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VR/AR for Users with Tic Disorders: Challenges and Opportunities

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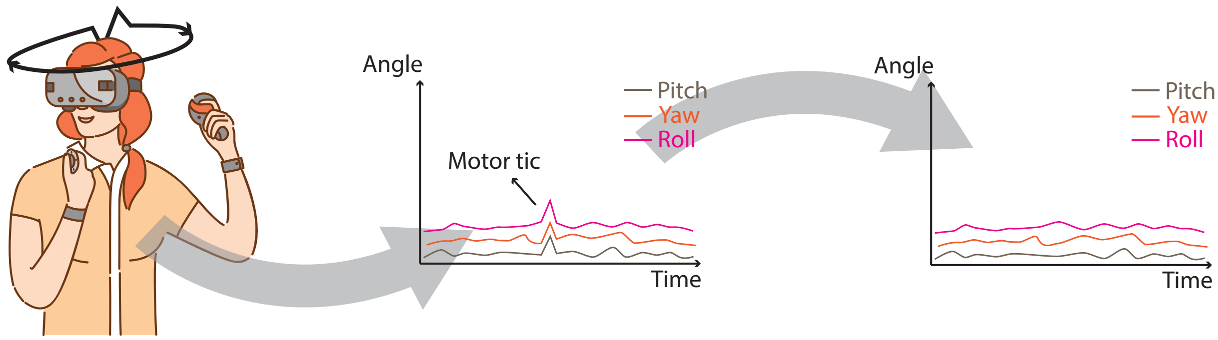

Figure 1: Schematic view of how signal processing could detect and filter motor tics. VR and AR often rely on head-, eye- and hand-input for control. Tic disorders, especially motor tics, disrupt this traditional AR/VR control cycle. Adjusting AR/VR, e.g. via signal processing — is a potential way to make immersive technologies enjoyable and usable for people with certain manifestations of tic disorders

Abstract

Tics — sudden and irresistible movements, sounds, or behaviour of people — can severely impact people's lives. Interactive technologies such as virtual reality (VR) and augmented reality (AR) can potentially act as entertainment and productivity technologies that can handle tics. However, current AR/VR technologies are not ready for many people with tics as the tic itself — especially motor tics — prevents usage as many user interfaces rely on hand-, head- and eye-interaction. However, these body parts often affect motor tics, preventing an enjoyable, immersive experience. In this position paper, we outline the basics of tic disorders, connect tic disorders to head-mounted displays, and outline challenges and opportunities. By scoping literature and relying on anecdotal data, we speculate on whether and how we can design immersive applications and technologies for people with tic disorders. We stress that working with users and the availability of public data sets is essential for research and development. The prediction, filtering, or leveraging of tic-induced motion patterns especially seems to be a promising research avenue. In addition, we outline potential strategies such as input remapping and modifying the audiovisual output of the HMD could be improved to prevent or inhibit tics. Overall, we open the discussion about the design of immersive experiences for people with tic disorders.

Index Terms: Virtual Reality, Head-Mounted Displays, Tic Disorders, Tourette's Syndrome.

1 Introduction

R1: "... but only if I find an extra large space to play due to my arm tics. Cause at least I can turn my body in a direction that won't hit something valuable, but in VR I have no perception of that" [16]

R2: "They were so heavy after a time my neck got tired and started to tic.[15]"

R3: "I play VR [...] and for me the pressure of the headset somehow makes the tics go away." [15]

R4: "There are games I really like that I am simply incapable of playing."[15]

R5: "I find that my motor tics stop as I get REALLY focused on the songs, but they'll come rushing back after the song is over. My vocal tics will happen while I play, though they are a lot less frequent." [16]

This anecdotal evidence from users with tic disorders trying and testing virtual reality (VR) highlights some nuances of VR's effects on tics — from neck strain, pressure, content, task, space, and aftereffects. While prior research has speculated on the use of virtual reality for the treatment of tic disorders [10, 11] research in the form of user studies, case studies, public data sets, and more is scarce or non-existent: the effect of virtual and augmented reality (VR/AR) on and for people with tic disorders remains underexplored. In this position paper, we outline tics and their connection to VR, some challenges that users with tic disorders face today when using VR, and opportunities for research to design HMD-based immersive experiences so that people with tic disorders can enjoy them. While tics manifest differently, we predominantly discuss motor tics and argue that working with users, creating public data assets, managing some tics with signal processing techniques, and exploring design strategies can make VR and AR enjoyable and useable by people with certain tic disorders.

2 Tics

Tic disorders are a set of conditions that have tics as a symptom, such as Tourette's Syndrome (TS), Chronic Tic Disorders (CTD), and Transient Tic Disorders (TTD). Their prevalence varies depending on the population studied, with studies reporting values of .77% for children and 0.05% for adults [12]. A tic is a sudden, stereotyped movement or sound typically performed secondary to an irresistible urge [12]. They typically consist of simple or coordinated, repetitive, or sequential movements, gestures, and utterances that mimic fragments of normal behaviour but are misplaced in context [8]. To complicate matters, tic disorders commonly present as

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co-morbid with other conditions. The most prevalent are attention deficit hyperactivity disorder (ADHD) and obsessive compulsive disorder (OCD). For example, they are present in 60-80% and 11-80% of TS patients, respectively [13].

The tics experienced by tic disorder patients are generally classified into the following three types [7, 22]:

1. Motor tic,
2. phonic (or vocal) tic, and
3. behavioural tic.

Motor tics are movements of the face or body, such as blinking, tapping, or neck jerks. *Phonic tics* comprise a range of vocalisations, including grunts, coughs, and random words. *Behavioural tics* can be comprised of touching others or objects, temper fits, and argumentativeness. Motor and vocal tics can also then be separated into clonic, dystonic, and tonic tics: (1) clonic tics involve only a single muscle or group of muscles, causing a brief, jerking movement; (2) dystonic tics are slower, causing a briefly sustained abnormal posture; (3) tonic tics reflect an isometric contraction, typically manifesting with a brief tension of abdominal or limb muscles [7].

Environmental and psychological stressors can exacerbate tics, and it has been shown that tics are worsened by some expressions of acute stress [5]. Current clinical evidence indicates that tic severity and frequency are mainly influenced by an overlap of (1) high or low sensory stimulation, (2) anxiogenic (anxiety-inducing) situations, (3) frustrating and anger-inducing contingencies, and (4) fatigue and sleep loss [5]. Treatment for tic conditions is incredibly complex, largely due to the high frequency of common comorbidities [2]. However, there are existing treatments and managements for certain diagnoses such as TS, including psychoeducation and reassurance, medication, behavioural therapy, and in rare cases, neurosurgery [17].

3 Tics and HMDs

In VR and AR, the position and movement of the head, eyes and body are often used for input. The head position controls the viewport and can be used for head-pointing, which requires relatively stable and precise control over the head orientation. Controllers or hand tracking are often used as a primary input method, meaning that a stable hand position and motor control are important. Some HMDs also incorporate gaze-based interaction, such as the Apple Vision Pro[1], which relies on stable eye gaze. In addition, gesture controls, such as those in the Apple Vision Pro, use hand tracking to take input based on controlled hand position and configuration.

The nature of HMDs and how we control them today pose several challenges when considering the basic nature of tics. For example, phonic tics could make voice-controlled experiences or those that rely on voice (such as social AR/VR applications) unenjoyable or unusable. Similarly, motor tics have the potential to negatively impact or even prevent viewport control, head pointing, eye pointing, and basic controller interactions. Here, even relatively simple experiences such as watching a 360° video become less enjoyable as, for example, motor tics affecting the neck and head prevent users from looking where they want to or disrupt the flow. Similarly, head- and eye-based pointing is impaired by such tics as the tic can present during the dwell period and prevent confirmation.

Still, virtual reality has been considered a compelling tool for people with tic disorders, especially for behavioural therapy. Inspired by the role VR plays in the treatment of other disorders, such as ADHD and autism spectrum disorder, Kim et al. [11] speculate that VR could provide an environment where people can overcome limitations of healthcare systems (lack of resources and therapists). They mention, among others, exposing users to repetitive and consistent training tailored to the specific patient. Similarly, Kahn et al. [10] highlight the possibility of using VR to connect people with simulated life-like therapists and point to positive results in cases with other disorders and mental health problems (see Valmaggia et al. [21])

We speculate that next to these therapeutic applications that focus on long-term behavioural changes and tic management, virtual reality can play a different role for a certain group of people with tic disorders — those where tics do not prevent them from using an HMD in general — in the form of games and entertainment (and productivity). However, with this opportunity, certain challenges arise that must be considered.

4 Challenges and Opportunities for HMDs and Immersive Applications

4.1 Working with users

When designing and developing for people with tic disorders, they should be included in the research early, before research proposals have been developed, so the activities are targeted to address the proper goals. As suggested by the anecdotes in section 1, the effects of VR and VR-HMDs on tics vary and are not obvious. This lack of understanding (and the lack of existing research) poses a high risk that researchers lack a proper understanding of tic disorders (e.g., the variety of effects it has on the user, such as pain) or that the imagined or developed solution is actually irrelevant (cf. "Disability Dongle"[2]) or even harmful (e.g., by accidentally triggering tics). Thus, creating and maintaining communities where users with tic disorders provide input and feedback while having fair access to results and findings is essential. Having these networks, researchers and developers can engage in goal-driven research where the research aim benefits both the user and the researcher. These co-design processes must be flexible, fair, and address collective benefits [14, 18].

4.2 Public data sets

To alleviate the burden of being part of the research cycle for people with tic disorders (which can be draining and require a lot of resources), researchers should strive to open-source data while following ethical guidelines, especially those regarding anonymization. Having these data sets eases development, at least from an implementation perspective. For example, Yosuke et al. [4] present such a dataset of average rotation velocity and acceleration of the head during tics but not for VR and Joke et al. [20] provide accelerometer signals of head movements and rotations during tics. While these non-HMD datasets provide some insight, hardware factors such as the weight and pressure of the devices, as well as software factors that trigger or inhibit tics, are not part of these datasets. Thus, dedicated datasets with annotations about the HMD are necessary. It is important to note that while these datasets support development, they are insufficient to guide and drive research due to the individual nature of tic disorders and their effects beyond the actual tic (e.g. mental health, pain).

4.3 Real-time Filtering and Prediction?

VR inherently relies on sensor data for interaction. From an engineering perspective, especially for vocal and motor tics, detecting, predicting, and filtering tics in the hands, eyes, head, and audio signal seems promising in providing an enjoyable and usable experience. Similar approaches have been used in non-immersive settings. E.g., Bernabei et al. [1] use an accelerometer to detect and quantify motor tics, Cernera et al. [3] use acceleration data and electromyogram data to detect and classify tics, and Tong et al. [19] propose a similar adaptation method based on eye gaze

[1]https://www.apple.com/apple-vision-pro/

[2]https://blog.castac.org/2022/04/disability-dongle/

for people with cerebral palsy. Such approaches could, for example, filter out movements induced by tics and, thus, avoid accidental interaction (e.g., a 360° video player could briefly pause or adjust the viewport, movements of an avatar could be smoothed, and 3D manipulations could ignore the tic). This naive signal-processing approach could be complemented by solutions that predict intention. For example, Isomoto et al. [6] predict dwell intention in VR. Adopted approaches could predict the intention of a dwell and sustain the dwell if an involuntary head movement happens during the dwell time period, enabling and supporting dwell-based interaction. Approaches like this seem — from a technological perspective — feasible for involuntary movements of the head, eye, and hands. Similarly, vocal tics could be detected and filtered from the audio signal to avoid accidental voice interaction during voice-controlled experiences or implement an "auto-mute" functionality during social AR/VR experiences. For both examples, the challenge is the unexplored factors such as pain due to tics during long-term interaction, the severity of tics (maximum acceleration, pressure, and torque), the influence of the virtual reality and the HMD itself, as well as individual characteristics and dedicated needs of the community — all require co-design with users and public data sets. Interestingly, if such solutions have value, they could be integrated into applications and the operating system.

4.4 Design for Tics and Accessibility

In addition to approaches relying on signal processing and machine learning, techniques that provide users with the agency to adapt the experience or automatically adapt could offer benefits.

For example, remapping inputs to modalities unaffected by a tic could avoid accidental interaction. Related, Jung et al. [9] show that subjects with Tourettes syndrome showed higher saccadic control, which might offer an opportunity for a special purpose input device leveraging symptoms of Tourette's syndrome instead of or in addition to trying to negate them.

As outlined earlier, tic severity and frequency are influenced by various factor combinations. Because sensory stimulation has been shown to affect both, accessibility menus should be integrated into HMDs and contain settings that control the audiovisual fidelity. This could be, for example, allowing for changing settings such as contrast, sound, and brightness but also about enabling/disabling visual details (or clutter) in the scene. An even more speculative approach is that advanced sensing, such as EMG or EEG, could detect the tic before it happens and adapt the immersive experience so that the urge to tic resides.

5 Conclusion

Tics are involuntary movements, behaviours, or vocalizations whose reasons are manifold. We believe that HMD-based applications, and especially HMDs, have the potential to provide people with tic disorders with means of entertainment, play, and productivity. However, designing for people with tics requires co-designing and including them in the design process in a fair way to prevent harm and to guide research. We hope this position paper will help kickstart and support the community-building process. Collecting data on tics — especially tracking data — and creating public (anonymized) data sets for research would foster research and development (and alleviate people with tic disorders from the mental load during co-design). Next to signal processing and machine learning approaches, accessibility options to adjust the audiovisual experience to minimise the risk of triggering tics is a promising research avenue. Overall, research on how VR and AR can contribute to the well-being of people with tic disorders is promising. It could offer this user group a so-far-overlooked entertainment and productivity technology.

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References

[1] M. Bernabei, E. Preatoni, M. Mendez, L. Piccini, M. Porta, and G. Andreoni. A novel automatic method for monitoring tourette motor tics through a wearable device. *Movement disorders*, 25(12):1967–1972, Sep 2010. doi: 10.1002/mds.23188 2

[2] A. Cavanna. The neuropsychiatry of gilles de la tourette syndrome: The état de l'art. *Revue Neurologique*, 174(9):621–627, Nov 2018. doi: 10.1016/j.neurol.2018.06.006 2

[3] S. Cernera, L. Pramanik, Z. Boogaart, J. N. Cagle, J. Gomez, K. Moore, K. Loong, M. S. Okun, A. Gunduz, and W. Deeb. The human tic detector: An automatic approach to tic characterization using wearable sensors. *Clinical neurophysiology*, 134:102–110, Feb 2022. doi: 10.1016/j.clinph.2021.10.017 2

[4] Y. Eriguchi, X. Gu, N. Aoki, M. Nonaka, R. Goto, H. Kuwabara, Y. Kano, and K. Kasai. A 2-year longitudinal follow-up of quantitative assessment neck tics in tourette's syndrome. *PLoS ONE*, 16(12):e0261560–e0261560, Dec 2021. doi: 10.1371/journal.pone.0261560 2

[5] S. C. Godar and M. Bortolato. What makes you tic? translational approaches to study the role of stress and contextual triggers in tourette syndrome. *Neuroscience & Biobehavioral Reviews*, 76:123–133, May 2017. doi: 10.1016/j.neubiorev.2016.10.003 2

[6] T. Isomoto, S. Yamanaka, and B. Shizuki. Dwell selection with ml-based intent prediction using only gaze data. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 6(3):1–21, Sep 2022. doi: 10.1145/3550301 3

[7] J. Jankovic. Phenomenology and classification of tics. *Neurologic Clinics*, 15(2):267–275, May 1997. doi: 10.1016/s0733-8619(05)70311-x 2

[8] J. Jankovic and S. Fahn. The phenomenology of tics. *Movement Disorders*, 1(1):17–26, Jan 1986. doi: 10.1002/mds.870010103 1

[9] J. Jung, S. R. Jackson, K. Nam, C. Hollis, and G. M. Jackson. Enhanced saccadic control in young people with tourette syndrome despite slowed pro-saccades. *Journal of Neuropsychology*, 9(2):172–183, Apr 2014. doi: 10.1111/jnp.12044 3

[10] K. Khan, C. Hollis, T. Murphy, and C. L. Hall. Digital and remote behavioral therapies for treating tic disorders: Recent advances and next steps. *Frontiers in Psychiatry*, 13:928487, 2022. 1, 2

[11] K. M. Kim, E. Bae, J. Lee, T.-W. Park, and M. H. Lim. A review of cognitive and behavioral interventions for tic disorder. *Journal of korean Academy of Child and Adolescent Psychiatry*, 32(2):51–62, Apr 2021. doi: 10.5765/jkacap.200042 1, 2

[12] T. Knight, T. Steeves, L. Day, M. Lowerison, N. Jette, and T. Pringsheim. Prevalence of tic disorders: A systematic review and meta-analysis. *Pediatric neurology*, 47(2):77–90, Aug 2012. doi: 10.1016/j.pediatrneurol.2012.05.002 1

[13] A. Kumar, W. Trescher, and D. Byler. Tourette syndrome and comorbid neuropsychiatric conditions. *Current Developmental Disorders Reports*, 3(4):217–221, Nov 2016. doi: 10.1007/s40474-016-0099-1 2

[14] E. J. McDonnell, K. A. Mack, K. Gerling, K. Spiel, C. L. Bennett, R. N. Brewer, R. M. Williams, and G. W. Tigwell. Tackling the lack of a practical guide in disability-centered research. In *Proceedings of the 25th International ACM SIGACCESS Conference on Computers and Accessibility*, ASSETS '23. Association for Computing Machinery, New York, NY, USA, 2023. doi: 10.1145/3597638.3615650 2

[15] Reddit. Does anybody have any experience with tics in VR? https://www.reddit.com/r/Tourettes/comments/dmyuk1/does_anybody_have_any_experience_with_tics_in_vr/. [Accessed 05-08-2024]. 1

[16] Reddit. Does anyone play or still play VR with tourettes/tics? https://www.reddit.com/r/Tourettes/comments/ufhsnb/

does_anyone_play_or_still_play_vr_with/. [Accessed 05-08-2024]. 1

[17] M. M. Robertson, V. Eapen, H. S. Singer, D. Martino, J. M. Scharf, P. Paschou, V. Roessner, D. W. Woods, M. Hariz, C. A. Mathews, R. Črnčec, and J. F. Leckman. Gilles de la tourette syndrome. *Nature Reviews Disease Primers*, 3(1), Feb 2017. doi: 10.1038/nrdp.2016.97 2

[18] P. Sendra. The ethics of co-design. *Journal of Urban Design*, 29(1):4–22, 2024. doi: 10.1080/13574809.2023.2171856 2

[19] C. Tong and R. Chan. Gaze-based interaction adaptation for people with involuntary head movements (student abstract). *Proceedings of the AAAI Conference on Artificial Intelligence*, 38(21):23669–23670, Mar 2024. doi: 10.1609/aaai.v38i21.30519 2

[20] J. H. M. Tulen, W. H. Groeneveld, Judith, Sander, and Ben. Ambulatory accelerometry to quantify involuntary movements and tics in the syndrome of gilles de la tourette. *Behavior Research Methods Instruments & Computers*, 33(3):357–363, Aug 2001. doi: 10.3758/bf03195389 2

[21] L. R. Valmaggia, L. Latif, M. J. Kempton, and M. Rus-Calafell. Virtual reality in the psychological treatment for mental health problems: An systematic review of recent evidence. *Psychiatry research*, 236:189–195, 2016. 2

[22] Y. Worbe, L. Mallet, J.-L. Golmard, C. Béhar, F. Durif, I. Jalenques, P. Damier, P. Derkinderen, P. Pollak, M. Anheim, E. Broussolle, J. Xie, V. Mesnage, K. Mondon, F. Viallet, P. Jedynak, M. B. Djebara, M. Schüpbach, A. Pelissolo, and M. Vidailhet. Repetitive behaviours in patients with gilles de la tourette syndrome: Tics, compulsions, or both? *PLoS ONE*, 5(9):e12959–e12959, Sep 2010. doi: 10.1371/journal.pone.0012959 2