IMMERSION ISSUES IN HAPTIC EXPERIENCES

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ABSTRACT

As a work in progress this paper intends to address actual immersion issues concerning mismatches in VR and Mixed Reality haptic experiences, in the relation between real/virtual space.

It considers the more recent developments in Brain Studies, Cognitive Sciences, and Physics and how these are affecting the concepts of Man, space, and human-space interaction.

The focus was on touch and haptic issues, namely mismatching of places and shapes.

In some examples these problems seem to be attributable to the resource to outdated theoretical practice frames (Euclidian-Newtonian), and the suggestion is that some of the issues could be solved by resourcing to Minkowki-Einsteinian space-time algorithms.

INTRODUCTION

This paper – as a work in progress – intends to address actual immersion issues concerning mismatches in VR and Mixed Reality haptic experiences, in the relation between real/virtual space.

It will initially address conceptual vocabulary problems, as the terminology used, adopted from other sciences, is theory-laden and in some cases obsolete.

New developments in Brain Studies, Cognitive Sciences, and Physics have affected the concepts of Man, space, and human-space interaction. So, and considering that Immersion presupposes a user/body with senses, acting/reacting to an environment (real or virtual), these concepts demand an updated re-definition in a new Minkowski-Einsteinian world.

Special Relativity theory replaces 3D movement by weaving patterns of complex 4D geometry, or sculpture, at the neural as well as the cosmic scale. Gravity as a force is abolished, to be replaced by pure geometry. Minkowski complex Geometry is already being used by game developers, namely for the creation of volumes, or movement.

The most recent Human Brain Projects are redesigning new brain atlas, redefining its characteristics, areas and functions.

The impact of all this new information is overwhelming. And as well as in the scientific fields, it will demand new research in all other human related areas.

Having in mind the new sensory/motor Homunculus map, the 5 senses will be quickly addressed to concentrate on Touch.

Considering the case-study experiences, the focus will be on the type of haptic gadgets used (wearable or external), resistance, mapping, as well as mismatches and warping.

In some examples these problems seem to be attributable to the resource to outdated theoretical practice frames (Euclidian-Newtonian), and the suggestion is that some of the issues could be solved by resource to Minkowki-Einsteinian space-time algorithms.

These haptic issues in the relation between user-body and the real or VR world need clarification in order to establish an operational basis that can become useful for further and posterior game, storytelling and cultural heritage practices.

CONCEPTUAL PROBLEMS

The word «**Immersion**», from the late 15th century, comes from the Latin *immersio*(*n*-), from *immergere* 'dip into'. Its senses are: 1. the action of immersing someone or something in a liquid; 2. deep mental involvement in something; or 3. (from Astronomy), the disappearance of a celestial body in the shadow of or behind another (O.E.D.).

The term has been updated and transformed to describe new experiences related to the internet world and virtual reality, and gave basis to multifarious definitions: the Saussurian "signifié"/signified acquired, anarchically, many "signifiants"/signifiers to encompass the needs of new realities in the computer world.

This option to return to dictionary definitions – here and in subsequent words/designations – is due to the fact that all these terms have been arbitrarily contaminated by the disciplines that chose to use them and became theory-laden – namely in/by a Euclidian-Newtonian universe – and so are also always right and always wrong.

The current definitions of **Immersion** – into a virtual reality – allude to the **perception** of being **physically** present in a non-physical **world**. This 'perception' is fashioned by surrounding the VR system **user** with **images**, **sounds** or other **senses stimuli** that provide an engrossing total **environment** (bold mine).

From the state-of-the art, either theoretical or practical, even the more recent speculations resort to specialists whose models are old. Immersion has been considered and related to the artistic experience (Frank Rose 2011), a feature of mental operations associated with narrative engagement (Marie Laure Ryan 1992) and go the par with the literary 'suspension of disbelief', a state of consciousness (Maurice Benayoun 2008) or separated into main practical categories (Ernest W. Adams, 2003/2012).

In all cases, the name-word is a metaphor used to describe a user (a body, a subject, a consciousness) in relation with a physical world (cosmos) experiencing (sensing / feeling) a relation with the environment - real or artificial - which can be more (or less) verisimilar.

All the definitions and terminologies – so far – have not considered the latest developments either in Brain Studies and Cognitive Sciences, Philosophical representation theories or Physics. They are operating in a Euclidian-Newtonian world ignoring the progress in Quantum Physics, disregarding Minkowski's Geometry, or Einstein's Special Relativity theory. The situation is more complex because in, and from, Games (making-of, mechanics or as an artefact) the Minkowski-Einstein theories and universe are already the rule.

All have as working material obsolete images of the world, of the human being, and so, of the human interaction with that world.

CONCERNING THE WORLD

«In spite of the fact that SR [Special Relativity] has been known for a century and Newtonian theory is only an approximation, all the theories of biology, evolution, and neuroscience today still remain resolutely rooted in the Newtonian System. For example, evolutionary theory today describes 3D organisms competing in a 3D space in a separate time and changing their structures dynamically as they do so. These organisms only appear to be moving because they are observed by the Observer on its time travel along their common time dimension. Whereas all these dynamic changes are described in SR as features of the static 4D sculpture of the world lines of these organisms.» (Smythies 2018:8).

Newtonian vs. Einsteinian worlds

The world is described by Newtonian theory as a collection of 3D objects extended in a 3D space. They exist in a separate time that flows independently.

Their movement in space during time is determined by Newton's laws of motion – gravity as an attractive force between objects.

The new 3D experiences – probably due to the influence of games – try to adapt the linear (1D) or 2D theories, with diverse results, as if 3D where an extension of both.

Concerning time and space, they root themselves on a Newtonian world, not considering the most recent theories about the universe 4D.

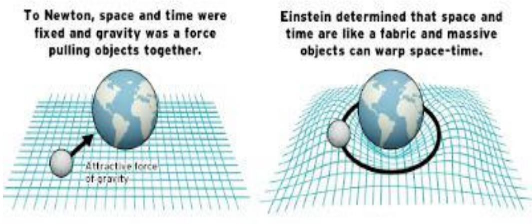

Figure 1: Newton vs. Einstein worlds

For Penrose: «what we perceive as moving 3D objects are really successive cross sections of immobile 4D objects past which our field of observation is sweeping.» (Smithies 2018:6).

Here, the Observer is not the physical body of the scientist, but a Self or Observer that can move in time in the way described.

SR replaces 3D movement by weaving patterns of complex 4D geometry, or sculpture, at the neural as well as the cosmic scale. Gravity as a force is abolished, to be replaced by pure geometry.

From Euclidean to Minkowski Geometry

In 3D space, the differential of distance (line element) is defined by coordinates that are the differentials of the three spatial dimensions.

By 1907 Minkowski, based on the previous work of Lorentz and Poincaré, and considering SR introduced by his former student Albert Einstein (1905), advanced that time and space are not separated entities but intermingled in a four dimensional space–time.

Minkowski space-time appears to be very similar to the standard 3D Euclidean space, but there is a crucial difference in regards to time.

In "Minkowski space-time" geometry there is an extra dimension (coordinate X0) derived from time, such that the distance differential fulfils where dX = (dX0, dX1, dX2, dX3) are the differentials of the four space-time dimensions.

This suggests a deep theoretical insight: special relativity is, analogous to the rotational symmetry of Euclidean space, a rotational symmetry of our space-time. Just as Euclidean space uses a Euclidean metric, so space-time uses a Minkowski metric:

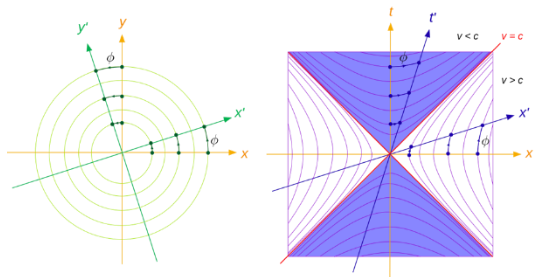

Figure 2: Orthogonality and rotation of coordinate systems compared - Maschen

Basically, SR can be stated as the invariance of any space-time interval (that is the 4D distance between any two events) when viewed from any inertial reference frame.

However, if this distance is transferred from a static to a dynamic perspective, it has to consider a mutual interference: the angled x' line in the image follows the line of simultaneity at event 0 for worldline t'.:

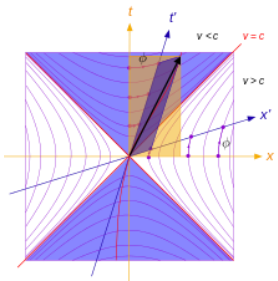

Figure 3: Wordline's variances - Tom Slijkerman

So, if the relation between two events/objects is considered from a mobile standpoint, it has to reflect the interference of the speed of the object in respect to the Observer, and that its own line of simultaneity is not horizontal, but is angled in the same but opposite angle as its worldline.

All equations and effects of SR can be derived from this rotational symmetry (the Poincaré group) of Minkowski space-time.

Minkowski complex Geometry is already being used by game developers, namely for the creation of volumes, or movement.

The Hyperbolic Games 2.0 4+ (2018 Jeff Weeks) – for PC and mobile apps – combine a multi-connected topology with a non-Euclidean geometry.

Mathematically they illustrate the hyperbolic plane, as a live scrollable object; the «under-appreciated fact that the two traditional models of the hyperbolic plane are simply different views of the same fixed-radius surface in Minkowski space…»

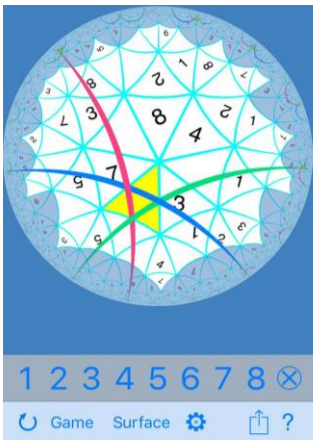

Figure 4: The Hyperbolic Games 2.0 - Jeff Weeks

Einsteinian worlds

Special Relativity uses a 'flat' 4-dimensional Minkowski space – an example of a space-time.

Organisms do not evolve in a block universe – rather the Observer sees successive cross sections of the organisms 4D physical structure that is simply more complex the further up the time dimension the Observers travel.

MIT Game Lab provides *OpenRelativity* (2012) an open-source Unity toolkit, designed to let developers integrate space-time-bending and accurately simulate SR effects of Einstein's special relativity, such as: «Lorentz contraction, time dilation, Doppler shift and the searchlight effect»:

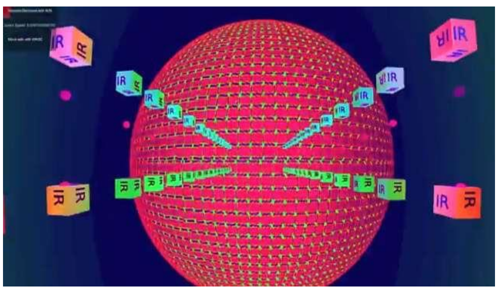

Figure 5: The IR/UV spectrum effect in OpenRelativity – MIT GameLab 2012.ewton vs. Einstein worlds

They also created two games with this software. *A Slower Speed of Light* (2013) – a first-person game prototype in which players navigate a 3D space while picking up orbs that reduce the speed of light in increments; and Einstein Playground (2016) – now a immersive SR VR experience at The Charles Hayden Planetarium.

Besides the incipient *Velocity Raptor* (TestTube 2011) there is available on STEAM since 2015 *Relativity Wars* – A Science Space RTS, a strategy/action game, set in a universe advertised as obeying Einstein's theories of relativity.

Figure 6: Relativity Wars - A Science Space RTS - FunGameCo

The need to consider the SR picture only comes in effect when the deeper questions as to the nature of reality are addressed (Smythies 2018:8): «This realization also requires radical changes in our ideas of what brain "events" actual consist of in a Minkowskian block universe».

Brain "events" are not composed of moving 3D atoms but of successive 3D cross sections of the static 4D world lines of these atoms. (Smithies 2018:8)

However, this does not require any changes in the practical day to day experimental neuroscience for which Newtonian terminology seems quite sufficient.

CONCERNING THE SUBJECTS BODY

– Brain Studies

Here the body will also be regarded in its etymological, dictionary terms: «1. The physical structure, including the bones, flesh, and organs, of a person or an animal.» from Old English *bodig*.

Among the organs, the brain will be considered.

The most recent studies – The Human Brain Project Home, the Brain Initiative, The Human Connectome Project, and The Functional Connectome Organization – are sketching a new brain atlas redefining its characteristics, areas and functions.

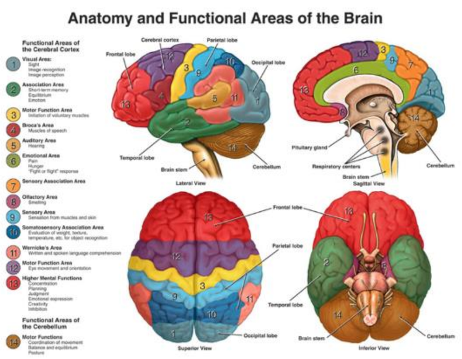

Figure 7: Anatomy and functional areas of the brain

To this now ‘traditional’ representation of the brain, an old known part (Sir Francis Crick; Christof Koch) – *The Claustrum* – has suddenly acquired new importance (Ramachandran 2013). It is a thin sheet of neurons laying between the insular cortex and the *striatum*, reciprocally connected with almost all cortical areas (motor, somatosensory, visual, auditory, limbic, associative, and prefrontal), presently proposed as the ‘seat of consciousness’:

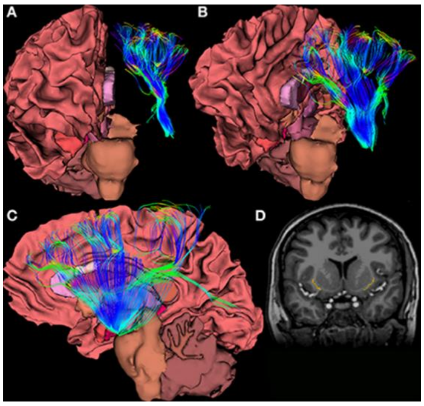

Figure 8: (A–C) Scanner showing white matter pathways emanating from the region of the human *claustrum*. (D) Binary label mask drawn of the left and right *claustra*.

Studies from the Functional Connectome Organization, based on single-scanner sampled 5216 UK Biobank participants, mapped «sex differences in brain volume, surface area, cortical thickness, diffusion parameters, and functional connectivity between adult males and females in the range between middle- and older-age.» (Ritchie 2018). Gender differences are shown in blue-pink:

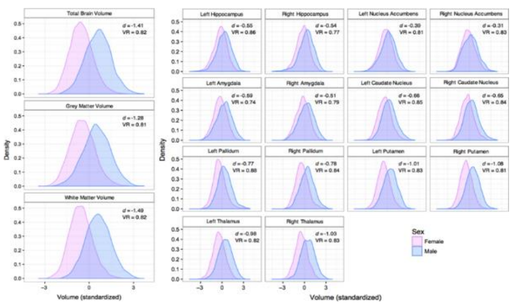

Figure 9: Sex Differences in the Adult Human Brain – Cereb Cortex

Discrepancies in Volume, Surface area and Cortical Thickness are shown below:

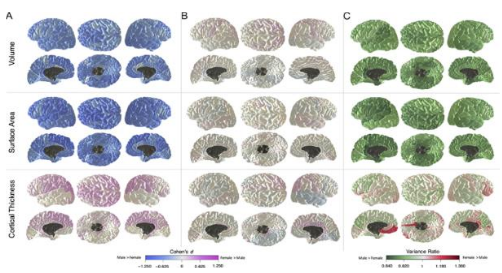

Figure 10: Sex differences in the Adult Human Brain – Cereb Cortex

These gender differences are biological, and consequently will have functional consequences at neurodevelopment.

This study is accompanied by cognitive tests at a very rudimentary level (Verbal-numerical reasoning/fluid intelligence; Reaction Time - modelled on the game of ‘snap’).

The authors explain: «Functional connectome organization showed stronger connectivity for males in unimodal sensorimotor cortices, and stronger connectivity for females in the default mode network. This large-scale study provides a foundation for attempts to understand the causes and consequences of gender differences in adult brain structure and function». And conclude: «providing a clear characterization of neurobiological sex differences is a step towards understanding patterns of differential prevalence in neurodevelopmental disorders» (Richtie 2018).

The impact of this all new information is overwhelming. And as in Sciences fields, will demand new research in all the human related areas.

Experiences have been made mapping the cerebral zones reacting to words. There is a Brain dictionary – (https://www.youtube.com/watch?time_continue=1&v=k61nJkx5aDQ) and IMR scans show the different areas awakened by game-playing, or during storytelling:

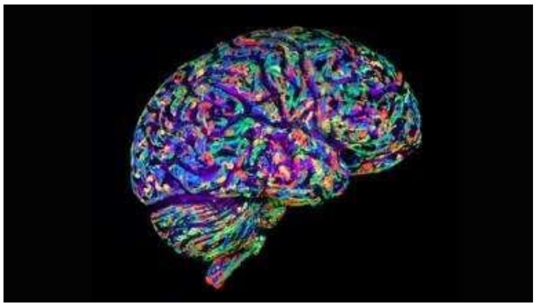

Figure 11: Brain illuminated during Storytelling

Theoretical neuroscientists are working to develop a multi-scale theory of the brain that synthesizes top-down and data-driven bottom-up approaches.

CONCERNING THE SUBJECTS BODY

– consciousness – perception – feelings - sensations

These areas are beings studied by Cognitive Sciences, Neuro philosophy, with admirable new results and due to the vastness of their implications – either for game-playing either any kind of storytelling or cultural heritage – are being considered for a future work.

Within that area are included arguments about perception, its controversies about ‘direct’ and ‘indirect realism’ – either if the immediate objects of perception are distal physical objects (as in naturalistic metaphysics, common sense and ordinary language) or if conscious experiences consist of reconstructions from information encoded in neural states and is hence indirect (a brain computation - neuroscientists).

– the five senses

As stated above, body will be considered in its etymological sense. This option to return to the dictionary is also due to the contamination the term has suffered either from Biology, Philosophy, New Media, Interactive art or Post-humanities studies (i.e., culturally constructed body; embodiment; body-image; body-schema; relational-process).

The issue with these classifications and ontologies is the same as with Immersion – both are based on out-of-date theories, and either consider the body as a robot, or a relational process.

Here, the brain will be addressed, among the organs.

The Sensory-Motor Homunculus

For the moment, what can directly affect kinetic and haptic experiences has to do with the so called Sensory/Motor Homunculus, a new atlas of the relationships between body and brain:

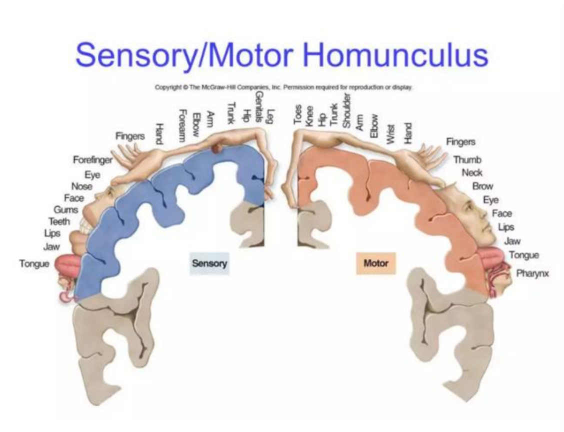

Figure 12: The sensory Motor Homunculus

This new mapping of the relationships between body and brain shows the bi-partition of activities – sensory (feeling) /motor (action) – but more importantly, exhibits considerable difference in intensity, a hierarchy of the prominence that each of the several limbs and parts of the human body have in brain activity.

– some of the five senses issues

Sense – Is a faculty by which the body perceives an external stimulus; one of the faculties of sight, smell, hearing, taste, and touch. Origin Late Middle English (as a noun in the sense ‘meaning’): from Latin *sensus* ‘faculty of feeling, thought, meaning’, from *sentire* ‘feel’. The verb dates from the mid 16th century.

The traditional definition of the ‘five senses’ – bearing in mind the Homunculus – might also need a readjustment, but will here be considered as is.

– Sight

The main mechanism of visual brain is information compression – the incoming picture via retina is divided into successive frames, first in the lower visual cortex (V1), then superimposed and transmitted to the higher visual cortex – saving computational resources.

The picture is built from information provided directly by the retina together with the memories stored in the higher visual cortex (Smithie 2018: 2)

Recent studies show that vision is dispersed by at least three different brain areas. So, the processing of colour, shape and motion of visual stimuli is carried out in quite different locations, and at different speeds – colour being the fastest, followed by shape and motion. Somehow at the highest level all these separate computations are amalgamated into the unified visual object that we see.

Visual neurons, when stimulated into a conscious visual experience, can be changed by epigenetic manipulations into functioning auditory neurons – resulting in a conscious auditory experience.

The same neurons, stimulated by differently ingresses, can give different conscious visual experiences (i.e. geometrical patterns, or oily swirls).

The new brain research and neuroscience theories are studying vision quite in depth. They show that the act of perceiving visually is a complex composite computation.

– Hearing

Concerning this sense, the only useful remark here is the existence of music-colour synesthesia, and that there are visual stimuli that can be changed into hearing experiences, and vice-versa. (Curwen 2018:96).

– Taste and smell

Taste and/or smell have been subject to some avant-garde artistic experiences – namely Tate Gallery (London), Robotarium (Bruges), etc., but are not relevant for this study.

– Touch – Haptic

Haptic perception (Greek: "suitable for touch") literally means the ability "to grasp something". Awareness, in this case, is achieved through the active exploration of surfaces and objects by a moving subject, as opposed to passive contact by a static subject during tactile perception (Hackfelt 2018).

The term Haptic was coined by the German Psychologist Max Dessoir in 1892, when suggesting a name for academic research into the sense of touch in the style of that in "acoustics" and "optics" (Hackfelt 2018).

Gibson (1966) defined the haptic system as «the sensibility of the individual to the world adjacent to his body by use of his body». Gibson and others further emphasized what Weber had already realized in 1851: the close link between haptic perception and body movement, and that haptic perception is active exploration.

Haptic or kinesthetic communication recreates the sense of touch by applying forces, vibrations, or motions to the user – directly or indirectly

CONCERNING THE SUBJECTS’ BODY

– the relationship with space

So, leaving perception issues for future work, we will be addressed Proprioception

Proprioception - from Latin *proprius*, meaning "one's own", "individual", and *capio*, *capere*, to take or grasp, is the sense of the relative position of one's own parts of the body and strength of effort being employed in movement [3].

It is the ability to sense stimuli arising within the body regarding position, motion, and equilibrium.

Even if a person is blindfolded, he or she knows through proprioception if an arm is above the head or hanging by the side of the body. The sense of proprioception is disturbed in many neurological disorders.

In humans, it is provided by proprioceptors in skeletal striated muscles (muscle spindles) and tendons (Golgi tendon organ) and the fibrous capsules in joints.

It is distinguished from exteroception, by which one perceives the outside world, and interoception, by which one perceives pain, hunger, etc., and the movement of internal organs. This suggests that while these components may well be related in a cognitive manner, they may in fact be physiologically separate. (Hakfelt, A. 2018).

Haptic technology

Under this category can be included all types of gadgets that enhance/replace bodily functions, either as a prosthesis directly applied to the human body, or as an external accessory – wearable, or belonging to the environment. The former can include head mounted displays, gloves, coats or shoes, i.e.. The latter can include objects providing haptic EMS effects as walls, gates, sliders, boxes, and projectiles.

Here as well are being created ontologies of haptic systems and controllers, i.e. considered 'active', 'passive' or 'Encounter-type' (Zhao 2018) – but all gadgets have to be active and deliver some kind of interaction and feedback. Either wearable or external, static or dynamical, they can provide muscular stimulation to create an effort / resistance effect – which can go from a single point kinesthesia to larger parts of the body.

These gadgets are employed to allow the human body to interact with Augmented, Mixed or Virtual Reality environments (Raptis 2018). Their aim is said to be to fool the human 5 senses (sight, sound, touch, smell, taste) by creating a sensation of Presence or Full Immersion – that would allow the user to perceive the digital environment as being physically real.

This perspective is ignoring two elements that are vital for any good VR experience – one is the adoption/embodiment of the position of the Omniscient Narrator, the other the aesthetic factor. As an example of these two features, that transport the VR experience to another 'brain' level not yet systematized is the film #DoWhatYouCant Samsung Ostrich Commercial (2017) - https://www.youtube.com/watch?v=wdL3zfxzueQ

Figure 13: #DoWhatYouCant Samsung Ostrich Commercial (2017)

Besides these, and as a unique intentionally aesthetical experience, created by Studio Swine in Milan during the 2017 international design week, is *New Spring*. It consists of a tree-like sculpture in the centre of a dark room, featuring cascading, scented, mist-filled blossoms that burst and evaporate upon contact with the skin, but live for a few moments when met with textured fabrics (http://edition.cnn.com/style/article/milan-design-week-cos-studio-swine/index.html).

Mismatching

In more down to earth experiences of haptic props there are issues in attaining a perfect coincidence of places and shapes between the real and virtual object – mismatches and warping – «which may lead to poorer sense of presence» and, what can be really important: «to decreased manipulation performance during the interaction» (Zhao 2018).

Mismatching can lead to loss of verisimilitude. It can happen in shape, alignment, and speed of action. Its consequences are space warping.

This issue has demanded to be approached by the full 3D mapping of one, or pairs, of complex surfaces in 3D spaces. The original legend to the image below says: «We present a new optimization based technique for 3D haptic retargeting of complex shapes. From left to right, a) A user interacts with a tracked physical prop (a coffee mug) while wearing an HMD, b) the virtual view of the user, showing a tea cup and retargeted hand position, c) the outline of the hand shows its position in the physical world, and the transparent coffee mug shows the shape and position of the real physical prop super imposed over the user's view, d) a 2D example of our method which shows how space is warped to retarget a square to a circle and move the position and orientation of another rectangle. The blue vectors represent the direction and magnitude of the spatial warping.» (Zhao 2018):

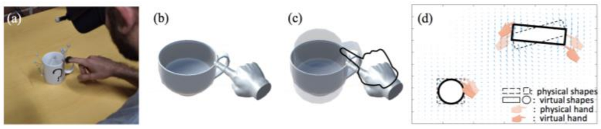

Figure 14: 3D haptic retargeting of complex shapes

Mismatching consequences are space warping and pseudo-haptic feedback, approached by the full 3D mapping of one or pairs of complex surfaces in 3D spaces – in a Newtonian world. Probably some of the above issues could be solved by recourse to Minkowki-Einsteinian space-time algorithms and avoid retargeting needs. More so due to the fact that the magnitude of the 3D spatial warping angle seems – just from an optical perspective – very similar to the 4D dynamic representation of wordline variances as in Figure 3.

Visual Dominance in Haptic experiences

When there is a conflict between an observers' sense of vision and touch, vision becomes dominant. In the experiences the users «preferred to think that the object was most similar to the distorted visual image, rather than the actual physical shape that they felt» – this is an issue that will have to be addressed via Brain Studies.

Mastering tactile interaction at close range is the first step to advance to more complex haptic interfaces – holograms, distant objects – in order to widen its applications in storytelling, gaming, cultural heritage, manufacturing, medical, and other industries.

CONCLUSION

The newest advances in Brain Studies and constellation areas are imposing a paradigm change in theory and practice, and affecting the concepts of man, space, human-space and human-computer interactions – to be updated and made more conform to a Minkowski-Einsteinian world.

The aim of this paper – a work in progress – was to hierarchize the principal issues to be addressed and establish some guidelines for future work.

The focus was on touch and haptic issues – probably the easiest of the 'senses' to be addressed in such a context. The dis-connections between gadget users and AR/VR have to be disentangled without human help or interference from the observer.

To solve mismatching and warping issues without the presence of the physical body of the Observer can contribute to the development of wide spread everyday use gadgets – from mobiles, oculus, prosthetic limbs or devices, i.e. – to probably future more complex applications spreading from cultural heritage tours, augmented training, to no-manned apparatus.

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