Image Contact
Haptic Actions in Virtual Spaces

Carolin Höfler

Abstract Since the beginning of the twenty-first century, touch has experienced a programmatic boom again. Numerous approaches in the fields of human-computer interaction, virtual reality, and game design are raising the art theoretical and aesthetic ennoblement of the sense of touch to the actual sense of reality. Current media technology efforts are guided by the goal of enhancing the visual perception of digital 3D worlds through matching and complementary tactile impressions. The touch of material shapes and structures is becoming increasingly important, especially when the recipient wearing a head-mounted display has no visual access to the things being identified by touch. But what perception of the senses and their peculiarities motivate and shape these developments? What understanding of space underlies the haptic image environments? This article takes the prominence of the haptic materials in current VR games, and experiments as a starting point for thinking about promises and disappointments of sensory feedback systems. Based on multi-sensory approaches developed at the Bauhaus in Dessau during the 1920s, the article discusses alternative designs of physical-virtual fields of action.[1]

Keywords Virtual reality, immersion, haptic imagery, sensory modalities, touch information, spatial experience, feedback systems, digital-physical interaction, virtual embodiment, enactivism

1 The matter of reciprocal relationships between the visual and tactile space in VR settings was a subject at the interdisciplinary conference *Mit weit geschlossenen Augen. Virtuelle Realitäten entwerfen* (*Eyes Wide Shut. Designing Virtual Realities*), 31 May—1 June 2017, at KISD—Köln International School of Design of TH Köln, organised by Carolin Höfler and Philipp Reinfeld in cooperation with the Institute of Media and Design of TU Braunschweig. An edited volume of the conference will be published soon by the Wilhelm Fink Verlag.

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Trompe-corps

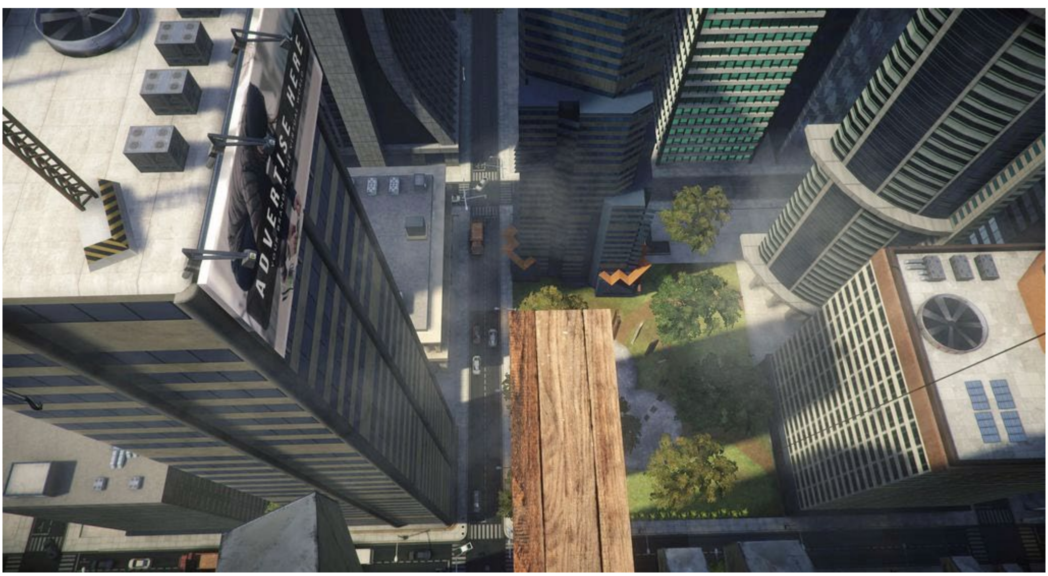
Facebook, Samsung, Google, and HTC are pushing into the mass market with their new virtual reality glasses, and promise users complete engrossment in immersive visual worlds. With the help of the latest generation of head-mounted displays, the advertising messages are unanimous: virtual realities are finally becoming 'real' (see Höfler 2018). The combination of two technical processes in particular gives reason to hope for an increase in reality: the stereoscopic visual impression and the delay-free tracking of head movements. They convey the impression of being with things and interacting with them, not *in front* of an image but *in* a visual space.

More than ever before, the discourse of a seamless fusion of real physical and computer-generated space in a mixed reality is dominating the research and development fields of human-computer interaction, virtual and augmented reality as well as game and interaction design. In such a mixed reality, either the physical environment is enriched with virtual information—as in augmented reality scenarios—or the virtual environment is enhanced with physical information—as in virtual reality applications that work with haptic feedback. Both manifestations would form intermediate stages in the "reality-virtuality-continuum" as researchers Paul Milgram and Fumio Kishino described it in their writings in the early 1990s (Milgram et al. 1994, 283).

The discourse on the intensive fusion of the virtual and physical world focuses on the holistics of the extended total space, which is primarily seen. In current developments, this holistic view of space is to be supported by further sensory perceptions. What unites the new VR installations and experiments is their relationship with the body of their recipient, which is no longer intended to be a mere observer but to experience the virtual scene with her entire body (see e.g. Nori 2017). The virtual world, through which the recipient with VR glasses on her head moves, is to be intensified on the one hand by the use of real-world elements, whilst on the other hand it is to appear even more intense than the physical world. To achieve this state of consciousness of intensified perception, aspects of virtual 3D environments are physically materialised and integrated into the VR setting.

One such work which seeks to deepen sensual perception in this way is *Richie's Plank Experience* by the Australian game developer collective Toast VR (see Toast VR 2016) as seen on *» Figure 1*. With VR glasses on his head, the recipient finds himself in a big city and enters the virtual elevator of a skyscraper. The door opens high above a skyline. A beam protrudes out over the abyss. In the physical presentation room, there is only a wooden board on the floor on which the headset wearer balances.

But through the images the wearer sees through his glasses, it seems as if he is stepping out onto a life-threatening unsecured wooden plank, especially since a fan is blowing wind in his face. He peers down into dizzying depths through his glasses, as the wind blows more and more powerfully (*» Fig. 2*). The body reacts energetically. The headset wearer tentatively gropes into the abyss with his foot—it is firm and stable, yet the images show him that he is falling.



Toast VR, Richie's Plank Experience, 2016.
Fig. 1 Installation view, Frankfurter Kunstverein.
Fig. 2 Virtual reality game, screenshot.

Currently, numerous VR projects are being developed that aim to stimulate not only what the eye sees but what all the senses perceive, such as *Swing VR* by Christin Marczinzik, Thi Binh Minh Nguyen, and Felix Herbst, in which you sit on a swing with VR glasses and gaze at a fantastic landscape (see 2015). The more you swing, the higher you fly. The involvement of the viewer in the fictitious spatial scene is not only achieved here through immersive images but also through the physical movements with which the images can be controlled. Who is driving whom or what, and what is cause and effect in the relationship between man and machine can no longer be clearly determined. Precursors of such an oscillating experience can be found in interactive installations that are experienced with full physical effort. In “Run Motherfucker Run” by Marnix de Nijs (2001/2004), the viewer literally walks through a projected film (» *Fig. 3*).

Fig. 3 Marnix de Nijs, *Run Motherfucker Run*, 2001/2004. Installation view, Frankfurter Kunstverein.

Her physical movement on a treadmill triggers various scenarios, as she decides which path she wants to take within the visual space. The projection shows a combination of film and 3D images of a gloomy urban environment, which makes the run seem like an escape. If the user immediately stops running, the belt that continues to move throws her to the ground. The treadmill as the central input device leads to a special form of physical mobilisation. The picture positioned directly in front of the viewer, diminishing the distance between subject and object, between the person watching and the things being watched, makes the (re)acting body become itself a medium for its individual imagination and self-deceit.

As architecture critic Niklas Maak recently noted, all these media installations are about intensifying body perception and pushing back knowledge of the real physical environment and situation: "The classical 'Trompe-l'œil' is followed by the 'Trompe-corps'" (translated from German by the author, Maak 2018). But do the scenarios really exhaust themselves in deceiving the body of the recipient, as in the representation of great heights? Is it not also a matter of using the body to re-establish a relationship to the physical world? Works such as *Richie's Plank Experience* or *Swing VR* aim not only to deceive the body through the image but also to realise the image through the body. The image experiences its realisation when the viewer stands on a real plank or sits on a real swing, for example, even if these things are represented differently visually and spatially. The sensory and motor perceptions, the experiences of balance and imbalance bind the body back to the physical space. However, the gaze remains unleashed, which is reinforced by other sensory perceptions, such as the feeling of the wind in the air. In this way, the digital image world triggers violent physical reactions. The memory of an experience in virtual space is often more intense than that of an event in physical space. Involved in the interactive moving images, the body, in the sense of enactivism, actively creates an experience in virtual space that is not stored as a virtual imagination but as a real experience (see Breyer 2016, 43). This shifts the meanings that the recipient assigns to the physical and mediated sensory impressions.

Starting from here, the question arises as to how perception changes when the physical space in which the headset wearer is located is not replaced by fictitious visual worlds but is digitally constructed and can be viewed and controlled through a VR headset? Similarly, perception may also change when aspects of virtual space are physically reproduced and are thus experienced haptically. A VR headset then gives the impression of being transparent by allowing the user to look into a photorealistic, stereoscopic digital model of their immediate surroundings. Only the contrasting comparison of the virtual visual space and the physical model space provides revealing insights into the construction of reality and virtual worlds, as Ken Perlin, computer scientist and founder of the Media Research Lab at New York University, recently discussed (see Munich ACM SIGGRAPH 2015). The new conditions of human perception in relation to technically constructed realities become visible primarily through the evaluation of perception alternatives.

Dialogic Spaces

At present, virtual reality parks are being created in the leisure and gaming sector that allow such a comparison of perceptions. In 2016, the US start-up with the speaking name The Void built an eponymous amusement park in Pleasant Grove, Utah, in which components of the virtual play spaces were physically materialised (see Gruber 2015). Visitors wear data glasses called Rapture HMD with two curved, extremely high-resolution screens, integrated headphones and a microphone. They also put on a vest and gloves, which contain numerous sensors for haptic feedback and body tracking. With the hardware attached to their bodies, they walk through an ensemble of physically constructed rooms, which in turn are equipped with numerous motion and interaction sensors. At the heart of *The Void* is a playing field called the *Gaming Pod*, a system of corridors up to 330 square metres in size, where players can move freely without the risk of bumping into obstacles (» *Fig. 4*).

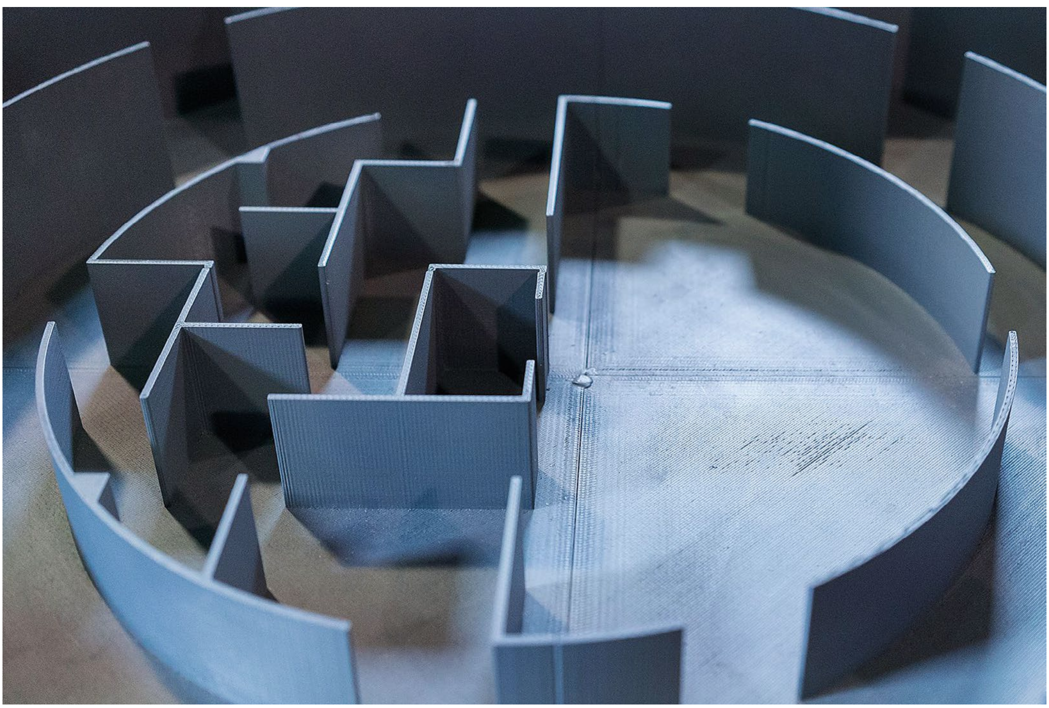


Fig. 4 Model of the playing field at the VR theme park *The Void*, Pleasant Grove, Utah.

The physical boundaries and objects of the playing field are integral parts of the digitally constructed visual spaces. The real game architecture is digitally modelled and incorporated as a visualisation into the VR headset, where it is overlaid with interactive moving images of textures and 3D figures. These projections appear exclusively in the virtual space, whereas the player's actions are performed simultaneously in the physical and virtual space. In this setting, the visitor, equipped with display and wearables, physically and digitally intervenes in the course of the game and tentatively controls the moving images projected onto the digital space surfaces. In order to involve the players even more intensively in the physical-digital construction of reality, specific facilities and equipment ensure that they can feel heat, cold, humidity, vibrations or differences in height, perceive smells and touch objects.

The Void's promise consists of fully immersive imagery, an extension of situated images into the depths of space, whose visual perception is enhanced by matching and complementary sensory impressions in physical space. But which perception of the senses and their peculiarities motivate and shape this promise? What does it mean for perception, orientation and navigation when real-time digital images reproduce the surrounding space but take away the immediate view of the space to be felt? So, what if visual space ("Sehraum") and physical tactile space ("Tastraum") are separated from each other and at the same time reunited by digital, real-time generated moving images of the surrounding space? What dependencies and interrelationships are there between the *physical here* and the *pictorial there*? What forms of attributions are developed when the pictorially depicted space corresponds to the size dimensions of the physically built surrounding space but still has other material and haptic qualities? What shifts in perception and scaling effects arise when—as in *The Void*—a scenic architecture of simple forms and solid materiality is palpated but a space of high density, fluidity, light and information is seen? Can perception be replaced by imagination?

Senses of Realness

Physical-digital environments like *The Void* are based on a holistically oriented model of sensory structure, according to which the senses, each belonging to a specific field of perception, perform synthetic services in the constitution of space. It is this conventional notion of the unity and weighting of the senses that today shapes the use and interpretation of virtual reality processes. Although sensory perceptions are intensively linked with each other, the physical-digital VR environments—especially in the game and entertainment sector—are based on a perception model in which seeing plays a central role and ranks hierarchically above the other forms of sensory perception. This is expressed, for example, in the fact that physical objects and room boundaries are reduced to simplify outer contours, whereas interactive moving images increase in detail and complexity. The method of screen-based, stereoscopic vision, which aims at heightening and intensifying the visual perception, can thus be regarded as a possible starting point for the reconceptualisation and radical expansion of the traditional hierarchy of the senses with vision at its peak (see Fehrenbach 2011). The classificatory scheme, in which priority is given to the sense of sight, is now motivated and influenced by the use and interpretation of mobile display techniques.

The renewed debate about the interaction of physical and cognitive performance in the experience of space can be understood as a continuation of a line of tradition that began in the sensualist aesthetics of the eighteenth century. Within this line of tradition, theorists and architects developed a perspective on space that exists only as a dependent on the recipient and the totality of his or her perceptual and emotional impulses (see Gleiter 2008, 113–26). This is determined by the idea of an emotional fusion of subject and object in aesthetic perception, for which Robert Vischer coined the term "empathy" or "Einfühlung" in 1872 (Vischer 1873, VII; 18–33). Instead of continuing the traditional procedures of representation, ornament, and iconography, the aim was to re-conceptualise architecture within the context of synaesthetic, visual-tactile perception. Insights into such a change of perspective were provided by the essays *Prolegomena zu einer Psychologie der Architektur* (Prolegomena to a Psychology of Architecture) by Heinrich Wölfflin in 1886 (see 1946), *Ueber den Werth der Dimensionen im menschlichen Raumgebilde* (On the Importance of Dimensions in Human Spatial Creation) by August Schmarsow (see 1896), and *Das räumliche Sehen* (The Spatial Vision) by Paul Klopfer (see 1919). Instead of a fixed spatial principle, a dynamic principle is used here, according to which space is created at the moment of perception. The notion of a moving, active recipient is regarded as a prerequisite for this kind of spatial formation. According to Schmarsow, space is created from a concatenation of mental images, from the physical movement, in the transition from the "tactile space" to the "face space" (1896, 50, 54–55). More systematically and dispensing with psychologism, philosopher Edmund Husserl summarised the concept of the sensomotoric connection of all senses and the sensual-bodily constitution of perception. The modern phenomenology of space, as Husserl established it in his lectures at the beginning of the twentieth century, assumes that the impression of space is related to the consciousness of one's own body movement and is the result of a sequence of perception in motion (see 1973, 155–56).

Referring to these phenomenological and psychological approaches of the first half of the twentieth century, Hungarian philosopher Alexander Gosztonyi tried to define the characteristics of the individual senses in his *Grundlagen der Erkenntnis* (Fundamentals of Knowledge) in 1972 (see 1972, 67–97). He not only considered the five classical senses i.e. sight, hearing, touch, smell and taste but also the "senses of bodily feeling", of which "the sense of vibration, the sense of temperature, the sense of balance, the sense of gravity and proprioception" were the most important (ibid., 67–68). His interest was directed towards the question of how the different senses compete or are linked with each other.

Constitutive for the prevailing physiological-rational understanding of human-computer interaction, virtual and augmented reality as well as game and interaction design is Gosztonyi's emphasis on the "quality of realness" ("Wirklichkeitswert") above all, which every sense has in two ways. Every sense has a "quality of reality" ("Realitätswert") and a "quality of evidence" ("Evidenzwert") (ibid., 68). According to Gosztonyi, the sense of touch, as a sense of nearness ("Nahsinn"), has a high quality of reality because it allows the material resistance to be experienced, whereas the sense of sight has a low quality of reality. The sense of sight, as a sense of farness ("Fernsinn"), has evidence of high quality because it is able to provide an overview and insight into formal relationships. According to Gosztonyi, it is the interplay between the qualities of reality and evidence that determines the degree of realness of the perceived environment.

Even though Gosztonyi regarded the reciprocal relationships between the senses as prerequisites for the construction of reality, he assumed a hierarchical order of senses: "The sense of touch is not dominant. [...] The one who sees subordinates the things touched, ranks qualities and forms of touch, and arranges it in order according to his field of view" (translated from German by the author, ibid., 81). Such traditional notions of the peculiarity and hierarchy of visual and tactile-haptic sensory perceptions continue to have an effect on the discussions about physical and virtual realities. The notion of the sense of touch as a somewhat concise sense of pressure, which generates reality all the more strongly, currently determines the design of mobile devices and interactive environments, whose physical interfaces provide haptic feedback. In contrast to the visual forms, the tactile forms are only weakly developed.

Circular Walking

The novel entanglements between the physical "form of being" ("Daseinsform") of the tactile space and the digital "form of effect" ("Wirkungsform") of the face space in physical-digital VR environments fundamentally change the conception and design of architectural space (Schmarsow 1896, 50). Design interest is increasingly focusing on the construction of specific fields of action, which are created by the interaction between human bodies, technical objects and physical environments. On the one hand, the built spaces are interconnected with the bodies and things through chips, tags and sensors, and on the other hand, they are designed for specific sensory perceptions. This means that space- and object-defining surfaces in the physical setting are shaped in such a way that assumed or desired sensory perceptions, spatial experiences and behaviours are created in the virtual. The design-guiding question then aims at the parameters that the physical space must fulfil in order for the user of the VR glasses to accept the virtual space as *real*. How can one design, create, and arrange a physical space and its form so that the impression of a sensory and emotional immersion, of control and intervention in virtual environments can be strengthened and best achieved?

This question is based on the assumption that the wearer of the headset accepts the virtual as a physical environment, especially if she or he can move in it as naturally as possible. But the physical perception is sometimes deceptive when the recipient is denied a view of the space to be felt. Other physical experiences can be attenuated by visually intensified perception: there can be great differences between a path actually taken and one that is simultaneously fulfilled virtually, without the recipient noticing.

This discrepancy between physical and virtual movement is the motivation behind the approach of *redirected walking,* which assumes that the headset wearer is relatively insensitive to turns when walking and has difficulty in estimating distances in virtual worlds (see Steinicke 2016, 59–86). Walking straight ahead blindfolded or wearing a VR headset usually ends up with the respondent walking ahead and slightly to the right or left without realising. These observations are used for the construction of physical-digital VR environments, especially when the physical walking area is limited compared to the virtual expanse. The headset wearer is then physically led around a corner, while she believes she is walking straight ahead in the virtual world. Currently, a radius of about 22 metres is still required so that the headset wearer does not realise that she is actually walking around in a circle (see ibid., 77).

A typical spatial configuration that permanently diverts walking is the *Unlimited Corridor,* which engineers and computer scientists at the University of Tokyo developed in cooperation with the US company Unity Technologies in 2016 (see Matsumoto et al. 2016a and 2016b). In this spatial installation, the headset wearer constantly touches the corridor wall with one hand to enhance the credibility of the virtual environment (» *Fig. 5*).

Virtual forks and intersections are physically recreated with an additional corridor in the middle. *The Void* also uses the principle of *redirected walking*. Chief illusionist Curtis Hickman developed a comparable infinite corridor for the VR arcade (see » *Fig. 4*). If several headset wearers are using the system simultaneously, they are directed via motion sensors and images to ensure that they do not walk into each other. Virtual doors act as barriers. A multidirectional variant of the *Unlimited Corridor* is the so-called *VirtuSphere,* which was originally used by the US military for training purposes (» *Fig. 6*).

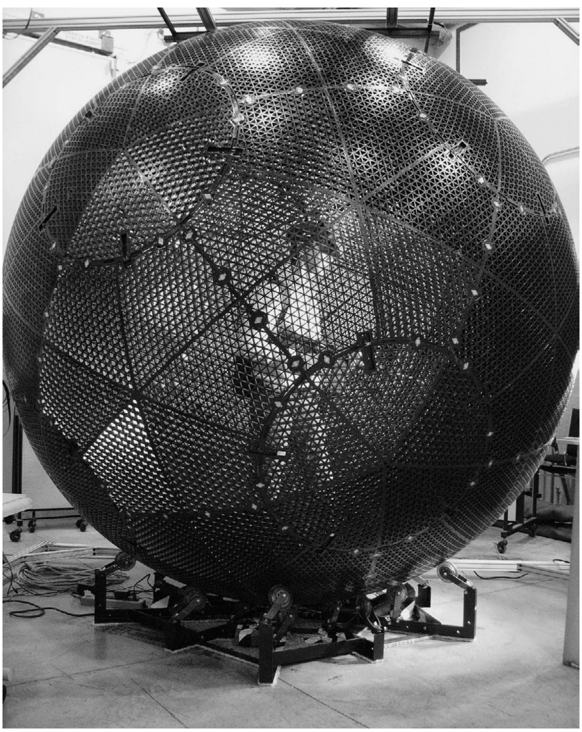


Fig. 5 Keigo Matsumoto & Team, *Unlimited Corridor*, University of Tokyo.

Fig. 6 *VirtuSphere*, Mounted Warfare TestBed at Fort Knox, Kentucky.

This is an accessible rotating sphere three metres in diameter, mounted on rollers. Whoever steps into it can walk in all directions without moving from the spot. With the help of a head-mounted display, the test subjects are transported into virtual worlds in which they can move freely. Sensors under the sphere register each step and transmit this to the display. Seen in this light, the sphere is a huge controller that can be operated with your feet. Three of these spheres are located in a casino in Las Vegas, and one sphere is located at the University of Bremen in the Department of Cognitive Neuroinformatics for the purposes of research into human orientation in virtual and physical spaces (see Cognitive Neuroinformatics 2016). This experimental system is also based on the assumption that the shown VR user can orientate himself best in unknown virtual worlds when he receives as many sensory impressions as possible. In addition to the feeling of walking and the image in front of the eyes, sounds and smells are then added. The type of moving ball is determined by an ideology that assumes that spatial perception and spatial movement follow the sensory impressions. The current physical-digital VR settings in the gaming and interactive entertainment industries are shaped by this idea. It is all the more astonishing how little the material and haptic properties of the real built space and the physical things are taken into account in such settings.

Haptic Seeing

The handling of haptic feedback in advanced VR applications reflects the polarisation of debates on the sense of touch both in European philosophy and in its scientific research (see Harrasser 2017, 8–9). On the one hand, touch is devalued in favour of sight and subordinated to it, assuming that the sense of touch is linked to a multitude of affect modulations and that touch evokes particularly violent, uncontrolled reactions. On the other hand, a kind of touch metaphysics—in this context Jacques Derrida refers to "haptocentric metaphysics" (2000, 179–80)—in which the sense of touch has a privileged position in terms of access to reality. The sense of touch is reflexively associated with authenticity. Touch functions as a last instance of certainty, in the sense that what touches me is real. The new devices also tie in with this promise of reality: in order to increase the degree of reality of a 3D environment experienced through virtual reality glasses, American manufacturer Microsoft recently developed the *Haptic Revolver* (see Whitmire et al. 2018). With this handheld device, a display carrier in a virtual poker game can sense different materials from playing cards to plastic markers to felt carpets (» *Fig. 7*).

As seen here, the *Haptic Revolver* contains a small wheel that rotates and is covered with various material textures. When the display carrier virtually reaches for a playing

Fig. 7 Virtual reality handheld controller *Haptic Revolver* by Microsoft, 2018.

card, the wheel rotates with the matching material under his index finger, giving the player the impression of touching a physical playing card that slides across a table surface. The movement is thus shifted from the hand to the material and the touch sensation is only imprecisely reproduced.

The preference for imagery over materiality goes even further: With novel haptic feedback systems, the tactile-haptic properties of an object are decoupled from its physical form and materiality and transferred into air pressure pulses or ultrasonic signals. In combination with a gesture control system, the *AIREAL* device from Disney Research, for example, enables the headset wearer to be touched by virtual objects in space—such as a butterfly projected onto the wearer's virtual arm (see Sodhi et al. 2013, 7; Rupert-Kruse 2018, 203–5). In order to evoke these haptic sensations, air vortices are produced within the device, which are shot at users with differing intensities, ranges and sizes (» *Fig. 8*).

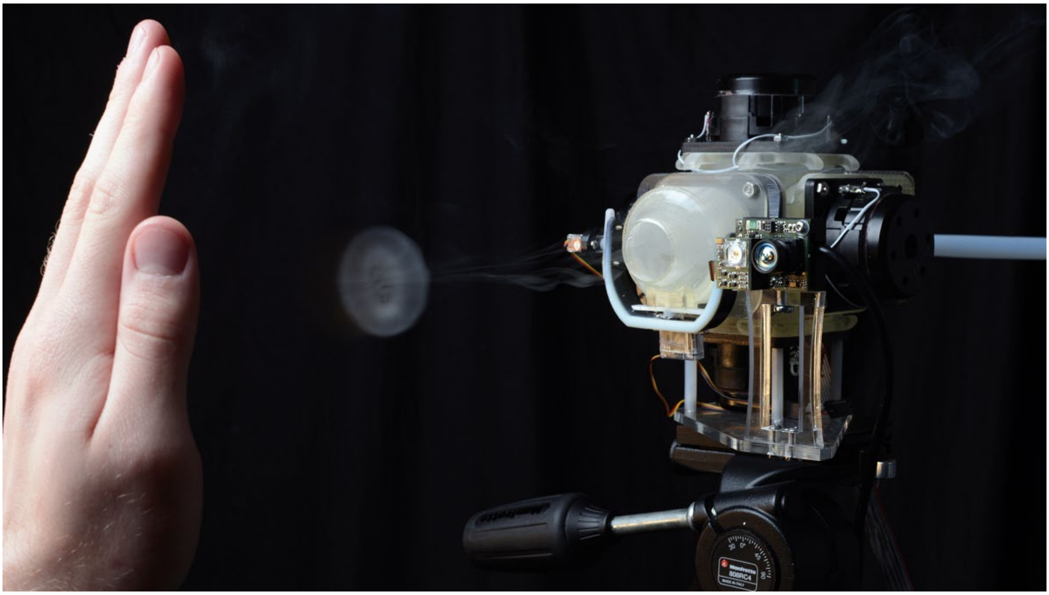


Fig. 8 The *AIREAL* device emits a ring of air called a vortex, which can impart physical forces a user can feel in free air, 2013.

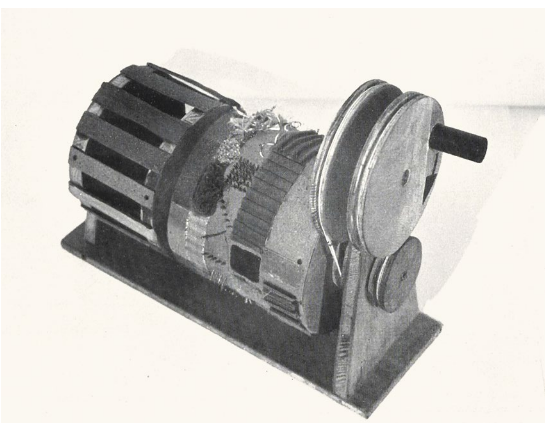
"An air vortex is a ring of air that typically has a toroidal shape and is capable of travelling at high speeds over large distances. Unlike laminar airflow, which quickly disperses, a vortex is capable of keeping its shape and form" (Sodhi et al. 2013, 3). In contrast, *UltraHaptics* enables haptic feedback via ultrasound (see Carter et al. 2013, 2–4). When the user guides a hand over an array of small loudspeakers, she thinks she feels three-dimensional surfaces. The small loudspeakers send specific ultrasonic signals that are perceived as slight vibrations on the skin. The claim of such technologies is to increase the degree of reality of what is being represented. But what kind of perception of reality is drawn when the tangible virtual objects and surfaces offer no haptic resistance? Instead of intensively interweaving the pictorial and the material, the physical diffuses into the virtual for the benefit of a performance that permanently reconfigures the potential relationship between physical and virtual reality.

Sense of Being Here

The widespread practice of centring the action in virtual realities on seeing, which is merely intensified by appropriate tactile impressions, proves to be too schematic. The superficial privileging of seeing fails to recognise the manifold intertwining of sensory impressions as well as the provocative effect of the sense of touch (see Harrasser 2017, 8–9). It leads to the development of very simplistic ideas about the interplay between physical and virtual perceptions. What is of interest here, however, is the potential of the haptic and tactile to create complicated and polyvalent relationships.

The fact that experimental tactile studies in early twentieth century art addressed the sense of touch as a *mediator* of the senses is the motivation to draw on them here (see Höfler 2019). It is no coincidence that Microsoft's *Haptic Revolver* is reminiscent of the rotating tactile drum that Rudolf Marwitz designed in 1928 in the preliminary course at the Bauhaus in Dessau (» *Fig. 9*).

It was above all Bauhaus master and photographer László Moholy-Nagy who used specially designed tactile boards and wheels to train haptic skills (see 1929, 21–32). With the fingers, the materials arranged on them could be distinguished according to their surface texture, whereas differentiation with the eyes was difficult (» *Fig. 10*). By grasping and feeling, a microstructural idea of things and materials could be gained, which seemed to be denser and more precise than any visual representation.



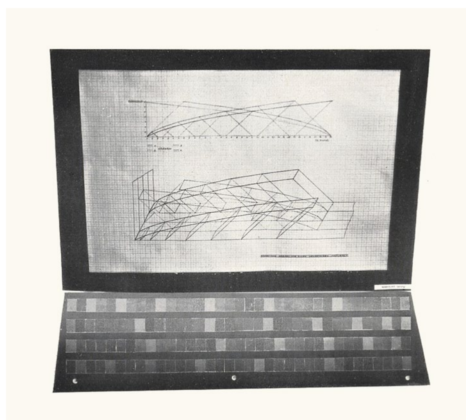


Fig. 9 Rudolf Marwitz (Bauhaus, 2nd term), Rotating tactile drum, 1928.

Fig. 10 Thomas Flake (Bauhaus, 2nd term), Tactile table in four rows of sandpapers, and corresponding diagram, 1928.

In such tactile experiments, the hand functions as a medium of recognition, exploration, and experience, thus contesting the eye's traditional primacy of perception and knowledge. This perspective captures materials and structures not as static forms of perception but as elements of experienced continuities. The fabric panels deliberately blur the distinction between optics and haptics and allow a form of tactile image to emerge. The touching feel and the feeling sight reinforce the belief in the reality of things and images.

The developers of haptic technologies for virtual environments also take this presence-giving power of touch as their starting point. However, the tactile studies at the Bauhaus aimed at designing sensory realities, whereas most VR applications deliberately try to cause sensory delusions. The construction of virtual illusions is still characterised by a traditional hierarchy and fragmentation of senses: the recipient wearing the headset subordinates the physical sensation to the virtual forms of vision.

With this in mind, the design experiments from Moholy-Nagy's preliminary course offer an almost subversive program. For they focus not only on a mobilisation of all sensory modalities but also on an act of perception in which the traditional hierarchy of senses is called into question. With such an abandonment of the hierarchy of senses, a productive reorientation of virtual design can also take place: away from the compulsion to produce a deceptively real representation of reality and towards the attempt to enable an immediate communication between bodies and materials that simultaneously reveals their mediation. In this paradigmatic shift, approaches that explicitly avoid polarisation and instead work out the medial character of the sense of touch move towards the centre of attention. In this process, not only the material but also the skin as a medium comes into focus—the skin, which makes contact with the physical and virtual world by forming a border to it, which stretches out to capture signals (see Harrasser 2017, 7). An approach designed in this way enables means of dealing with physical-material things in VR settings that sees them not merely as passive carriers of meaning or mute witnesses of visual representation but that acknowledges their bulkiness and their own life. Then, the sense of touch can also be an impetus and provocation of unexpected haptic experiences that deform intentional, purposeful action and produce deviations (see Rheinberger 2016, 42, 45, 64). In this perspective, the space of seeing is first generated as the space of touch.

In light of the tentative and experimental character of the sense of touch, the question also arises as to which alternatives to bodily immersion in 3D spaces can be developed. Which media strategies in dealing with virtual reality can there be that undermine submersion in immersive environments and thus provide transparency about the techniques that users are succumbing to? How can fragmentation be dealt with even within an immersive environment? Such strategies of infiltrating and breaking are based on a way of thinking that aims to overcome traditional opposites between body and mind and interprets sensory perceptions neither in an individualistic-hierarchical nor in a collectivistic-holistic way. In this perspective, seeing, hearing, and feeling are not understood as naturally given abilities but as medial practices (see Ochsner/Stock 2016, 9). Such an approach requires different models and narratives of the physical and material design in VR settings than those that only see image carriers or perception amplifiers in it. Haptic architectures and objects must be conceived and designed that do not permanently confirm the characteristic experience of being within a virtual environment (*sense of being there*) but rather invalidate it by creating a sense of being present in physical space (*sense of being here*). In this way, they could produce perceptions and meanings beyond the moving images of the displays, which the recipient would first have to interpret in relation to the perceived 3D spaces; and which would not constantly rely on affirmation and affective impact but on disturbance and doubt. What is needed, then, is a design of the physical-virtual that is "intolerant of unambiguity" (Harrasser 2017, 12).

Figures

Fig. 1, 3: Photo by Norbert Miguletz (Frankfurter Kunstverein 2017).

Fig. 2: Screenshot by Toast VR 2016.

Fig. 4: Photo by Tom Connors 2015. Accessed January 1, 2020. https://www.theverge.com/2016/7/1/12058614/vr-theme-parks-disney-six-flags-the-void-ghostbusters-virtual-reality.

Fig. 5: Photo by Unlimited Corridor Team 2016. Accessed January 1, 2020. http://www.cyber.t.u-tokyo.ac.jp/~matsumoto/image/uc/uc_web.jpg.

Fig. 6: Photo by Paul Monday 2007. Accessed January 1, 2020. https://en.wikipedia.org/wiki/VirtuSphere#/media/File:Virtusphere.jpg.

Fig. 7: Photo by Microsoft 2018. Accessed January 1, 2020. https://www.microsoft.com/en-us/research/publication/haptic-revolver-reconfigurable-virtual-reality-controller.

Fig. 8: Photo by Rajinder Sodhi/Disney Research (Sodhi et al. 2013, 1).

Fig. 9, 10: Photo by Clasen/Dessau (Moholy-Nagy 1929, 25, Fig. 5 and 28, Fig. 8).

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