDG Goals

I feel that my research would match closest to UN SDG goal 4 and 10, as it could have a lot of benefits for learning, education and inclusiveness.

- **UN SDG 4 – Quality Education:** In furthering the understanding of auditory-visual associations, a framework can be formalised to help aid in designing interfaces for the future that can help with personalised learning, garnering more focus and attention.
- **UN SDG 10 – Reduced Inequalities:** Creating different ways to interact with interfaces and providing a more personalised experience can help people from diverse backgrounds access and use tools.

Research in HCI with regard to personalised and adaptive interfaces should attract partnerships with industry from areas such as the Entertainment, Education and Health and Wellbeing sectors.

References

[1] - D. A. Carmichael, M. P. Down, R. C. Shillcock, D. M. Eagleman, and J. Simner, 'Validating a standardised test battery for synesthesia: Does the Synesthesia Battery reliably detect synesthesia?', *Consciousness and Cognition*, vol. 33, pp. 375–385, May 2015, doi: 10.1016/j.concog.2015.02.001.

[2] - C. V. Parise and C. Spence, 'Audiovisual crossmodal correspondences and sound symbolism: a study using the implicit association test', *Exp Brain Res*, vol. 220, no. 3-4, pp. 319–333, Aug. 2012, doi: 10.1007/s00221-012-3140-6.

[3] - S. Lacey, M. Martinez, K. McCormick, and K. Sathian, 'Synesthesia strengthens sound-symbolic cross-modal correspondences', *Eur J Neurosci*, vol. 44, no. 9, pp. 2716–2721, Nov. 2016, doi: 10.1111/ejn.13381

[4] - D. Johnson, C. Allison, and S. Baron-Cohen, *The prevalence of synesthesia*. Oxford University Press, 2013. doi: 10.1093/oxfordhb/9780199603329.013.0001.

[5] - C. van Campen and C. Froger, 'Personal Profiles of Color Synesthesia: Developing a Testing Method for Artists and Scientists', *Leonardo*, vol. 36, no. 4, pp. 291–294, Aug. 2003, doi: 10.1162/002409403322258709

[6] - R. Poguntke, M. Wirth, and S. Gradl, 'Same Same but Different: Exploring the Effects of the Stroop Color Word Test in Virtual Reality', in Human-Computer Interaction – INTERACT 2019, vol. 11747, D. Lamas, F. Loizides, L. Nacke, H. Petrie, M. Winckler, and P. Zaphiris, Eds. Cham: Springer International Publishing, 2019, pp. 699–708. doi: 10.1007/978-3-030-29384-0_42.

[7] - D. Wu et al., 'Optimal Arousal Identification and Classification for Affective Computing Using Physiological Signals: Virtual Reality Stroop Task', IEEE Trans. Affective Comput., vol. 1, no. 2, pp. 109–118, Jul. 2010, doi: 10.1109/T-AFFC.2010.12.

[8] - S. Gradl et al., 'The Stroop Room: A Virtual Reality-Enhanced Stroop Test', in 25th ACM Symposium on Virtual Reality Software and Technology, Parramatta NSW Australia, Nov. 2019, pp. 1–12. doi: 10.1145/3359996.3364247.

View my publications here!

Host Institution

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

Maynooth University
National University of Ireland Maynooth

TU DUBLIN
Ollscoil Teicneolaíochta Bhaile Átha Cliath
TECHNOLOGICAL UNIVERSITY DUBLIN

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin