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Anatomy of a Hug in Virtual Reality

Leonel D. Deusdado, Alexandre F. J. Antunes*

Research Centre in Digitalization and Intelligent Robotics (CeDRI), Polytechnic Institute of Bragança (IPB), Campus de Santa Apolónia, Bragança 5300-253, Portugal

Abstract

Over time, there has been an increase in research on how to improve emotional state rehabilitation processes, and it is notable that the use of technology has had a positive result, with increasing accuracy. Serious Games (SG) for Virtual Reality (VR) are extremely beneficial in this regard, and the use of haptic devices as a tool for researchers and medical teams is increasing in popularity. The current study aims to conduct an initial investigation into the use of a haptic vest to see if haptic touch can aid in emotional conditioning, which may result in improved disease and phobia rehabilitation, and whether different interactions with virtual scenarios, such as a virtual hug, can increase immersiveness. The investigation seeks to discover the most effective ways to convey a virtual to physical hug using the haptic device. Previous research has revealed a high level of participant interest, as well as increased immersion in SGs realism, leading to additional research and implementation.

Keywords: Virtual touch; Haptic device; Virtual hug; Virtual emotions; Emotional education.

* Leonel D. Deusdado. ORCID: 0000-0002-9944-4386
E-mail address: leodeus@ipb.pt
* Alexandre F. J. Antunes. ORCID: 0000-0001-6988-8237
E-mail address: alexandrejarosz@ipb.pt

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1. Introduction

Under the historical perspective of humanity, various methods have been defined to treat diseases and health problems in order to alleviate an individual's suffering. The use of electronics and digital processes in healthcare, has grown significantly in research over the years, bringing innovative products and applications [1, 2], however often faster and with greater coverage. Despite the more serious issues, it is possible to overcome emotional difficulties such as phobias, anxiety, and depression, among others, and this is now being addressed more effectively [3]. One method for making treatment and rehabilitation more interesting for patients is to use Serious Game (SG), and which facilitate patients' acceptance to participate in medical treatment sections in a safe method, sometimes without realizing it. A fantastic integration opportunity is to use SG in Virtual Reality (VR), a correlation that is also being investigated for a variety of diseases and phobias. When discussing SG in VR, immersiveness is enhanced by the use of goggles, also known as Head-Mounted Display (HMD) devices, providing an effective treatment for diseases and phobias. It is possible to conclude that immersiveness is crucial for this and that the larger it is, the more results it will provide [4], with great care required in the correlation and configuration to avoid undesirable results, as motion sickness or new phobias. The current study also aims to use a haptic device to identify potential interactions that increase immersiveness for SG in VR, bringing better experiences while using an HMD, and focusing on better treatment and rehabilitation. One interaction that has been shown to be important is a hug, as well as seen in previous research [5], which has already been studied in treatments as an emotional interaction between humans that can be beneficial and the perception of more comfortable types of hugs between people [6, 7]. The change in people's emotions when using such elements ignited a great interest for research, allowing for some of the experiments discussed further.

Some tests were conducted using different experiences about emotional education, which include a variety of mini-games that focus on providing the player with calm, energy, relaxation, and fear, among others, in order to understand which experiences in a VR SG people like the most. This study included 40 people from 7 different countries, being teachers and students. It included 7 men and 33 women, with 33 between the ages of 18 and 25, 5 between 26 and 35, and 2 between 36 and 50. Also, 26 people were having their first VR experience, 7 had previously experienced it with simpler devices, and 7 with similar devices. Following the VR experience, participants filled out a form to report their feelings, showed in the first half of Table 1, with the emotion, the respective number of choices, and its percentage.

Table 1. Virtual reality and haptic experience statistics.

Virtual reality experience		Haptic experience	
Feeling	Amount	Action	Amount
Anxiety	7 (17.5%)	Handshake	20 (50%)
Apprehension	6 (15%)	Hug	21 (52.5%)
Claustrophobia	3 (7.5%)	Kiss	7 (17.5%)
Fear	5 (12.5%)	Shoulder touch	9 (22.5%)
Impatient	2 (5%)		
Happiness	23 (57.5%)		
Relaxation	16 (40%)		
Tranquility	12 (30%)		
Wonder	1 (2.5%)		

They were also asked which virtual interaction they would feel most comfortable while using a haptic device to get the physical sensation, as shown in the second half of Table 1 with the action, the respective number of choices, and its percentage. Both percentages are based on the total number of choices among the 40 participants. The hug was the most interesting haptic interaction to the participants. For this reason, it became an interesting subject for researching to aid in the treatment and rehabilitation of diseases or phobias while people are playing a SG in a VR. The following section discuss notable works relevant to the current article's theme, followed by a simple analysis of the importance of a touch for disease and phobias treatment. The fourth section covers implementations and applications for using of a haptic vest to also the this type of treatment, followed by a brief evaluation and feelings caused by its use in a virtual environment, as well as the realism level enhancement felt by the survey participants. The sixth section presents conclusions for the led work and futures perspectives.

2. State of the art

The concepts of SG and VR can be used for a variety of purposes and have already seen prevalent application in the healthcare industry. Doctors are using this technology to reach new achievements in the treatment of many diseases. Schiza et al. conducted a review of the use of VR applications for neurological diseases [8], including dementia, stroke, spinal cord injury, Parkinson's disease, and multiple sclerosis, and reached the conclusion that they were positive and effective. Sobri et al. used haptics tactile feedback to help enhance their interaction with mobile applications for heart disease monitoring [9], increasing the level of usability by using their components to remind patients of important tasks such as taking medicine, which still requires medical proof. Michalakis et al. present a VR simulation of a schizophrenic's experience [10] with mind delusions and auditory, visual, and haptic hallucinations, using a haptic vest to simulate someone touching the person. Fadaei et al. developed a prototype haptic wear [11] for sensory-motor perception experimentation using mechanical back touches via hand commands and the generation of body illusions via human-finger pokes to provide greater realism in virtual environments. Tannert et al. used a haptic vest to provide real-time vibrotactile feedback to patients with balance problems [12], which they say is promising in reducing lower back tilt but not in controlling the center of mass. Adilkhanov et al. conducted a literature review on the use of haptic devices in virtual environments between 2010 and 2021 [13], analyzing their characteristics and uses, as well as exposing gaps and challenges for the use of such devices and other aspects. Lee et al. used vibrotactile feedback provided by a haptic vest in mixed reality to improve spatial awareness and object detection in people with visual impairment [14], and participants were able to avoid collisions with objects in the environment. García-Valle et al. use a haptic vest to understand how the user can benefit from its use in a VR [15], with most users understanding it to improve the virtual environment's performance by increasing its immersiveness and enhancing realism and sense of presence in the virtual world.

3. The importance of the touch for diseases and phobias

Hugging is a natural human behavior in which we express our feelings of affection, safety, friendship, and support, through this simple and powerful gesture [16]. Hugs come in a variety of styles and causes hormonal releases that reduce stress, control blood pressure, reduce pain, among other things. Other topics related to the theme of this work can be studied and would be extremely valuable in order to determine whether the use of the haptic vest can also induce such emotions in the person [17–20]. Nagy [21] conducted research to analyze spontaneous hugs in order to understand the average amount of time people take to hug and concluded that it is around 3 seconds of hugging plus 2 seconds of preparation and release. Another intriguing detail is that there was no gender difference in the experiment, only in terms of how well the two people got along. Furthermore, there has been research on which side humans hug more frequently, and most of them rotate to the right side [22], but for this work it will be used rotation to both sides in the vest implementation.

In order to improve the simulation in the haptic vest, another important question is which body regions receive touch, which are the least uncomfortable or most pleasant, and how much intensity is best during the hug. Cazzato et al. [23] conducted a research with 30 female participants and discovered that the abdomen was the least pleasant for touching, while the forearm and back regions were the most. It states that people enjoy the experience of touch and concludes that positive, affectionate touch promotes psychological well-being and protects physical health. Nonetheless, the conclusions contend that the tests cannot be applied to men, who are usually more sensitive to touch. Chest and abdomen had a greater feeling of sensitivity, causing the intensity of the front part of the torso to be reduced in the vest. Three hugs were planned to be implemented in the vest, as illustrated in Fig. 1. The first and most common is the criss-cross (a) [7], or classic, which has the arms crossed and heads next to each other being usually used by family, friends, acquaintances, and often to greet someone unknown. Other types of hugs include the one-sided (b), or protective, which is a side hug that conveys confidence and care, and is typically used by more intimate people, and the neck-waist hug (c), which is similar to the symmetrical or friendly hug in that it crosses both arms over or under the arms of the other person and is also a bit more intimate [19].

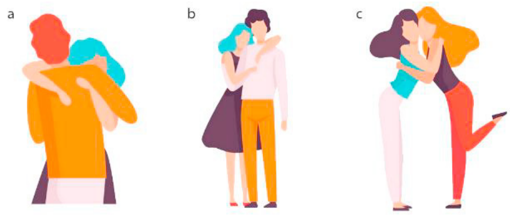

Fig. 1. (a) Criss-cross; (b) One-sided; (c) Neck-waist. [19]

Although the criss-cross hug is the most common and easiest for everyone to use, the other two types discussed can be used for testing with patients with better acceptance of the tool. Both hugs were implemented for both sides of rotation or position, right and left or up and down, increasing the variety of the haptic vest's use and adaptability to all users. understanding it to improve the virtual environment's performance by increasing its immersiveness and enhancing realism and sense of presence in the virtual world. Also, intriguing is the possibility of hugging a pet, whether a dog or a cat, which may provide some additional benefits than hugging a human being. The implementation of hugs in the haptic vest will be addressed more thoroughly in subsection 4.3, Hug Implementation.

4. Vest implementation and its applications

As haptic devices have been increasingly used in virtual experiences with interesting results, as seen in previous sections, the current work seeks to use a haptic vest to provide greater immersiveness for VR SGs and new experiences by providing the ability to physically feel the virtual interactions. In the medical field, such inclusion may result in a more elaborate exploration of situations, resulting in greater accuracy in disease and phobia treatment and rehabilitation strategies. There are several models of haptic vests for various purposes, the investigation used the TactSuit X40 model from the developer bHaptics [24], bringing 40 vibrotactile eccentric rotating mass vibration motors arranged in 5 rows by 4 columns on each side, for a total of 20 vibrotactile motors in the front and 20 more in the back. All of its vibration engines are configurable, allowing them to be customized to any usage requirement and in real time. It is possible to create animation patterns on bHaptics Designer website [25], which can be imported into a game creation engine. For this research, it is used Unity [26], which uses C# programming language and allows game creation with good applicability for the VR HMD Meta Quest 2 [27]. Also the vest itself by using the bHaptics Software Development Kit (SDK) [25], allowing the device use and configuration in Unity. The animation of the vibration motors is determined by which motor is activated, how long it is active, and its intensity. With a series of motors activation, an animation is created with smooth transitions that simulate some real-life interaction. Furthermore, such individual animations can be defined for each vibration engine, allowing for real-time animation generation by coding, which will be addressed further in this section. As previously stated, bHaptics' developer website [25] allows the creation of animation documents for their haptic devices. As a result, with the help of this online tool, pre-programmed animations such as the hug interaction with a Non-Playable Character (NPC) can be created. Animation files were imported into Unity [26] and configured by code to activate the vest in real time when a specific interaction occurs during the game. When using bHaptic's SDK [25], some code files that enable the connection with the vest system are imported into Unity. The hugging issues will be addressed more thoroughly in subsection 4.3, Hug Implementation.

Games allow multiple interactions with the player during gameplay, resulting in a massive variation of possibilities due to game events and the player's movement. This would make using the vest unfeasible due to the time-consuming task of creating animations for each possible interaction. A different approach was required to optimize its use for costlier and more real-time gameplay. To accomplish this, each vibration motor was linked to a invisible collision sensor in Unity [26], so the player cannot see it and each one is activated whenever an object in the scene makes contact with it. The sensors are attached to the player and follow his movements through the scene in the same order as the motors in the vest, as shown in Fig. 2 with the yellow cubes being the representation of the sensors. This implementation allows for the simulation of the sensation of physically touching objects in the scene, such as feeling a wall when approaching it (a), bumping into the pet as when moving around the scene (b), and bushes (c), among other possibilities. For the reason it is a game-time interaction, such implementations need a slightly more computational process. The *Mesh Collider* in Unity can take the entire mesh of the object and make the interaction more precise, but it requires a lot from the machine and can reduce the game's flow quality. An alternative is to use the *Box Collider*, which requires less computational effort but does not provide as much detail at the time of collision, necessitating careful definition of collision sizes for improved accuracy.

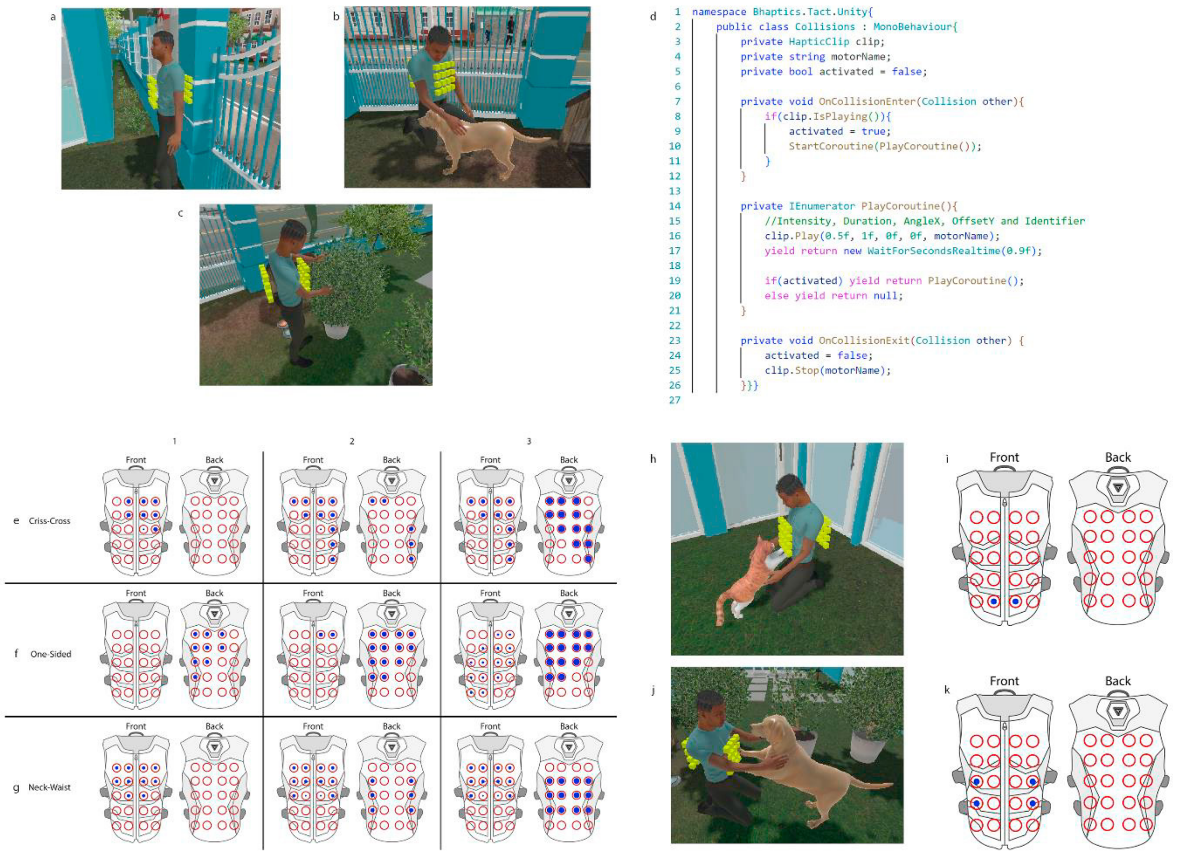

Fig. 2. (a) Wall; (b) Pet; (c) Bushes; (d) Collision code; (e) Criss-criss; (f) One-sided; (g) Neck-waist; (h) Cat hug; (i) Cat hug on vest; (j) Dog hug; (k) Dog hug on vest.

The new implementation needed new coding that first attempts to determine which sensor is intended for which vibration engine, as shown in (d). For the reason of the possibility of defining objects of no interest for the interaction, it is then checked if the collision object is valid to make the interaction. It is possible to start a loop that keeps the vibration motors active when in collision by using the function *StartCorroutine(function)* in code. The animations were designed to keep the vibration motors active for 5 seconds, as can be seen in the subsec 4.3, Hug Implementation, before calling the function that activates the animation again, which is the function *Play(parameters)* mentioned earlier, and so on while colliding with an object. As a result, a stop condition is required for when the sensor no longer contacts the object, using the *Stop(identifier)* function indicated earlier, which uses the identifier created to deactivate the respective vibration engine. When their respective Unity sensors come into contact with an object, only the vibration engines in their respective Unity sensors will be activated.

Some details were created for the implementation based on the section 3, The Importance of the Touch for Diseases and Phobias, that was previously presented. On the bHaptics developer website [25], a sequence of commands for the activation motors was defined in order to create the animations for each hug (criss-cross, one-sided, and neck-waist). Furthermore, all animations were set to a maximum time of 5 seconds, and the front region of the vest was programmed with lower intensity vibration motors being represented by the size of the blue circles which the smaller ones are lower intensity and greater ones higher intensity, for reasons that were previously discussed. Figure 2 depicts the motor progression for each hug. The transition between each step is done smoothly to aid perception of the animation's beginning, progression, and completion. The vest is in a neutral state before the first and last steps, i.e. all vibration motors are deactivated. The animations for the criss-cross and one-sided hugs are done on both sides, right and left, while the neck-waist animation is done on the top and bottom of the vest, making 6 animations from 3 types of hug. When the hug is finished, the reverse process of each animation begins, gradually undoing the hug.

The criss-cross hug (e), has the first step of activation of the motors on the chest (1), beginning at the front of the vest. This is followed by forearm contact on the side of the abdomen and in a shoulder (2), vest activation on the front and back, and the simulation of hands on the back at the end of the hug with upper back vibration motor activation (3). The One-Sided Hug (f), has the first step only on the side of the back to simulate the first contact (1), then a larger area of contact on the back and a little on the opposite shoulder in front portraying the forearm (2), and finally simulating the hand on the chest by activating a larger region on the chest (3). For the neck-waist (g), it begins with contact only on the chest (1), progresses to forearm contact on both front and back sides of the belly (2), and concludes with the full backhand hug (3). Although human contact through hugging can provide some benefits, it can also cause discomfort in some situations. A second intriguing proposal is the possible implementation of contact with a pet, can interact with a cat (h) and implement the interaction in the vest (i), or with a dog (j) and implement the respective interaction (k). Contact with a dog or a cat can elicit a wide range of emotions in humans. This allows each patient to select the type of contact that is most comfortable for them, and medical follow-up can confirm the best methodology for each patient based on their preferences and specific difficulties. Several activities can be specified in order to provide better adaptability and experience for pets inside the virtual environment, which can also be integrated with the haptic vest.

5. Evaluations of the case

The use of the haptic vest is intriguing because of how it can add realism to virtual games through real-time vibrotactile feedback. Despite this, some difficulties were identified during the planning, programming, and use of the haptic tool, one of which was the inability to know the rotation of the player's torso, which makes certain virtual world movements impossible by leaving the sensors always in the original rotation. For the reason the experience varies from patient to patient while in game, medical monitoring is essential to determine which patients could benefit from the presented technology. If there is no such understanding, it is possible that undesirable outcomes occurs, such as creating discomfort and minimizing the immersion of the player patient, thereby impeding treatment and rehabilitation. It is also clear that each SG must be adaptable to each type of disease or phobia, as well as each type of patient, and being once again medical monitoring is indispensable. Hugging and the perception of other objects in the scenario by the use of the vest can also bother a patient, necessitating a cautious approach because it is an act of more intense affection, requiring a person's acceptance for the practice of hugging. Previous studies used people without mental illnesses who had a wide range of emotions and opinions about wearing the vest, which will be discussed further.

The aim of increased immersion generated interest in evaluating a haptic vest, which offers new approaches that transform what is virtual into something physical via vibrotactile feedback. In previous research [5], 12 people were asked how they felt when wearing a haptic vest and whether there was an increase in the realism of the VR environment. The first half of Table 2 displays the feelings, as well as the respective number of options and their percentages. The second half of Table 2 addresses the users' response to the increase in the level of immersiveness when using the vest in a VR application, which means how much the haptic vest increased the participants' perception of insertion in the virtual environment. The level of immersion is displayed, with 1 being very bad and 10 being very good, as well as the number of options and their percentage. Both percentages in Table 2 are based on the number of responses compared to the total number of 12 survey participants. There were both positive and negative feelings when using the haptic device and the SG of VR in the HMD, with the majority being apprehension and happiness. This demonstrates a wide range of emotions, which is also directly influenced by what happens in the SG, but controlling and exploring emotion manipulation is feasible and can be beneficial for medical purposes.

Table 2. Haptic vest experience statics [5].

Haptic vest experience		Haptic vest immersiveness	
Feeling	Amount	Level	Amount
Anxiety	1 (8.33%)	1	0
Apprehension	4 (33.33%)	2	0
Claustrophobia	3 (25%)	3	0
Confusion	1 (8.33%)	4	0
Fear	0	5	1 (8.33%)
Impatient	2 (16.67%)	6	2 (16.67%)
Happiness	4 (33.33%)	7	3 (25%)
Relaxation	2 (16.67%)	8	2 (16.67%)
Tranquility	1 (8.33%)	9	1 (8.33%)
		10	3 (25%)

When looking at the responses aimed at the level of immersion, it is clear that all participants felt a greater level of immersion, and that improvements in the implementations of the correlation of the VR with the haptic vest are possible. There was also a report that 10 people did not experience any discomfort while wearing the vest, while 2 did.

6. Conclusions and future work

Hugging is a highly affectionate act between humans that conveys strong emotions. Its practice can provide several health benefits, including happiness, relaxation, and even the release of beneficial hormones. Doctors frequently use this act in the treatment and rehabilitation of diseases or phobias, seeking to maximize the benefits of the hug. With the advancement of technology and scientific studies linking it to health, the use of technological devices for medical assistance has increased noticeably. SG for VR is an excellent way to use technology, and research has demonstrated its effectiveness. Haptic devices are tools that are widely studied in conjunction with such games in order to increase their immersiveness and realism. This paper aimed to conduct an exploratory study of the use of a haptic vest to improve the immersiveness of SGs for VR in order to better understand if the tool can aid in the treatment and rehabilitation of diseases and phobias, primarily through the implementation of a virtual hug. To that end, the most comfortable hugs, common times, and most commonly accepted regions for haptic touch were investigated first. Previous tests show a large amount of positive emotions and increased immersiveness from wearing the vest, but it is important to use the device carefully and to be in close contact with the SG. There is a perceived lack of research linking all of the topics discussed, both individually and collectively. In order to prove the details of the theme addressed and the perception of new implementations, future works must be tested in collaboration with a medical team. It is also intriguing to consider the use of other devices that can measure heartbeat, stress, and other vital signs to capture what makes patients more comfortable in order to improve the treatment of diseases and phobias, which is something that must be done with great care for each individual case.

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References

[1] Inocencio Maramba, Arunangsu Chatterjee, and Craig Newman. Methods of usability testing in the development of ehealth applications: A scoping review. In-ternational Journal of Medical Informatics, 126:95–104, 2019.

[2] Esther P.W.A. Talboom-Kamp, Noortje A. Verdijk, Marise J. Kasteleyn, Mattijs E. Numans, and Niels H. Chavannes. From chronic disease management to person-centered ehealth; a review on the necessity for blended care. Clinical eHealth,1(1):3–7, 2018.

[3] Ruben Freitas, Vitor Velosa, Leonardo Abreu, Ricardo Jardim, João Santos, Beatriz Peres, and Pedro Campos. Virtual reality exposure treatment in phobias: a systematic review. Psychiatric Quarterly, 92:1–26, 12 2021.

[4] Aaron J Snoswell and Centaine L Snoswell. Immersive virtual reality in health care: Systematic review of technology and disease states. JMIR Biomed Eng, 4(1):e15025, Sep 2019.

[5] Leonel D. Deusdado and Alexandre F.J. Antunes. Virtual reality haptic device for mental illness treatment. Procedia Computer Science, 219:1112–1119, 2023.

[6] Lena M. Forsell and Jan A. Åström. Meanings of hugging: From greeting behavior to touching implications. Comprehensive Psychology, 1:02.17.21.CP.1.13, 2012.

[7] Anna L. Dueren, Aikaterini Vafeiadou, Christopher Edgar, and Michael J. Banissy. The influence of duration, arm crossing style, gender, and emotional closeness on hugging behaviour. Acta Psychologica, 221:103441, 2021.

[8] Eirini Schiza, Maria Matsangidou, Kleanthis Neokleous, and Constantinos S. Pattichis. Virtual reality applications for neurological disease: A review. Frontiers in Robotics and AI, 6, 2019.

[9] Muhammad Sobri, Mohamad Taha Ijab, and Norshita Mat Nayan. Integration of haptics tactile feedback into heart disease monitoring mobile application: A conceptual model. Procedia Computer Science, 161:1258–1265, 2019. The Fifth Information Systems International Conference, 23-24 July 2019, Surabaya, Indonesia.

[10] George Michalakis, Michail Pavlou, Giannis Gerogiannis, Vasilis Liapis, Ioanna Terzi, Apostolos Tsagarakis, Raphailia Asimakopoulou, Dimitris Bitzas, and Konstantinos Moustakas. Another day at the office: Visuohaptic schizophrenia vr simulation. In 2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), pages 515–516, 2020.

[11] Atena Fadaei Jouybari, Kenny Jeanmonod, Olivier A. Kannape, Jevita Potheegadoo, Hannes Bleuler, Masayuki Hara, and Olaf Blanke. Cogno-vest: A torso-worn, force display to experimentally induce specific hallucinations and related bodily sensations. IEEE Transactions on Cognitive and Developmental Systems, 14(2):497–506, 2022.

[12] Isabel Tannert, Katrin H. Schulleri, Youssef Michel, Steeven Villa, Leif Johannsen, Joachim Hermsd¨orfer, and Dongheui Lee. Immediate effects of vibrotactile biofeed-back instructions on human postural control. In 2021 43rd Annual International Conference of the IEEE Engineering in Medicine Biology Society (EMBC), pages 7426–7432, 2021.

[13] Adilzhan Adilkhanov, Matteo Rubagotti, and Zhanat Kappassov. Haptic devices: Wearability-based taxonomy and literature review. IEEE Access, 10:91923–91947, 2022.

[14] Jun Yao Francis Lee, Narayanan Rajeev, and Anand Bhojan. Goldeye: Enhanced spatial awareness for the visually impaired using mixed reality and vibrotactile feedback. 2021. Cited by: 2; All Open Access, Bronze Open Access.

[15] Gonzalo García-Valle, Manuel Ferre, Jose Breñosa, and David Vargas. Evaluation of presence in virtual environments: Haptic vest and user's haptic skills. IEEE Access, 6:7224–7233, 2018.

[16] Phil Stewart. Scientists to save 5,000-year-old embrace. https://www.reuters.com/article/us-italyembrace/scientiststosave5000year-oldembraceidUSL12831255020070214, 2007.

[17] Hidenobu Sumioka, Aya Nakae, Ryota Kanai, and Hiroshi Ishiguro. Huggable communication medium decreases cortisol levels. Scientific reports, 3:3034, 10 2013.

[18] Mario Suárez-Morales, Cecilia Úrsula Mendoza-Popoca, and Raúl Carrillo-Esper. The embrace of the people to their expression in life and art. Revista Mexicana de Anestesiologia, 46(3):216 – 225, 2023.

[19] Psicologia-Online. Tipos de abraço e seus significados. https://br.psicologia-online.com/tiposdeabracoeseussignificados1061.html#anchor 0, 2022.

[20] Sukhman Rekhi. Hugs: Benefits, research, quotes. https://www.berkeleywellbeing.com/hugs.html, 2023.

[21] Emese Nagy. Sharing the moment: The duration of embraces in humans. J. Ethol., 29:389–393, 05 2011.

[22] Julian Packheiser, Noemi Rook, Zeynep Dursun, Janne Mesenhöller, Alrescha Wenglorz, Onur Güntürkün, and Sebastian Ocklenburg. Embracing your emotions: affective state impacts lateralisation of human embraces. Psychological Research, 83, 02 2019.

[23] Valentina Cazzato, Sofia Sacchetti, Shelby Shin, Adarsh Makdani, Paula D. Trotter, and Francis McGlone. Affective touch topography and body image. PLOS ONE, 16(11):1–24, 11 2021.

[24] bHaptic. Tactsuitx40. https://www.bhaptics.com/tactsuit/tactsuitx40, 2023.

[25] bHaptic. Developer. https://www.bhaptics.com/support/developers, 2023.

[26] Unity. Unity. https://unity.com, 2023.

[27] Meta. Meta. https://www.meta.com/quest/products/quest2/, 2023.