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Sense of Being Here

Feedback Spaces Between Vision and Haptics

Vertiginous Bodies

Facebook, Samsung, Google, and HTC are making headway on the mass consumer market with their latest virtual reality glasses, promising users a total immersion into pictorial worlds. By means and with the help of head-mounted displays – as the advertising slogans unanimously stress – virtual reality (VR) will eventually become authentic and real. It is in particular the combination of two technological methods that causes hope for increasing the *realism* of an observer's visual experience: Stereoscopic 3D and precise, low-latency head tracking are supposed to boost the impression of being not just *in front* of an image but *being part* of an image space and interacting with things and processes happening *there*. If the movements watched via head-mounted displays do genuinely match the perception of body movements, this will not only alleviate the user's feeling of motion sickness but also strengthen the user's impression of realness of the visually perceived environment. In this perceptual situation, the user might stress that the technological system can be controlled, thus providing the virtual system with credibility and enhancing its acceptance.

The promise of a nullification of the discrepancies between virtual and physical reality immediately evokes associations related to the prophetic description of the *Ultimate Display* by Ivan Sutherland in the year 1965, according to which it would be possible to generate virtual experiences able to persuade and convince our senses:

> *The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal.*[1]

In the realm of the design and development areas of human-computer interaction, virtual and augmented reality, and game and interaction design today, the discourse centers more than ever around a *fusion* of the virtual and physical space into a *mixed reality* that is prevalent in research and discussion. In that respect, mixed reality is understood to consist of environments and systems aiming at coupling a real-physical action space to a synthetic, computer-generated image space – with those two spaces hardly distinguishable from each other.[2] In such a mixed reality, it

1 Ivan E. Sutherland, The Ultimate Display, in: *Information Processing 1965. Proceedings of IFIP Congress* 65.2 (New York, May 24–29, 1965), pp. 506–508, p. 508.

2 Paul Milgram, Haruo Takemura, Akira Utsumi and Fumio Kishino, Augmented Reality. A class of displays on the reality-virtuality continuum, in: *Proceedings of SPIE. Telemanipulator and Telepresence Technologies* 2351 (Boston, October 31–November 1, 1994), pp. 282–292.

1 Toast, *Plank Experience*, 2016. Exhibition view, art association Frankfurt (Frankfurter Kunstverein), 2017.

is either the physical surroundings that are enriched with virtual information, like in augmented reality scenarios, or it is the virtual surrounding that is extended by physical information, like in virtual reality applications using tactile feedback. Both variations are considered to represent interim stages in the so-called "reality-virtuality-continuum", as the researchers Paul Migram and Fumio Kishino stressed in their writings from the early 1990s.[3]

The discourse on a seamless fusion of the physical and virtual worlds grows in importance in the current discussion on "phygital" objects and surroundings which are touted as new forms for a computerized world access.[4] Having its origin in the USA, the marketing term *phygital* consists of the words *physical* and *digital* and refers to the linkage of physical objects and surroundings with their virtual representation, or vice versa the coupling of virtual things to a physical equivalent in a digital network. The network enables these things and surroundings to connect and exchange data. The development of phygital objects and spaces is in particular spurred by mobile display techniques, through which the interaction between display and user is enhanced. In contrast to augmented reality scenarios, in which digital elements can be blended into the physical environment, phygital applications instead use physical elements to be projected into a VR setting. In both cases, however, the key idea is a fusion of both worlds.

In the discourse on the melting of the boundaries between physical, virtual and imaginary worlds, much attention is paid to the idea of the holistic nature of the space as a whole being primarily *seen*. In current developments, this holistic view of space is to be supported by further sensory perceptions. What the new VR installations and experiments have in common is the relation to the recipient's body: The recipient no longer serves as a pure watcher alone, instead their entire body should be capable of experiencing the virtual surroundings.[5] On the one hand, the impression of realness of the virtual world is supposed to be reinforced through real-world elements in virtual spaces. On the other hand, it is intended to let the virtual world appear even more intensely than its physical counterpart. In order to find stimuli to actually achieve the state of intensified perception, facets and spots of virtual 3D environments are brought into the game, physically materialized, and internalized into the VR setting.

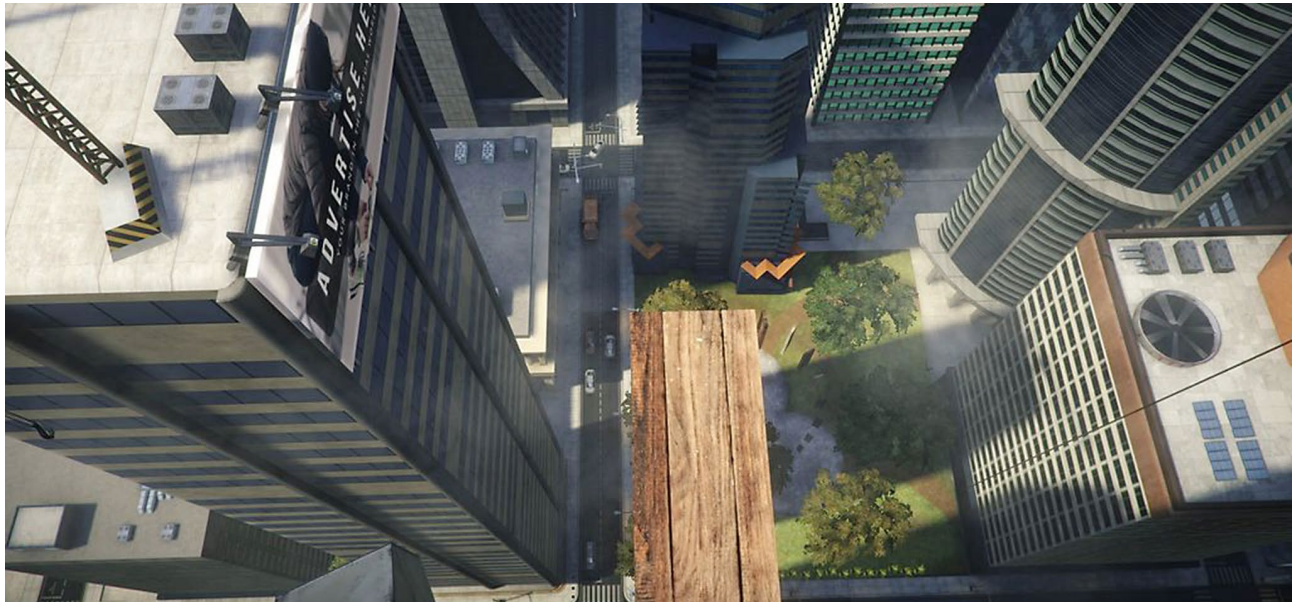
One such work trying to intensify and enhance the user's perception is delivered by the Australian game developing collective Toast with its project *Plank Experience*.[6] The recipient, with his VR glasses on his head, finds himself situated in a big city, heading up the elevator of a skyscraper. The door opens high above the skyline. A plank juts out over a deep abyss. According to the real physical presentation space, it is just a wooden board on which the VR user balances (fig. 1). But for the recipient, perception changes since the pictures of the VR glasses make him believe that he is stepping onto a loose and life-threatening balancing plank, while a ventilating fan blows into his face simulating wind (fig. 2). His glasses let him look into dizzying depths with the wind growing stronger and his body reacting more and more energetically.

3 Ibid., p. 283.

4 For example Alica Rosenthal, Phygital Marketing. Die analoge und digitale Welt verschmilzt, https://webmatch.de/blog/phygital-marketing-die-analoge-und-digitale-welt-verschmilzt (accessed January 1, 2018).

5 For example, see the exhibition *Perception is Reality. On the Construction of Reality and Virtual Worlds,* exhibition, curated by Franziska Nori (Frankfurt/M., Frankfurter Kunstverein, October 7, 2017–January 7, 2018), https://fkv.de/en/content/perception-reality-construction-reality-and-virtual-worlds (accessed January 1, 2018).

6 Toast, Richies's Plank Experience, https://toast.gg (accessed January 1, 2018).



2 Toast, *Plank Experience*, 2016. Rendering.

With the display on his head, the user fumbles around with his feet. The physical ground is hard and stable, but the pictures give the impression that the user is about to fall.

There are many examples of similar projects and pieces of work that are willing not only to stimulate the eye but are trying to stimulate all senses, for instance the project *Swing* by Christin Marczinzik and Thi Binh Minh Nguyen. Here, wearing one's VR glasses, one can place oneself on a swing and gaze out at a wonderful landscape.[7] The stronger one swings, the higher one gets. Thus, the swing as an interface intensifies the physical perception in such a way so that not only the sense of sight and touch are stimulated, so is the sense of balance. Such a sensual state of involvement of the viewer leads to a special kind of strengthening and mobilizing one's physical senses and powers: the picture directly located 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.

7 Christin Marczinzik, Thi Binh Minh Nguyen, *Swing VR. An Immersive VR Experience,* http://christin-marczinzik.de/portfolio/swing-vr (accessed January 1, 2018).

3 Somniacs, *Birdly*, 2015–2018. Photo.

Trompe-corps

A corporeal experience even further out there is the intention behind the installation *Birdly* by designer Max Rheiner, which provides the viewer with fictional pictorial spaces to explore along with a fictitious body as well.[8] *Birdly* is intended to make movements and situations instrumentally perceptible – movements that are not normally tangible for the human body. It is about modeling an artificial nature in which the user may have the intuitive experience of being a bird. In contrast to ordinary flight simulators, the user takes the flight position of a bird rather than simply piloting the run-of-the mill airplane or spaceship; and, in doing so, he interacts with the installation via whole body movements that mimic a bird in flight. To more intensely experience the scene presented in VR, the viewer is lying face down on a rack with two wings which he can grasp ahold of and move up and down through vigorous arm movements (fig. 3). With the palm of the hand spinning upward, one gains altitude, the palm of the hand spinning down, one loses height. During gliding flight, the viewer will have a soft wind blowing in one's face, generated, similar to *Plank Experience*, by a ventilating fan. The airflow increases with increased flapping. In order to achieve this state of acting, and being a genuine bird, *Birdly* uses photorealistic 3D graphics provided via head-mounted displays of the newest generation and sensorimotor couplings. The display shows pictures of a flight over Manhattan, Dubai, or Singapore (fig. 4). The bird's-eye perspective emphasizes panoramic views and monumentalizes the surrounding spaces. The recipient cannot see all of the scene before him at once but rather has to look back and forth, side to side. This gives the impression of a closer proximity and a stronger involvement for the recipient in flight.

But it isn't the immersive pictures alone that involve the user in this fictional space and special pictorial scene; rather it's a physical-material apparatus through which the special flight movements in these pictorial spaces can be steered, managed, and controlled that really solidifies the illusion. The body's physical presence experiences much greater feedback, reinforcing the user's experience of the physical world while – paradoxically – the actual physical space in which the apparatus and the display and the user

8 See Max Rheiner, *Birdly*, Zurich University of the Arts (ZHdK). Interaction Design, 2013–2014, http://iad.zhdk.ch/de/projekte/birdly (accessed January 1, 2018). In 2015, Rheiner founded out of ZHdK the company Somniacs which established *Birdly* as a commercial product.

4 Somniacs, The *Birdly* aerial view of Manhattan, New York, 2015. VR Rendering (Oculus Rift). Generated by an earlier version of the simulator (current version *Birdly* Serial Edition, 2016).

are situated is left aside and replaced by totally different virtual surroundings, similar to typical flight simulators and VR games.[9] Thus, the rather small laboratory-like indoor space is turned into an urban, large-scale outdoor space being viewed from dizzying heights.

These and similar other media installations represent an attempt at intensifying bodily perception and playing down common knowledge about real-physical surroundings and situations as well, as German architectural critic Niklas Maak recently pointed out: "The classical 'Trompe-l'œil' is followed by the 'Trompe-corps'."[10] But do these VR scenarios amount to nothing more than deceiving the recipient's body, for example by provoking dizzying heights? Is not another main idea here to allow the body to (re-)identify with the physical world? *Plank Experience* not only aims at the body's deception through imagery, it also aims at the image's materialization through the body. The image

9 Principally Michael Friedman, Head-Mounted Display Screens. A (De) construction of Sense-Certainty, in: *MediaTropes* VI.1 (2016), pp. 114–136.

10 Niklas Maak, Kunst und virtuelle Realität. Der schwindelnde Körper, in: *Frankfurter Allgemeine Zeitung*, January 5, 2018, http://plus.faz.net/feuilleton/2018-01-05/der-schwindelnde-koerper/99295.html (accessed January 5, 2018). Translation from German by the author.

becomes real if the beholder is standing on physical ground, for instance, even if that ground is portrayed spatially and visually differently. The sensory and motor perceptions, the experiences of balance and imbalance, cause the body to reconnect to the physical space. However, the vision stays unbound by physical and practical limits. The visual perspective can be reinforced by other sensory impressions, for instance caused by a ventilating fan, serving as boosting elements for heavy bodily reactions to digital imagery.

The recollection of things, actions, and experiences in virtual space is often more intense than recollecting an experience in physical space. In the virtual space, it is possible to experience situations that can't be felt in the physical space, situations that are maybe too dangerous to expose oneself to in the real world. Involved in interactive moving images, and in line with the theory of enactivism, the body directly and actively frames and generates an experience that is stored not as a virtual imagination but as a real experience.[11] As a consequence, associations and meanings, which the recipient assigns to the physical and media-generated impressions, do blur and shift. What this shift can ultimately evoke and entail for our perception, consciousness, and memory is not yet clear and remains a little researched area.

Closely related to this is the question of how and how much our perception changes if the physical room where the user is located is not replaced by fictitious pictorial worlds but instead digitally constructed and can be operated and steered via VR glasses. By the same token, the question arises as to how our perception changes if facets of the virtual space are physically reconstructed and are thus perceptible for the body. VR glasses seem to appear transparent since they let the viewer look into a photorealistic, stereoscopic digital model of his direct environment. Thus, only a comparison between the contrasts and similarities of the virtual pictorial space and the physical model space can serve as a tool to gain reliable and informative insights on the construction of reality and virtual worlds, as the computer scientist and founder of the Media Research Lab at New York University, Ken Perlin, recently stressed.[12] It is rather through the analysis of these alternative experiences of space that the new conditions of human perception in relation to technically constructed realities can be made tangible. In order to illustrate the analytic potential of virtual-physical spaces, a case study from the game and leisure sector will serve as an example.

Phygital 3D Spaces

In 2016, a US start-up in the city of Pleasant Grove, Utah, opened an amusement park called The Void which features something quite different from the commonly known fun-fair rides and flying constructions. Visitors to this park are equipped, rather, with advanced VR hardware in order to interact with virtual and physical 3D settings and accomplish feats they could not otherwise experience due to spatial and physical limits of the real world and since the laws of physics cannot be repealed, like fighting dragons or even being hit by enemy bullets. Visitors wear data glasses called Rapture HMD with two curved, extremely high-resolution screens, integrated headphones, and a microphone.

11 Thiemo Breyer, Philosophie der Verkörperung. Grundlagen und Konzepte, in: Gregor Etzelmüller, Annette Weissenrieder (eds.), *Verkörperung als Paradigma der theologischen Anthropologie*, Berlin/Boston: De Gruyter, 2016, pp. 29–50, p. 43.

12 Munich ACM SIGGRAPH Chapter, Ken Perlin – Prototyping the Future, https://vimeo.com/145127565 (accessed January 1, 2018).

5 A player at *The Void*; Player's view, Pleasant Grove, Utah, 2015/16. Screen shots.

Additionally, they wear a waistcoat and gloves comprising numerous sensors for haptic feedback and body tracking.

With this virtual reality hardware, they pass through an ensemble of physically built rooms with numerous motion and interaction sensors. The Void's key component is a pitch called the *Gaming Pod*, an area of almost 330 square meters with a collection of moveable walls creating a maze of bending corridors. When players walk on virtual trails, through these corridors, they can move freely, without being pushed to an obstacle. The physical boundary and the objects of the pitch are integral components of the digitally constructed 3D image spaces. The physical game architecture is digitally remodeled and visualized and inserted into the VR glasses, where it overlaps with interactive moving images and 3D figures (fig. 5). These projections appear exclusively in the virtual space, whereas the player's actions are carried out simultaneously both in the physical and virtual space. Thus, head-mounted displays and tactile interfaces are ideally called upon to give consistent information in order to trigger parallel sensations. In this setting, the visitor, equipped with a display and wearable devices, physically and digitally intervenes in the game process, thereby exercising partial control and managing the moving images projected onto the digital 3D surfaces. The intended loss of control, primarily caused by the unfamiliar linkage between complex virtual-physical image space data, is thus an essential constituent of the game; it adds to the thrill.

"The goal is to attain total immersion", claims James Jensen, co-founder and Chief Visionary Officer of The Void.[13] In order to incorporate players more (and even fully) into the physical-digital settings of reality, special mechanisms, tools, and devices are provided to let players feel sensations like heat, cold, humidity, vibrations, height differences, and to allow them to touch objects or perceive bad or pleasant scents. *Gaming sickness*, as a common characteristic of many photorealistic PC or console games, is eliminated, the providers of The Void stress, citing the doubling of two different spaces as a main reason: "Any movement made in the

13 James Jensen, as cited in Angela Gruber, Virtual Reality Theme Park: The Void. Der erste virtuelle Freizeitpark, in: *Die Zeit*, June 8, 2015, http://zeit.de/digital/games/2015-06/virtual-reality-the-void-freizeitpark/komplettansicht (accessed January 1, 2018). Translation from German by the author.

virtual world is to the visitor also a movement made in the real world. The visitor doesn't feel any discrepancy, so he will not feel ill. The game is real."[14]

The Void's promise thus consists of a fully-immersive imaginary world, of an extension of images brought into the depths of space for viewers, with their *visual perception* being boosted through given and complementary, mutually supportive, sensory impressions in the physical space. But what kind of idea and conception of the senses and their peculiarities is this promise motivated and influenced by? What does it mean for our perception, orientation, and navigation if digital real-time images reproduce the surroundings but deprive us of a direct view of the physical space – if the visual space (Sehraum) and the tactile space (Tastraum) are disconnected, only to be reconnected through digital, moving images of the surrounding space generated in real time?[15] What dependencies and reciprocal relationships exist between the *physical here* and the *pictorial there*? What categories are being developed if the depicted and disconnected space complies with its physically real spatial dimensions, but differs in its qualities? What perception shifts and scaling effects come into play or originate if – as it is the case with regard to The Void – a stage set architecture of simplified form and materiality can be recognized by touch, while a space of high density, fluidity, light, and information is experienced visually? How does the visual perception influence our tactile perception if the VR player sees his gloved hands on the display, but does not wear gloves at all (fig. 5)? Is it possible to replace sensation with imagination?

Hierarchy of the Senses

Phygital experiences like The Void are based on a holistically oriented model of the structure of the senses according to which the senses, being part of different fields of perception, render synthetic performances in the process of the constitution of space. Until today, this idea of an entity of the senses, and also of its hierarchical structure, has characterized the interpretation and the application of imaging techniques. Although sensory perceptions are closely interconnected, physical-digital VR environments, in particular in the gaming and entertainment area, are based on a model of perception in which vision plays the key role and ranks first, followed by the senses of hearing, touch, taste and smell. For example, this is expressed by the fact that the geometric forms of physical objects and surfaces are radically reduced and simplified, whereas the interactive moving images gain 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 reconceptualization and radical expansion of the traditional hierarchy of the senses with vision at its top. 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.

This revived dispute on the interaction between physical and cognitive performances in the experience of space can be regarded as the continuation of a tradition stemming from the ideas of sensualistic aesthetics in the 18th century. Following that tradition, theorists and architects

14 Ibid.

15 The matter of the 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*), May 31–June 1, 2017, at KISD – Köln International School of Design of TH Köln, organized by Carolin Höfler and Philipp Reinfeld in cooperation with the Institute of Media and Design of TU Braunschweig.

developed a perspective towards the idea of built space, stressing that it only exists in dependence upon the recipient and the entirety of his perceptions and emotions.[16] The decisive idea behind it was the approach of an emotional merger of subject and object in aesthetic perception, which later, in 1872, would be coined by the German philosopher Robert Vischer as the term of "Einfühlung" or "empathy", as it is often translated.[17] Instead of following traditional proceedings of representation, ornamentation, and iconography, aesthetic efforts at that time were rather aimed at reconceptualizing architecture in the context of a synaesthetic, optical-tactual perception. Insight into that shift of perspective provide, for example, the essays *Prolegomena zu einer Psychologie der Architektur* (Prolegomena to a Psychology of Architecture) by Heinrich Wölfflin, *Ueber den Werth der Dimensionen im menschlichen Raumgebilde* (On the Importance of Dimensions in Human Spatial Creation) by August Schmarsow, and *Das räumliche Sehen* (The Spatial Vision) by Paul Klopfer.[18] Instead of having an idea of space as an immutable entity, the named authors advocate for a more dynamic principle according to which space is generated in the very moment of perception. The idea of a moving, active recipient is thus a prerequisite for space and its creation. From the bodily movement on – in transition from the "tactile space" to the "face space", as Schmarsow points out – space comes into being as a concatenation of mental imagery.[19] It was philosopher Edmund Husserl who recapitulated – skipping the idea of psychologism – the approach of a sensomotoric linkage of all senses and the sensuous-bodily state of perception more systematically. Modern phenomenology of space, as Husserl has established it in his lectures at the beginning of the 20th century, assumed the impression of spatiality to be in connection with the awareness of one's own body movement and thus the result of a lasting sequence of perception.[20]

Referring to these phenomenological and psychological approaches of the first half of the 20th century, Hungarian philosopher Alexander Gosztonyi tried to define the peculiarities of the senses in his *Grundlagen der Erkenntnis* (Fundamentals of Knowledge) from 1972.[21] In his analysis, he not only took into account the classical senses like sight, hearing, taste, smell, and touch but also the "senses of bodily feeling" categorizing the senses of vibration, temperature, balance, gravity, and proprioception as the most important ones.[22] His interest was mainly aimed at analyzing how the different senses either compete or diffuse.

A constitutive element for the dominant physiological-rational understanding of human-computer interaction, virtual and augmented reality, as well as game and interaction design, is primarily Gosztonyi's emphasis on the "quality of reality" according to which every sense is supposed to have a "quality of realness" (Wirklichkeits-

16 An overview on the aesthetics of empathy is given by Jörg H. Gleiter, *Architekturtheorie heute*, Bielefeld: transcript, 2008, pp. 113–126.

17 Robert Vischer, *Über das optische Formgefühl. Ein Beitrag zur Ästhetik*, Leipzig: Hermann Credner, 1873.

18 Heinrich Wölfflin, Prolegomena zu einer Psychologie der Architektur (1886), in: Idem, *Kleine Schriften (1886–1933)*, Basel: Benno Schwabe & Co., 1946, pp. 13–47; August Schmarsow, Ueber den Werth der Dimensionen im menschlichen Raumgebilde, in: *Berichte über die Verhandlungen der Königlich Sächsischen Gesellschaft der Wissenschaften zu Leipzig. Philologisch-Historische Classe* 48 (1896), pp. 44–61; Paul Klopfer, Das räumliche Sehen, in: *Zeitschrift für Ästhetik und Allgemeine Kunstwissenschaft* XIII (1919), pp. 135–149.

19 Schmarsow 1896 (as fn. 18), p. 50, pp. 54–55.

20 Edmund Husserl, *Ding und Raum. Vorlesungen 1907,* Den Haag: Martinus Nijhoff, 1973.

21 Alexander Gosztonyi, *Grundlagen der Erkenntnis*, Munich: C. H. Beck, 1972, pp. 67–97.

22 Ibid., pp. 67–68.

wert), subdividing it into a "quality of reality" (Realitätswert) and a "quality of evidence" (Evidenzwert).[23] According to Gosztonyi, the sense of touch serving as sense of nearness (Nahsinn) therefore has a high quality of reality since it allows for a feeling of material resistance, whereas the sense of sight has a lower quality of reality. The sense of sight serving as sense of farness (Fernsinn), however, is supposed to have a high quality of evidence as it allows having oversight of and insight into complex formal contexts. But, as Gosztonyi posits, only the interplay of quality of reality and quality of evidence determines the degree of realness of the environment being perceived.

Even if Gosztonyi identified the reciprocal effects of the senses as prerequisites for the construction of reality, he assumed a hierarchical structure to exist: "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."[24] Such traditional approaches of the peculiarity and the hierarchy of visual and tactile-haptic sensory perceptions had a lasting effect on the debate on physical-virtual realities. It is the idea of the tactile sense as a simple pressure sense with a high quality of reality that currently dominates the design of mobile devices and interactive surroundings whose interfaces give haptic feedback. In contrast to the forms of sight, the forms of touch are rather poorly developed.

23 Ibid., p. 68.

24 Ibid., p. 81. Translation from German by the author. Original quote: "Der Tastsinn ist nicht dominant […]. Der Sehende ordnet das Ertastete den Sehformen unter und ordnet die Tastqualitäten und die Tastformen in das Sehfeld ein."

Feedback Design

The new entanglements between the physical "form of being" (Daseinsform) of the tactile space and the digital "form of effect" (Wirkungsform) of the visual space in phygital VR environments fundamentally alter the idea, concept, and design of architectural spaces.[25] With regard to the realm of designing, the construction of specific spaces of action characterized by the interplay between human bodies, technical things, and physical surroundings is currently coming more and more to the focus of attention. On the one hand, the built spaces are being cross-linked through chips, tags, and sensors; on the other hand, they are designed to evoke specific sensory experiences. This means that the material surfaces and objects of the physical space are modeled in such a way that certain (expected or desirable) sensory perceptions, environmental experiences, and behavior patterns come into being in the virtual space. Relevant to the design and the construction of the physical space is the question of how to develop its parameters so that the VR glasses user will accept the virtual space as a *real* space. 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 display user will accept the virtual surroundings as realistic and authentic as possible if he can move through them as naturally as possible. However, body perception can sometimes be deceptive, especially if the recipient wearing the head-mounted display has no visual access to the space being identified by touch. The intense visual perception

25 Schmarsow 1896 (as fn. 18), p. 50.

can alleviate other physical experiences: Visually perceived paths are therefore usually different from physical paths. It is this discrepancy between physical and virtual movement that the approach of *redirected walking* takes into account. Redirected walking assumes that the display user, while passing through virtual worlds, is relatively insensitive to rotations and curves and underestimates egocentric distances.[26] No matter how hard a test person tries to walk in a straight line while blindfolded or with VR glasses on his head, he often ends up going in circles without realizing it. These observations are utilized for the construction of physical-digital VR environments, in particular in those cases where the physical space is limited compared with the potentially infinite virtual space. As a result, the display user is physically guided around a curve while he thinks he is moving straight. According to current knowledge, it only requires a 22-meter radius in order to make the user think that he is walking a straight line, while he is actually walking in circles.[27]

A typical space configuration that permanently redirects the walking direction is the *Unlimited Corridor* developed in 2016 by engineers and computer scientists of the University of Tokyo in cooperation with the US company Unity Technologies (fig. 6).[28] In this spatial installation, the display user touches the corridor wall with one hand in order to enhance the virtual environment's credibility.

6 Keigo Matsumoto & Team, *Unlimited Corridor*, University of Tokyo, 2016. Photo.

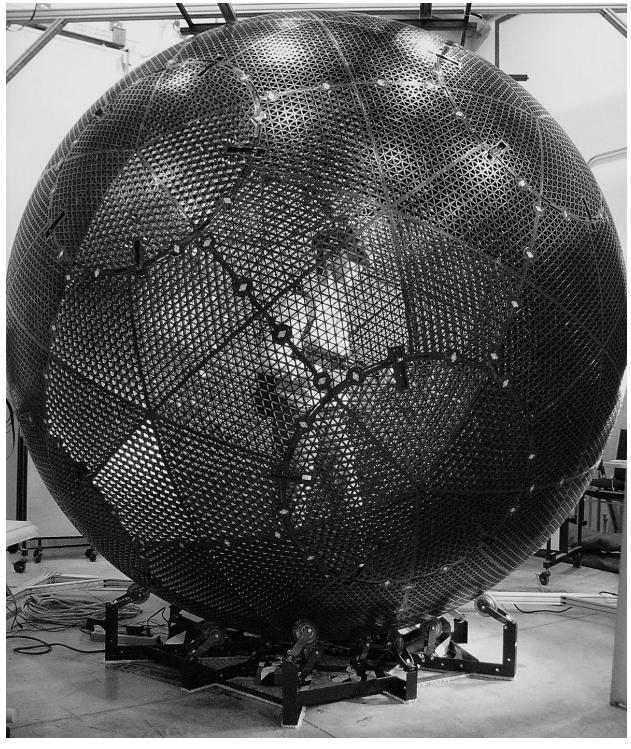
Virtual crossroads and turnoffs are physically reproduced through an additional corridor in the center. The Void is an advocate of the redirected walking principle, too. Its Executive Illusionist Curtis Hickmann developed a similar endless corridor for the VR game hall.[29] At the very same time, the system can be used by several users simultaneously, movement sensors and images actively guide users not to bump and crash into each other, with virtual doors serving as barriers.

26 Frank Steinicke, *Being Really Virtual. Immersive Natives and the Future of Virtual Reality*, Cham: Springer, 2016, pp. 59–86.

27 Ibid., p. 77.

28 Keigo Matsumoto, Yuki Ban, Takuji Narumi et al., Unlimited Corridor. Redirected Walking Techniques Using Visuo-Haptic Interaction, in: *Proceedings of ACM SIGGRAPH 2016 Emerging Technologies*, Article No. 20 (Anaheim, CA, July 24–28, 2016), https://dl.acm.org/citation.cfm?doid=2929464.2929482 (accessed January 1, 2018); see also the video of VR experiments: Keigo Matsumoto, Unlimited Corridor, https://youtube.com/watch?v=THk92rev1VA (accessed January 1, 2018).

29 See the model of The Void's playing field https://theverge.com/2016/7/1/12058614/vr-theme-parks-disney-six-flags-the-void-ghostbusters-virtual-reality (accessed January 1, 2018).



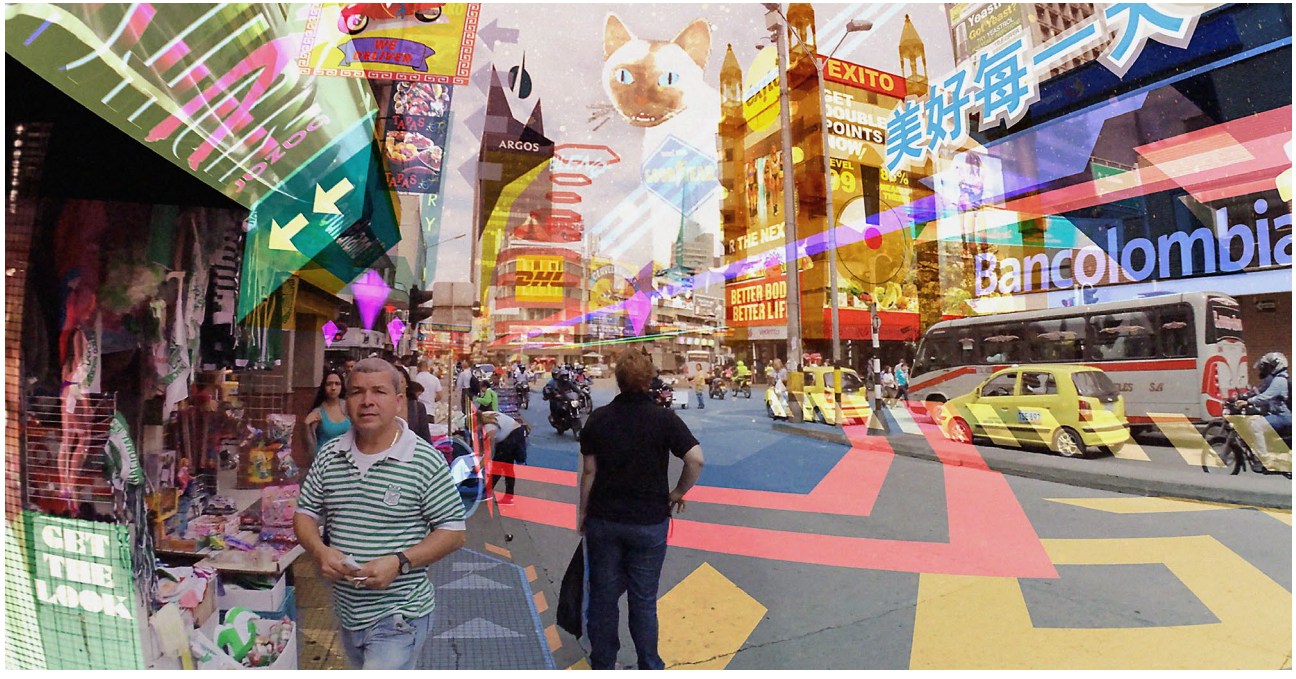
7 *VirtuSphere*, Mounted Warfare TestBed at Fort Knox, Kentucky, 2007.

A multidirectional version of the *Unlimited Corridor* is the so-called *VirtuSphere* originally used by the US military for training purposes (fig. 7). It is a ball to walk-in with a diameter of 3 meters supported on rollers. After entry, users can walk in any direction without changing their position in the physical space. With the help of a head-mounted display, test persons are transferred to virtual worlds in which they can move about freely. Sensors beneath the ball record any step and transmit the information to the display. In that respect, the space of the ball is rather a gigantic joystick managed, operated, and steered with the users' feet. Three of these balls are located in a Las Vegas casino, one ball can be found at the University of Bremen in the department for cognitive neuroinformatics, for the purpose of research on human orientation in virtual and physical spaces.[30] This experimental system also supports the idea that the VR user has the best orientation in unknown virtual worlds if he is provided with as many sensory impressions as possible. Besides the feeling of moving and watching 3D pictures of the virtual world, the setting can be complemented with sounds and odors. Such a maneuverable ball is characterized by an ideology insinuating that space perception and space movement follow sensory impressions. That idea has a strong impact on the development of today's phygital VR settings in the realm of game and interaction design. Yet, it is quite astonishing though that the material and atmospheric characteristics of real space receive so little attention in those settings.

Hallucinatory Interface

It even seems that the contradiction between physical spatiality and virtual imagery will sharpen: The visual-material, tactile-haptic, and olfactory features of space are being decoupled from their physical shape and materiality and transferred into visual information. The physical diffuses into the virtual for the benefit of a performance that permanently reconfigures the potential relationship between physical and virtual reality.

30 Kerstin Schill, *Räumliche Exploration (VirtuSphere)*, University of Bremen, working group Cognitive Neuroinformatics, http://cognitive-neuroinformatics.com/en/research/projects/raeumliche-exploration (accessed January 1, 2018).



8 Keiichi Matsuda, *Hyper-Reality*, 2016. AR rendering.

Number and complexity of this projected imagery will in the near future certainly increase. Given the ubiquity of cameras and the availability of a billion photos online, recent years have witnessed new options for image-based 3D data capture and 3D reconstruction of physical spaces and objects.[31] With the help of photogrammetric techniques and procedures in computer graphics and computer vision, it is possible to generate, from a variety of images, photorealistic and editable digital models of those scenes, which can then later be integrated into virtual reality surroundings. In the ideal case, the display user can record his physical surrounding space via a digital video camera attached to his glasses, can process that information into 3D spaces and 3D objects through image-based geometry reconstruction software, and can eventually embed them into the VR scene – and all this in real time.

31 Simon Fuhrmann, Fabian Langguth, Michael Goesele, MVE – A Multi-View Reconstruction Environment, in: *Proceedings of the Eurographics Workshop on Graphics and Cultural Heritage* (Darmstadt, October 6–8, 2014), https://gcc.tu-darmstadt.de/media/gcc/papers/Fuhrmann-2014-MVE.pdf (accessed January 1, 2018).

The possible consequences of this continuous transformation of physical spaces into virtual imagery is outlined by Japanese architect Keiichi Matsuda in his short movie *Hyper-Reality* (fig. 8).[32] Just like in a computer game, the viewer is watching the action from first-person perspective of a protagonist moving through a consumer's day-to-day world, totally saturated by media and promotions. He takes the bus, gambles online, chats with a job manager about current vacancies, and enters the question "Who am I?" into a search engine. In the supermarket, there are new ads and apps perpetually popping up, and a small dog on the shopping cart serves as a shopping companion, reporting special offers via GIF animation. While in this visual supersaturation, innumerable background sounds rumble, roar, and ring. In *Hyper-Reality*, Matsuda coped with a specific kind of the interplay of virtual and physical realities – with augmented reality (AR). In contrast to VR displays, visual access to the physical space is still possible, but it is modified through interactive 3D projections. While doing so, the user is looking through transparent screens on which he is watching the projections. They constitute the front. Behind it, a real-physical space opens up. Thus, this procedure interlinks a flat with a deep space.

The technique of combining detailed virtual image information up front, with less detailed physical space configurations in the back, is closely associated with postmodern strategies of space-formation. The *Hyper-Reality* architectures, for instance, can be regarded as contemporary versions of the *decorated shed* which Robert Venturi and Denise Scott Brown considered to be a postmodern building type par excellence. In *Learning from Las Vegas* (1972), they deciphered the aesthetic functionalism of a commercial entertainment industry whose symbolism and imagery were particularly oriented towards the visual perception of motorists and pedestrians.[33] From the buildings along the Las Vegas Strip, they derived the building type of the *decorated shed* which is simple in configuration and form, but whose message is intricately designed and offensively put to the front of the façade – as ultra-large illuminated panels and signs. *Hyper-Reality* then appears to be an even more exaggerated version of the Strip. The digital symbols covering the city like a virtual skin are individually customized to those who pass through, can be dynamically modified, and are, in the truest sense of the term, transparent and easily comprehensible.

Hyper-Reality emphasizes the leveling of deep structures as a constitutive feature of physical-digital worlds, even though the pioneers of VR and AR systems originally came forward with a contrary promise. Given the revocation of deep structures, one is tended to consider the *Hyper-Reality* environments as an epitome of the late capitalist culture of spectacles and simulacra, as Fredric Jameson in his 1984 book *Postmodernism, or The Cultural Logic of Late Capitalism* had stressed.[34] With regard to a postmodern space that appeals to all senses, Jameson coined the term of "hyperspace".[35] He understood it as a spatiality characterized by a plenty of indissoluble and interwoven surfaces. He exemplified this idea of "depthlessness" in particular via the lobby of the Westin Bonaventura hotel in Los Angeles: "I am tempted

32 Keiichi Matsuda, *Hyper-Reality. A New Vision of the Future*, https://vimeo.com/166807261 (accessed January 1, 2018).

33 Robert Venturi, Denise Scott Brown, Steven Izenour, *Learning from Las Vegas. The Forgotten Symbolism of Architectural Form*, revised edition of the 1972 publication, Cambridge, MA/London: The MIT Press, 1977, pp. 87–103.

34 Fredric Jameson, *Postmodernism. Or, The Cultural Logic of Late Capitalism*, Durham: Duke University Press, 1991.

35 Ibid., p. 44.

to say that such space makes it impossible for us to use the language of volume or volumes any longer, since these are impossible to seize."[36] He stressed that such a space was filled with diaphanous materials, illuminating phenomena, and ongoing, continuous movements to such an extent that its material-constructional spatial boundary is forced back to vagueness: "Hanging streamers indeed suffuse this empty space in such a way as to distract systematically and deliberately from whatever form it might be supposed to have [...]".[37] It is as if the effectual spatial boundary seems to dissolve, dilute, and overlay all spatial regions. As if it merges into diversified layers, into limiting structures being at once open and enclosed floating through space as aerial objects. From these observations, Jameson concluded the existence of a modified spatiality – one that substitutes "depth" with "surface" and allows for an intensified form of what in German would be called *Sehenlassen* or letting itself be seen.[38] The numerous activities, moods, and ambiances in the hotel lobby make the observer feel as if he had totally immersed into the space: "[...] a constant busyness gives the feeling that emptiness is here absolutely packed, that it is an element within which you yourself are immersed, without any of that distance that formerly enabled the perception of perspective or volume. You are in this hyperspace up to your eyes and your body."[39] The feelings of disorientation and dizziness which Jameson identified to be the very effects of the hyperspace are, by implication, fundamental experiences also detected by various observers – from Rem Koolhaas to Jean-François Lyotard – when faced with the forces of capitalism unleashed and the aesthetic experiences of post-modernism.[40] In the age of VR and AR and the Internet of things, *Hyper-Reality* can be understood as an amplified sequel and fearsome intensification of those experiences and emotions.

Other Images, Other Spaces

With the growing penetration of new VR and AR glasses onto the mass market, relations between bodies and outer and inner environments become increasingly interconnected via screen-based, interactive moving images. The interactions with and through screen images lead to a specific alignment of the body in both the virtual and physical space. Being a player in physical-digital theme parks like The Void or supposedly flying via the full-body installation of *Birdly* are aimed at generating an intense perception and a powerful body mobilization. The visualizations of objects and spaces installed through the glasses actively affect the user's position and movement in the physical space and also have an impact on the user's spatial disposition towards the display, the apparatus, and the architecture. If the physical space with its haptic surfaces and things to be perceived and identified is digitally reproduced and visually brought into the displays, the physical space will transform into phygital surroundings, inducing the beholder to go through specific experiences and actions. It is thus not only important how the phygital 3D space is visually presented and perceived; critical is how the given data of both environment and body interact and communicate – also with regard to an interaction pattern between display imagery and the beholder's perceptions and actions.

36 Ibid., p. 43.
37 Ibid.
38 Ibid., p. 49, p. 12.
39 Ibid., p. 43.
40 Jean-Francois Lyotard, *Leçons sur l'Analytique du sublime*, Paris: Galilée, 1991.

Considering the increasing integration of VR and AR systems into economic and design-related processes and given the growing impact of display images on a computerized world access, many questions arise, in particular with regard to the issues of authorship, final authority, and decision-making autonomy of the actors involved: What industries and sectors will further develop and advance the potentials of these physical-virtual spaces of experience and action, and for what purposes? How will the observer be influenced? Who designs and is in charge of the content and type of physical-virtual experiences? Which interactive screen images will be provided? What emotional and mental experiences shall be triggered? Even though the action taking place in the huge spectacle of games and artistic installations has, in the first place, no far-reaching effect for the real-physical world, the perceptions and experiences made in those physical-virtual settings do create an intensity of experience which must be perceived to be real. As a result, virtual reality experiences will certainly be establishing themselves as a new category of spatial experience and will thus give a strong impetus to sensory perceptions, actions, and decisions in non-digital spheres of life.

Further, the scientific utilization of virtual reality tools will have far-reaching implications for knowledge production and evidence acquisition, for instance in investigative analysis and 3D crime scene reconstruction. The fact that architecture and the arts also harness forensic methods based on virtual reality is illustrated by the interdisciplinary research group Forensic Architecture and its project *77sqm_9:26min*, which through imaging techniques tried to resolve the case around German intelligence officer Andreas Temme with regard to the NSU-murder of Halit Yozgat in 2006.[41] This case mingled 3D image space analysis with criminology, political enlightenment, and legal proceedings. Knowing that virtual reality tools provoke perception shifts and scaling effects, it is quite astonishing that the actors involved have such a high confidence in imaging techniques being applied in those cases for the purpose of fact- and truth-finding.

Criticism and skepticism regarding how the recipient can be captured, deceived, and manipulated in VR environments is more effective through designing critical spaces. This raises the question of how alternative forms to physical immersion into 3D spaces can be devised and developed. Is it possible to maybe reduce the intensity of virtual 3D surroundings? In coping with VR, which medial strategies exist that circumvent the almost total immersion into virtual spaces and which provide transparency about the techniques that users are succumbing to? How can more heterogeneous, fragmented, and conflicting formal systems be applied in immersive environments?

Those strategies of undermining and disturbance are based on a conceptional approach which tries to overcome the traditional antagonisms between body and mind and which interprets sensory perceptions neither individualistic-hierarchically nor collectivist-holistically. From this perspective, seeing, hearing, and feeling are not being understood as naturally given skills, but as specific effects of socio-technical assemblages and as medial design practices.[42] This involves not only experiences of visual-spatial relations, but experiences of social relations as well. How can display users get in touch and interact with each other?

41 Forensic Architecture, *77sqm_9:26min*, investigation, 2016–2017, http://forensic-architecture.org/case/77sqm_926min (accessed January 1, 2018).

42 Beate Ochsner, Robert Stock (eds.), *senseAbility. Mediale Praktiken des Sehens und Hörens*, Bielefeld: transcript, 2016.

And how can they get in touch and interact with those not equipped with a display?

In such discontinuous settings, what is and will be the function of architecture? In hyper-realistic phygital VR environments, the materially bound spatial forms primarily serve as image carriers and step behind the digital interface. The question arises as to how to envision, design, and develop an architecture that does not constantly validate the perception of being in a virtual space (*sense of being there*), but rather challenges it through creating a sense of presence in the physical space (*sense of being here*). What other perceptions could be triggered by physical spatial forms if only they provided meanings and messages beyond the moving images of the displays – to be decoded and interpreted by the recipient in relation to the visually perceived 3D spaces? What if these perceptions, meanings, messages, codes, images did not rely on affirmation and affective adaption, but on disturbance and doubt instead?

Figures

1 Toast, *Plank Experience*, Frankfurter Kunstverein, Photo: N. Miguletz. https://fkv.de/sites/default/files/styles/680x540/public/FKV_Perception%20is%20Reality_Ausstellungsansicht_Toast_2.jpg?itok=YHOUdOBg (accessed January 1, 2018). Reprinted with permission.

2 Toast, *Plank Experience*, https://toast.gg/release/ (accessed January 1, 2018). Reprinted with permission.

3 Somniacs, http://somniacs.co/media.php (accessed January 1, 2018). Reprinted with permission.

4 Adam Savage, Tested, Flying the Birdly Virtual Reality Simulator, https://youtube.com/watch?v=gWLHIusLWOc (accessed January 1, 2018). Reprinted with permission.

5 THE VOID, First look at THE VOID, https://youtube.com/watch?v=cML814JD09g, 0:58, 0:59.

6 *Unlimited Corridor* Project Team (Keigo Matsumoto, Representative), Japan, http://cyber.t.u-tokyo.ac.jp/~matsumoto/image/uc/uc_web.jpg (accessed January 1, 2018). Reprinted with permission.

7 Paul Monday, https://en.wikipedia.org/wiki/VirtuSphere#/media/File:Virtusphere.jpg (accessed January 1, 2018).

8 Keiichi Matsuda, Still from *Hyper-Reality*, 2016, http://hyper-reality.co/assets/HQ_images/hyper-reality_03.jpg (accessed January 1, 2018). Reprinted with permission.