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ABSTRACT

Shaping both the environment and the embodiment of the users in that virtual world, VR offers designers and cognitive scientists the unprecedented potential to explore virtually a vast set of interactions between persons, and persons and their environment. By design, VR tools offer a formidable opportunity to revisit the links between body movement and lived experiences, and to experiment with them in a controlled, yet engaging and ecologically valid manner. In our multidisciplinary research-creation project we ask, How can we design (virtual) environments that specifically encourage interactions between multiple persons and that allow designers, scientists and participants (users or 'immersants') to explore the very process of interaction itself? Building on our combined experience with dance improvisation research and interactive virtual spatial design, we document a multi-user VR experience design approach we name Shared Diminished Reality (SDR), where immersants are co-present and able to move together while their bodies and the environment are represented in a minimalist way. Our working hypothesis is that non-anthropomorphic embodiment of oneself and one's partner(s) combined with open-ended exploration focus the attention of users on the quality of the interaction and encourages

playfulness and creativity. We present the Articulations VR platform and its design history, as well as design evaluations of SDR in a laboratory setting and through a mixed reality performance, interrogating the impact of our minimalist approach on user experience and on the quality of the interaction.

Keywords: copresence, dance improvisation, research-creation, multi-user experience design, enaction, non-anthropomorphic avatars, Virtual reality, mixed reality performance

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1 INTRODUCTION

The question of embodied interactions has emerged as a central theme in the cognitive sciences, robotics and related fields, extending older philosophical preoccupations. Philosophers from Bergson (1939) and Mearleau-Ponty (1945), to Noë (2012) and Manning (2009) have indeed insisted on the role of bodily actions in the construction of space and perception more generally. According to the enactive cognition stance, how we move in our environment and how we experience it as a world is a circular, co-constitutive process (Merleau-Ponty 1945; Varela et al. 1991). In other words, we realize the world by interacting with it and by realizing the world, we realize ourselves: we are present (Noë 2012 ; Manning 2009).

The recent and growing development of virtual reality (VR) tools allows us to design new lived worlds: to construct and visit new spaces, to try new practices and to interact with new contexts. Shaping both the environment and the embodiment of the users in that virtual world, VR offers designers and cognitive scientists the unprecedented potential to explore virtually a vast set of interactions between persons and their environment, new ways to be present to oneself, to the world and to others.

By design, VR tools offer a formidable opportunity to revisit the very link between body movement and lived experiences and to experiment with it in a controlled, yet engaging and ecologically valid manner. In this context of application, the design of the environment is usually under focus, allowing researchers to experiment with how subjects interact with the features of the virtual environment. Yet, a more recent focus in cognitive sciences research and experience design in VR (Greenwald et al. 2017 ; Wienrich et al. 2018) concerns the interaction between persons, giving a central role to relationality itself (De Jaegher et al. 2010, Laroche et al. 2014). Indeed, when the couplings between perception and action of two or more persons become intertwined, the dynamics of bodily interactions give rise to the experience of being ‘co-present’ (Froese et al. 2014a, Froese et al. 2014b). For Manning (2009), ‘relational movement’ (the way we move in relation with other bodies/selves) underlies our own sense of self (‘bodying’) and our being in the world (‘worlding’). By interacting and moving together, we participate in each other’s experiences and sense-making (De Jaegher and Di Paolo 2007). In other words, the way our lived experiences become meaningful and our world imbued with sense emerges from our active bodily encounters with our environment, and especially with others (McGann and De Jaegher 2009).

How can we design (virtual) environments that encourage interactions between multiple persons and that allow designers, scientists and participants (users or ‘immersants’) to explore the very process of interaction itself? A number of members of the research project previously addressed the formal study of open-ended interpersonal interaction by designing GIGs, an acronym for (in person) Group Improvisation Games. This consists in bringing groups of participants to explore their reciprocal interactions and to do so freely within a simple set of constraints (Himberg et al. 2018). How can VR support and contribute to the improvement of the methodological set-ups employed in this kind of research? And, in turn, how can this

line of research inform multi-person VR design? In this paper, we propose to use the tools of VR to control and manipulate the coupling between perception and joint action and thereby evoke differential affective experiences. For this purpose we propose a conceptual framework we name "shared diminished reality" (SDR). In this framework, inspired by the cross-perceptual paradigm (Auvray et al. 2009), immersants are co-present and able to move together but their bodies, and the environment are represented in a minimalist way. This allows the user to focus his/her attention on experiencing the interaction itself and allows the designers or scientists to track the core dynamics of the interactions between participants.

In order to present the SDR framework, we first review the potential of VR for the scientific and artistic research around movement and in particular relational movement, focusing specifically on what we consider minimalist designs. We will then turn to the interdisciplinary design and design-history of our shared VR platform (Articulations) which represents an attempt at instantiating SDR. In this paper, Articulations serves as both a theoretical object through which to reflect on SDR and an empirical testing ground of its art-science potential. In the second part of the paper we report two forms of design evaluation, one as cognitive science research (the 'laboratory installation') and the other in the 'practice as research' tradition (the 'research-creation installation').

1.1 Use of Virtual Reality for the study of the cognition of movement, presence and affect

The increase in computer graphic capacities and the rise of immersive technologies in recent years have brought about the conception of new tools for the in-depth observation, study, and manipulation of the mechanisms of bodying and worlding. VR provides the capability of creating custom experimental installations where the environment, our own appearance, and the presence or representation of others, can all evolve and adapt dynamically to (joint) behaviours while carefully controlling action-perception coupling parameters.

VR has seen its scientific use spread and is considered by now as "valid and highly ecological without compromising experimental control" (Loomis et al. 1999). It has been used in a wide variety of fields including psychology, anthropology, ergonomy, neurosciences, both as an experimental tool and as a therapeutic application (Okun 2017), particularly in the treatment of mental Illnesses (Wiederhold and Riva 2019 ; Freeman et al. 2017). It has been applied to the study of the psycho-affective dimensions of art and mediated communication (Quesnel et al. 2018), and in the exploration of social mechanisms at play during interaction, in particular the feeling of co-presence (Garnier et al. 2017).

Interestingly, one of the first experiments to validate the potential of VR as an experimental paradigm targeted body ownership (Slater et al. 2010). The "rubber hand illusion" experiment (Botvinick and Cohen 1998) has shown that visuotactile stimulation gives the illusion of embodiment with a substitute hand. Such embodiment techniques have been shown to result in the illusion of body ownership over the surrogate body – whether a physical manikin body (Petkova and Ehrsson 2008) or a virtual body (Slater et al. 2010). The very sense of self can be altered when inhabiting an artificial enveloppe. Numerous studies (Banakou et al. 2013 ; De la Peña et al. 2010 ; Kilteni et al. 2013 ; Lugrin et al. 2016 ; Peck et al. 2013) observed how users' virtual appearances can affect their thinking, feeling and acting. For example, Banakou et al. (2018) explored how switching between bodies can help the user to work on personal issues from an outside point of view. Yee and Bailenson (2007) provided evidence for what they named "Proteus Effect": how the participant avatar's appearance affects the participant's behaviour, during virtual experience but also following it. When it comes to social interaction in VR, Nowak and Biocca (2003) showed that the degree of empathy that immersants express for each other isn't correlated to the anthropomorphism of the avatars.

Rather, the willingness to contribute to a group task as well as the performances obtained, are more linked to visual similarities between participants and self-identification (Wallace and Maryott 2009 ; Van der Land et al. 2015). Anthropomorphism often leads to expectations that can't be met, while iconic representations may lead to more excitement (Nowak and Biocca 2003).

Along similar lines, anthropomorphic cues are not necessary for copresence to emerge. For example, Froese et al. (2014a, 2014b) used Lenay and colleagues' "cross-perceptual paradigm" (Auvray and Rohde 2012), where sensory information about the other is reduced to a very minimal representation: pairs of participants explore a one-dimensional space with their finger on which they received a tactile stimulation whenever an other entity (the partner, a lure following the partner at a constant distance, or a static object) was present in their receptive field. This minimal sensorimotor structure was sufficient enough to bring about collective dynamics between human partners participants. Indeed, Auvray et al. (2009) showed that even when participants could not consciously differentiate between the (responsive) partner and the (non-intentional and sensory deprived) lure, they were attracted by each other's movement so that they spent more time interacting with each other than with the lure (in other words, they found each other collectively before each could find the other). When participants were invited to cooperate to find each other and co-regulated their interaction, they were able to recognize the other during these minimal interactions, and the feeling tended to be mutual (Froese et al. 2014a, 2014b).

1.2 Minimalist immersion

VR can propose either a modelisation of the real world based on an environment which imitates or mirrors the real world, or the creation of an artificial environment which does not correspond to anything which exists (Fuchs et al. 2006). It almost always also reduces or diminishes the richness of perceptual information, by design or by the limitations of the current technology. We find that this potential of VR to reduce, simplify, prune or limit the perceptual field and the sensorimotor contingencies of the experiencer echoes a fundamental aspect of both art making and experimental science.

The tendency towards abstraction[1] and minimalism[2] is indeed one of the major characteristics of artistic practice in the 20th century and can be found in a variety of artistic fields and media, be it visual, sound, or movement arts (such as dance or theatre). Similarly, a basic property of any experimental apparatus is to abstract away multiple features of the real world in order to be able to isolate the effect of specific factors or their interactions. Learning from minimalist art and science making, we suggest that the reduction or simplification of sensory data in immersive VR is a design feature rather than a problem to overcome.

As an important emerging medium within the digital arts, VR challenges our perception of space, time, and self for narrative and esthetic purposes. Through the use of graphic enhancement and motion capture, numerous contributions in dance and other interactive art have explored, through abstraction, the materiality of bodies themselves. Bodies can appear as made of smoke, sand, dismembered or decomposed. In *"Ballet Rotoscope"* (Euphrate, 2011), the japanese collective decomposes the movement of a ballerina and alternatively replaces it by trails drawn by her hands, or by bounding boxes. In *"Co:lateral"* (Barros & Moura, 2016-2019) and *"Unnamed Sound Sculpture"* (Onformative, 2012), the body textures are made of shades, sparky particles and smoke, making the movement and the body limits blurrier. In *"CLINAMEN"* (Harcier, 2020), three dancers are composed of multiple spheres, moved by randomly placed movement trackers on their whole bodies. Bodies are mixing, making it harder to differentiate one from another. In

[1] See the artists, Vassily Kandinsky, Kasimir Malevitch, Robert Delaunay, Piet Mondrian

[2] See the artists, Frank Stella, Donald Judd, Carl Andre, Dan Flavin

these artworks, dancers' expressivity remains perceivable through the abstracted qualities of motion, and through their appropriation of space.

These experiences and artworks demonstrate how VR design choices impact the way we build our representation of the world. Digital paradigms can also affect our sense of self and allow one to play with the contours of otherness, and limits of human-like entities. In *"Body Remixer"* (Desnoyers-Stewart et al. 2020), several users see their own silhouettes displayed as particles on a wall, and a single user experiences the scene through a VR headset. In *"Your Place And Mine"* (Sra et al., 2018), the authors explore the idea of moving and dancing simultaneously in different locations, embodied into realistic human avatars. In *"Spheres, a Dance for Virtual Reality"*, Sarah Neville (2019) adds the idea of haptic connexion to others. A single participant interacts in VR with abstract silhouettes and some luminous spheres are connected to their hands. When they enter in contact, the participant feels a vibrating feedback from the controllers. Some VR platforms now allow multiple users to dance together with different levels of avatar realism (DanceVR, WaveVR, VRChat). While the user can only control the hands and head of the avatar (no foot tracking), the rest of the body is animated in either autonomously or in a concordance with the tracked members. Taken together, this corpus exemplifies that more than being a technical constraint, the idea of reducing the set of perceptive information coming from our own body and from social interaction offers new directions for inquiry and artistic creation.

Building on these ideas, in January 2019, we initiated the Articulations project, a collaboration between the virtual spaces design research group at the ENSADLab and the ICI project (Himberg et al. 2018) research group interested in the study of interaction through joint dance improvisation. The project led to several public presentations as well as the formalization of a concept that we call Shared Diminished Reality (SDR). We next discuss the platform and its design process, and then propose a formalization of SDR and two different evaluations of our approach.

2 THE ARTICULATIONS PLATFORM

2.1 The research creation process

Financed by the new ArTec graduate school (http://eur-artec.fr/), the Articulation project stands at the tangential point between the artistic and scientific practices, exploring what minimalistic body representation in VR can offer, both as an artistic material and a research tool. The initial idea of this research was to study interpersonal dynamics and emergence of autotelic creative behaviours through the abstracted representation of movement and bodies, made possible by the use of virtual reality.

The operating principle of the project was to foster a real-time innovation dynamic between the artists, the scientists and the designers through constant iteration between interface development and technological improvements. The process included in-group residencies and workshops, structured experimentations and performances open to the public.

In the three residencies that took place in 2019, we invited the team and various guests – artists, cognitivists, philosophers, anthropologists, designers – for a collaborative experience, letting everyone's domain of knowledge or practice influence the design process. Immersing ourselves in a shared virtual reality scene, we explored what seemed relevant, avoidable, and essential to let a playful sense of self emerge.
As questions and suggestions arose about the virtual surroundings and the form of the avatars, we took advantage of the quick editing capacity of VR, manipulating at will the reduced bodies and environment

Figure 1. On the left: Two participants testing the platform during the ENSAD public event.

Figure 2. On the right: Articulations team preparing the performance with two hip-hop dancers

appearances. Designing through experience, as well as through debriefing and sharing, we sought to reach a balance between shaping a comfortable visual experience, and keeping a relatively abstract scene that would let us explore how body diminution influenced our willingness to engage in the virtual relationship.

The creative residencies also allowed us to collectively formulate hypotheses we then tested more formally during a series of public sessions and open-ended aesthetic insights that led to the development of a VR-dance performance. Collectively, they led us to the development of the Articulations platform: a minimalist environment where subjects interact in a minimalist manner.

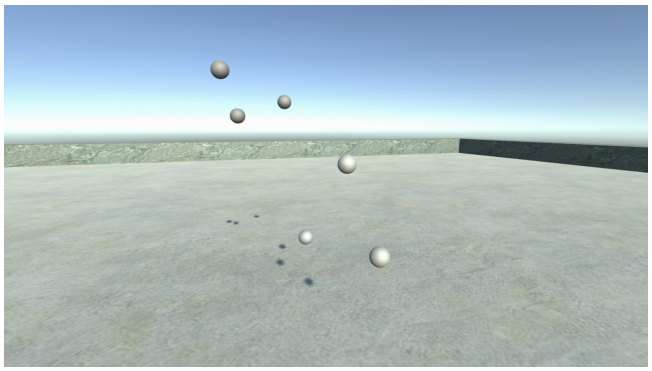

Figure 3. Third person point of view

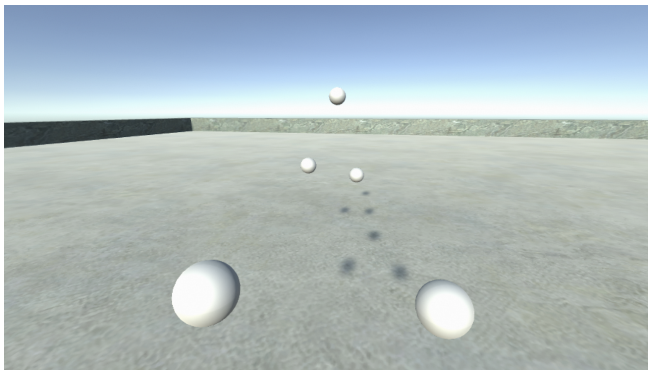

Figure 4. First person point of view

In this platform, participants are equipped with virtual reality helmets and two wrist trackers. Once immersed, they see two spheres representing their own hands that move in accordance with their movements. When the scenario is started, the other participant appears, consisting of three spheres representing the positions of their hands and head (Figure 3 & Figure 4). Several changes in the environment and the appearance of the participants can be automated or manually controlled by the team via an external interface.

The design goal was to play with the perception of oneself, of the other, or of movement itself, in time and space and how such changes influence the feeling of being independent or the sense of togetherness. Considering the research on Proteus effect (Yee and Bailenson 2007) and how avatar representation can influence how users behave, spheres were chosen as the embodiment shapes. Through our own experience

we believed that this design simplicity would allow our users to approach the experience with a fresher and more "neutral" state of mind.

The virtual environment itself was chosen to provide a good balance between minimalism and comforting surroundings. The wide blue sky, the natural-like lighting and the marble floor offer something rich enough to arouse the desire and confidence to explore while focusing the user's attention on the interaction with the other or with the behaviour of one's avatar. At times during the experience, participants see their appearances or that of the environment change: an addition of a mirror (Figure 5), differentiating the colours of the participants' spheres (Figure 6), making them invisible, replacing them with particle systems whose behaviour changes according to movement qualities, or more abstract forms.

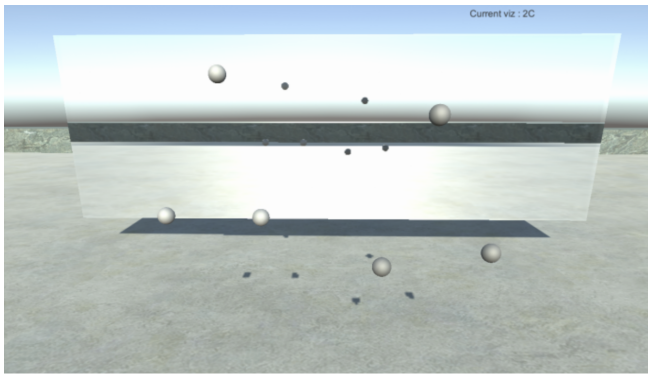

Figure 5. General point of view of the mirror condition with similar colors

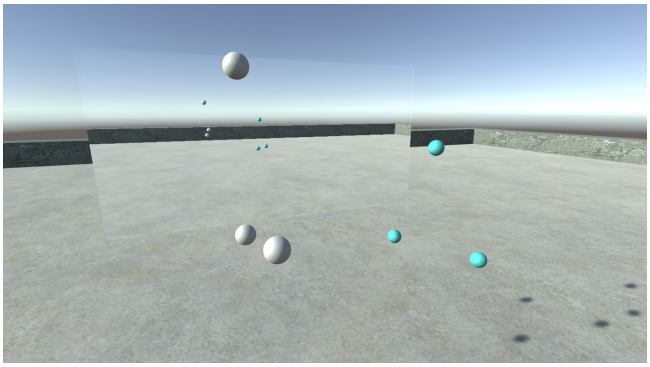

Figure 6. Third person point of view of the mirror condition with different colors

2.2 Design Details

In terms of software, the Articulations project provides a multiuser virtual platform, with a networked client server architecture (Figure 7), all developed using the Unity3D platform .

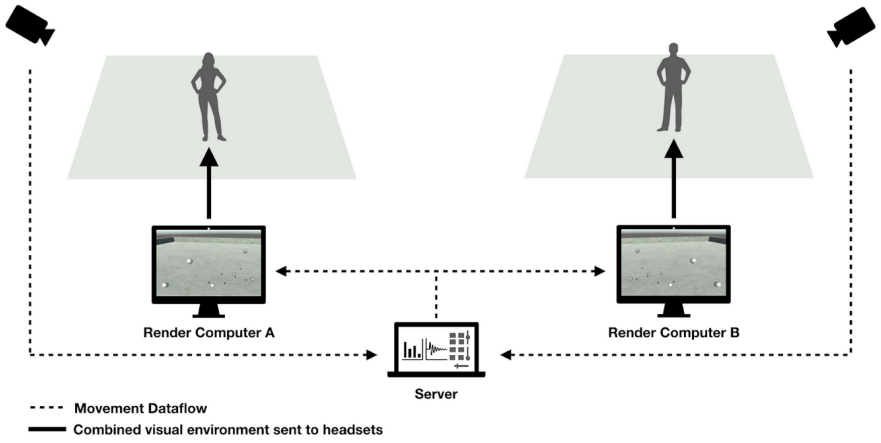

Figure 7. Illustration of the Articulations basic technical setup. Additional 'viewer' devices can be connected to the server.

For the first exploratory phase of the development, additional tools, plugins and frameworks provided by the Unity 3D community were used. This allowed us to quickly prototype a server client architecture

of a virtual multiuser environment. This first version was developed in order to conduct experiential sessions during the team's first residency, which took place in Meriel, France, in May 2019. This prototype allowed for up to four users, using the HTC Vive, to be simultaneously immersed inside the same virtual environment (VE) through a network of clients.

Each user was represented with three spheres, initially two of the same size for the hands and one third, bigger, for the head. The larger head sphere integrated a black rectangular shape where the user's face would be, in order to indicate the head's orientation. The hand spheres were driven by the Vive controllers. The goal of these sessions was to experiment with the appearance of the avatar, as well as to better define the needs in terms of environment and interaction design. During the residency, interdisciplinary discussions led to eliminating the difference between the spheres so the head and the hands were the same size and no head orientation was shown. This minimalism decreased the anthropomorphism and seemed to increase the playfulness of the encounters. Based on feedback from the Meriel residency, the second phase of the project was launched. It was decided to opt for a custom developed OSC based client/server system[3], which would allow us to better handle the connections and the interactions implemented, and also render our platform independent from third party developers. This is of great importance, as Articulations is a research project and parts of it are intended to be eventually made open source, so that other researchers can further contribute to its evolution.

The architecture allows for a single server to host multiple clients which are assigned roles. The two main clients are the immersed participants while other clients can connect, assigned the role of a viewpoint. The server handles the evolution of the VE and the multiple conditions that are implemented in the form of scenarios. The server is in charge of creating data files to store all the information during each session, such as date and time, the conditions used, the duration, as well as the position and rotation of all the tracked body parts of each client.

A separate interface was designed for the viewpoint clients, which allows them to either mirror the viewpoint of one of the main clients, or manipulate a virtual camera to navigate the VE. A viewpoint client cannot alter the session and is not visible by the main clients. The view point client (Figure 8) was conceived for three potential purposes: having a rendition of the virtual scene projected on a screen, in order to give the audience a third person point of view; tracking an external tablet that would serve as a virtual camera with the possibility to move freely into the physical space; and allowing participants to do a post-experiment re-viewing and commentary of their performance.

The environment can evolve on demand: from a minimalist arena to a dance studio, or to more artistic landscapes. The ambient light, symbolized by a sun, can go from deep night to full daylight, its intensity varying according to the time of day chosen. A mirror (an optional feature that played an important role in our experimentations) allows participants to see what they look like and how their movements appear (both individually and as an ensemble).

A critical aspect of the installation design, whose importance we came to appreciate more fully through experimentation, is the mapping between the physical and virtual localisation of the two movers in space.

In the first prototype we developed (on the left in Figure 9) the physical action space and virtual space were superposed. This choice was motivated both by an implicit heuristic of the research team to maximize

[3] We chose OSC as it is a widely used protocol in the field of digital art, making it easy to handle data exchange even for non-expert coders and artists. Furthermore, the whole data encapsulation system is pretty simple and straightforward, making it simpler to build a customizable and flexible networking system.

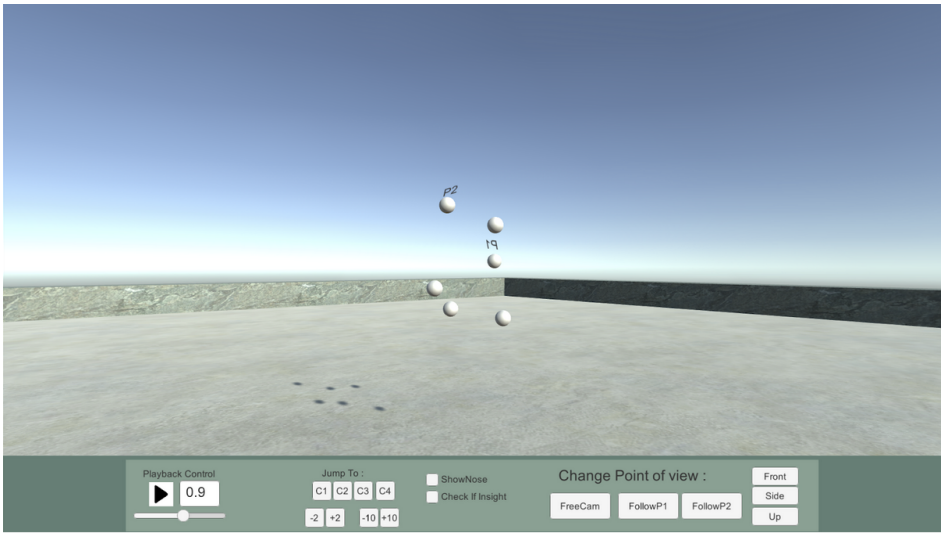

Figure 8. The user interface named as the "Viewer", where one can watch a live or past performance from a third point of view

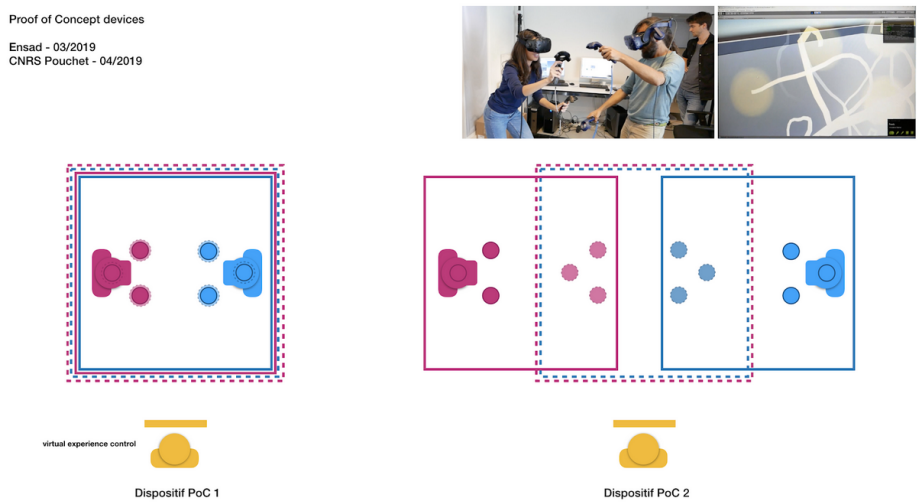

Figure 9. First platform proof of concept, with shared (left) and separate (right) physical spaces

the overlap between the virtual and physical interaction and technical limits of the tracking devices. The size of the virtual space and the location of the avatars in it were identical to the physical space (participants could physically touch each other) and so the participants were offered a partially coherent visual, tactile and auditory experience. However, since the avatars only represented 3 points on the body, the rest of the body was invisible (partially dematerialized), generating surprising (and potentially dangerous) collisions in the physical space.

For technical reasons (helmet cables getting intertwined) and to avoid recurring collisions between the subjects, it was decided to separate the respective positions of the participants, distancing them from one other physically, while keeping a face-to-face position in the virtual visual space (on the right in Figure 9). The new arrangement thus produced a different mapping between visual, haptic and auditory feedback. The body of the other was visually dematerialized. This dematerialization was confirmed by the absence of haptic contact. The distancing attenuated auditory cues from the partner, which also reduced and altered the verbal interactions.

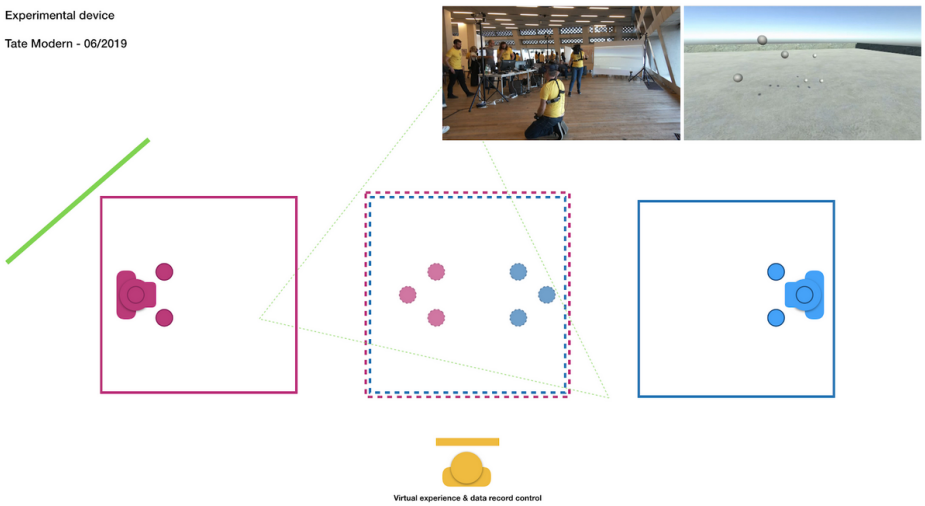

Figure 10. Spatial configuration used during the workshop at the Tate Modern in June 2019. The green triangle represents the viewpoint of the camera projecting a 2D representation of the experience on a screen (the green bar).

For the public event that took place in the Tate modern museum in June 2019, we made use of the wireless vive set-up for the first time. This setup allowed for lighter and freer movements by the participants but required total separation of their physical positions (Figure 10). The total decoupling of the visual spheres from the physical position of the partner's body prevented many participants (naive regarding the workings of the platform) from making the connection between their physical partner and the 3-sphere avatar. Similarly, for an outside observer it became harder if not impossible to 'read' the mapping between the physical and virtual interactions. The same spatial configuration was later used for an experimental session in the Pouchet CNRS center in Paris.

3 SHARED DIMINISHED REALITY

Through our research-creation process, we found that dissolving (the experience of) humanness by minimizing the visual perception of one's self and one's partners seemed to enhance creativity and expressivity flow.
Deprived of most usual communication clues and with diminished environmental distraction, participants dynamically engaged in responsive interaction, and deployed rich ingenuity in creating a shared vocabulary through abstract movement. In line with Heider & Simmel (1944) and Lenay's group (Auvray et al. 2009 ; Deschamps et al. 2012), we observed how simple objects in movement can convey emotion, and be the basic building blocks of a relationship as long as we find in the moving object a sense of "otherness". From an experience design perspective and in dialogue with cognitive science, art performance, anthropology and sociology, we would like now to summarize how these observations address the design research field, by formalizing them into a more general concept that addresses inter-relational dynamics through abstraction in VR. We call it Shared Diminished Reality (SDR), recognizing that shared VR requires only minimal design features, and this may be ideal in foregrounding interactive copresence in a shared space.

As we discussed above, VR always diminishes the users' experience of their own body and the environment. By removing their bodies, we, as designers, modify their bodying experience with the world, and therefore their sense of being and presence. The SDR perspective builds on this fundamental aspect of VR to explore new paradigms of interaction at the frontiers of humanness and relationship

by tweaking bodily appearances and expressive channels. New behaviours emerge through these virtual interactions, with which users compose relations and experiences.

Virtual bodying is afforded/possible as long as users are able to easily feel present. Sense of presence, as a concordance of senses of agency, self-location, and body-ownership (Kilteni et al. 2012), may be reached as long as the virtual world's rules are understood and integrated. In a Diminished Reality design, one aims at offering the minimal set of information allowing for rapid and intuitive self-location and self-motion perception (Lopez et al. 2015). However, the affordances of the environment (what one can do or how one can interact with it) should be minimized. The proximal or action space of the user should remain purposefully empty. When alone in the diminished environment, after a few seconds of uncertainty, the user has 'figured out' their location and organization in space. However, when Diminished Reality is *"shared"*, body-ownership, agency and ultimately the sense of presence emerge through interaction with another. Making Sense (of self and the world) becomes inherently relational, fostering the necessity to engage with the other. The user's (re)actions create differences that are used dynamically as affordances for the sense making by the other (De Jaegher and Di Paolo 2007 ; Kimmel et al. 2018).

SDR is therefore a framework for designing multi-user experiences, where the main goal is to find the right balance between removing as many bodily and environmental affordances as possible while providing the minimum needed to allow a sense of (co)presence, expressivity, and interaction. We consider that balance as central in shared VR, and decisive to give our users a space to let (collective) creative flow happen (Csikszentmihalyi 1997). SDR proposes to shape the channel of interaction so to make the (shared) sensory-motor loop lighter and more transparent to the users and researchers.

In Articulations, our goal was to focus on the observation of shared movement and emergence of collective creative flow. In phase with the enactive literature and priming effects that are operant also in the virtual, the world was carefully shaped with a naturalistic open sky and a vast floor, showing clearly that nothing in the global environment had to be figured out. Making use of smooth spheres as avatars, the bodies remained minimized to very basic information. We invited the users to freely explore the environment. There was no 'task' or goal to be accomplished, leaving the users to (co)create their own experience. Finally, to minimize the presence of technology, we chose to replace the cable with a Wifi adapter, and the controllers with trackers placed on their wrists. That gave our users the ability to move into the scene with less attention regarding the hardware and keeping their hands free, concentrating on inhabiting the interactional scenario. Everything was designed to keep the focus on movement relationalities.

4 EVALUATION

The Articulations experience has been created through interdisciplinary innovation. A critical component in such a process is the (collective) evaluation of 'working hypotheses' regarding the effect of certain parameters on user/'in-world' experience leading to design choices. Design evaluation is in reality an ongoing dimension of the design process itself. However, in a design research process there are 'major' moments where intuitions, ideas, observations or accidents/surprises that emerged during the design process inform a more formal evaluation step. We present this evaluation step of the platform and the SDR framework it embodies two distinct epistemological forms:

- A "laboratory" installation for movement interaction studies: An installation that takes the form of a laboratory experiment, allowing us to collect both real time kinetic data and post-experience subjective reports. The installation is used to test specific hypotheses or answer specific questions. Below we briefly discuss an experiment that used kinetic data to test our hypothesis that reduced visual feedback of one's

own body increases interpersonal coordination. We will then turn to the analysis of user reports in order to evaluate whether SDR design brings about a creative attitude in participants, a meaningful relational experience between them, and the experiential effects of the minimalist body representation, minimalist decor and open-ended scenario/invitation.

- A ”research-creation” installation that made use of a performative form, based on the dematerialization of bodies in dance. Research creation evaluates a proposition in terms of whether it continually generates new questions. Through the creation process that we report here, new questions emerged about the potential of the hybrid virtual-physical space as ‘mixed reality’.

Below we discuss these two forms separately. However, it is important to keep in mind that in practice the different installations are not separate but interwoven and interconnected.

4.1 The Laboratory installation.

One of the original motivations for the Articulations project was the creation of a VR framework that allows for an ecological but controlled study of movement interactions. In this section, we first present a brief summary of an experiment reported elsewhere (Laroche et al., under review) to show how our platform can bring forth meaningful data on relational movement. Then, we report qualitative evaluation of user experience in SDR based on analysis of questionnaire and interview data..

To evaluate the potential of SDR as a fruitful context for the acquisition and the quantification of movement interactions data, we organized a number of public sessions that were conceived as ecological laboratory experiments making use of the Articulations platform. Participants were invited to explore the Articulations world in dyads (as described above). In the spirit of SDR design, there was no task or goal beyond autotelic exporation. The presence of a second participant in the virtual environment was not made explicit before the experience. As we mentioned earlier, one of the consequences of the reinforced dematerialization of the bodies through spatial dislocation, was that, if they were not warned, the participants did not immediately know the other spheres to be the physical partner. Without the ability to use voice, facial expression, limbs, fingers, or even orientation of the spheres as communication cues, participants needed to invent gestural strategies to dynamically figure out what relational situation they were in, and to potentially realize that another human inhabited the other spheres. In any case, this situation entailed a very playful exploration.

To evaluate how the design of the installation contributed to the movement dynamics and their associated experiences, we introduced slight design variations (e.g. the suppression of the visual feedback of the spheres representing one’s own hands) across the experiential sessions. Each session (lasting between 10 and 15 min) was thus composed by one baseline block and 2 to 3 blocks each introducing a different kind of variation. To analyze the gestural strategies deployed by the participants, we tracked and synchronously recorded the position of the 2x3 spheres at a rather high resolution (60 samples per second). This allowed us to analyze the entire trajectory of the spheres in the 3D space, and from there we were able to derive a number of kinematic features, such as the pace or intensity of movements, as well as their similarity across partners for instance. To explore the associated experiences of participants and see if they were related to kinematic features, we used questionnaires and interviews.

The kinematic study, performed in the Tate modern gallery in June 2019, provided interesting results (Laroche et al., under review). For instance, suppressing the visual feedback of one’s own hands increased the actual coordination of hands across partners, as if the lack of self-feedback prompted attention toward the coupling with the partner’s movements. By relating kinematic features to the experiential questionnaires,

we also observed that when the two partners moved more slowly and similarly in space, this correlated with their mutual feelings of closeness, particularly when they were unable to see their own hands in the virtual world. In short, the installation proved useful in revealing how changing the visual feedback leads to contrasting movement patterns and induces different qualities of experience that post-hoc questionnaires were able to probe (for more details, see Laroche et al., under review). More generally, the meaningful patterns uncovered by the experimentation demonstrate the usability and interest of SDR design for experimentation in socio-affective cognitive science.

We now turn to the experiential reports relating to how the SDR design was experienced by the users. The protocol and the observations described below come from a second experimental session (October 2019) performed in the Pouchet CNRS center in Paris. After each dyad completed their 12 minutes of improvisation (similar to the protocol used in the Tate) we proceeded to solicit their experiential reports in 3 stages. First, a pre-recorded message, played through the headset's headphones, prompted participants to verbally report their feelings while still navigating the same virtual environment with their own avatar, yet in absence of their partner's. They were asked to report their experience of the moment, as well as the changes they notice compared to the beginning of the experience, or anything else they wanted to share about the experience itself. After the headsets were taken off, the participants were accompanied to a small room where they completed a questionnaire (individually). The questionnaire was composed of a quantitative section (the participant was asked to indicate their adherence to 26 different assertions regarding the experience: from 0: not at all to 6: strongly adhering), and a section with open questions allowing for personal elaboration. Once the questionnaires were completed the two participants were interviewed, together, by two team members (an anthropologist and a psychologist) following a semi-structured protocol.

The choice and wording of assertions was grounded in reports collected from the users of the installation during the previous experimentations and collective retreats. Reviewing the answers to the questionnaires and the transcripts of the conversations from these earlier events, we identified statements that addressed one particular aspect of the personal experience. We extracted those representative of or similar to the other statements and those prototypical to the categories of the experience most relevant to our research interest (relational movement, bodying, immersion). Importantly, we formulated the questionnaire by staying as loyal as possible to the wording from the first-person experiences, reformulating them only when in need to precise, clarify or stylistically adjust the language. Adhering to the verbal descriptions provided by the participants themselves was fundamental to keep away from our abstractions and expectations and to address the subjective experiences directly.

The 26 assertions in the questionnaire could be split into 3 overlapping categories (Table 1). (i) assertions regarding the virtual environment and the degree of engagement in the experience (ex: 'I found the virtual space silent and seductive'), (ii) assertions regarding the participants' experience of their own body and movement (ex: 'I had a pleasant sense of lightness'), (iii) assertions regarding the relationship to the other avatar/participant (ex: 'my movements were motivated by what I thought the other person could see'). 6 of the assertions focused on the specific modulations introduced during the experience (ex: 'I did not pay attention to the reflection of our movements in the mirror'). The list of assertions was composed of positive and negative formulations and of evaluations associated with positive and negative valence). The ratings of the 6 assertions regarding the specific modulations were used as factors in the analysis of the quantitative date (Laroche et al., under review). Here we will focus on the rating of the assertions concerning the globality of the experience, proceeding by category. For each category we will point out assertions on which there was a relative agreement across participants (defined as a mean score higher than 3.5 or lower

than 2.5, with standard deviation lower than 2, cf highlighted rows in Table 1) and will provide related qualitative statements produced by participants during the monologue or interviews.

4.1.1 The virtual environment and the degree of engagement

Overall, participants found that the minimal aspect of the virtual environment was inviting (A9 m=4.48, sd=1.47) and enhanced their curiosity and creativity (A23, m=4.38, sd=1.6). Overall, the immersion experience was not disturbed by elements of the 'real world' (A11, m=1.55, sd=1.23). The absence of a pre-specified goal or instructions regarding 'what to do' did not hinder the experience (A32, m=1.79, sd=1.83). In the interviews, the term "silence" and the minimal aspect of the design came up a number of times:

"The silence was so deep that I could imagine wind just in my head, moving my hair, probably it was by hearing my own breathing." (P30)

"The fact that the environment was so minimalist allowed me to avoid parasitic variables to the experience so in my mind there is nothing to add." (P11)

Several participants shared that the experience produced a 'sensation of freedom' (P36, P43). Being immersed and totally engaged with the experience, participants had a sense that time was slowing down:

"Time seemed to pass much more slowly, I was thinking of nothing but the problem of the "spheres" in front of me." (P23)

Immersion in the experience could be so strong as to attenuate participants' interoceptive awareness:

"the feelings of the heat and exhaustion I accumulated while moving in this machine-heated room came to my awareness only at the moment I took off the headset." (P23)

This last comment highlights how VR immersion can have a powerful impact on one's experience of their own body and movement. A theme we turn to next.

4.1.2 The experience of one's body and movement

In the questionnaire, participants reported a sensation of lightness (A34, m=4.28, sd=1.56), once again suggesting an important impact of the immersive VR experience on their interoceptive and kinesthetic awareness and body image. This theme appeared also in the interviews:

"I still remember the first 20 seconds when I was learning to use the space, to use the absence of my 'body' and the transition in which I become immaterial. This condition is a bit weird, because I felt myself closer to the ground than I used to be." (P30)

One participant related this sense of lightness, or absence of a relationship to the floor (gravity), to a more fluid experience of their movement:

"No connection to the ground, allowing for a more fluid movement." (P29)

The impact of visual deprivation on the sense of weight also came up with respect to the scenario where the participant's own 'hands' were invisible to them:

"I did not feel the gravity of my hands." (P29) The minimal visual body representation heightened the kinesthetic quality of self awareness:

"My body mass didn't exist, only my movement." (P43)

"The opening of my movements towards a space that is larger, a more elastic feeling and warmth, a kind of inner energy." (P20)

Our questionnaires did not contain assertions concerning transformation or alteration of self-identity but in the interview this theme came up regularly:

"I understand myself better, it is clearer." (P52)

"I adopted and accepted the idea of being just 3 balloons, and I decided to feel myself fragmented." (P30)

"It is an experience that has awakened in me completely new sensations and emotions in relation to my body and its movements and its relationship to others." (P44)

As the last quote suggests, the experience of one's body and one's movement was intrinsically intertwined with the presence and experience of the 'other' (spheres of partner), or the relationship. We turn to the relational dimension of the experience next.

4.1.3 The experience of the relation

It is interesting to note that most participants were not immediately aware that the 'other' three spheres in the virtual environment were the avatars of their physical partner. Some realized this only when the mirror appeared, some only towards the end of the experience and some only during the interview. Despite this fact, participants did report an important positive impact of the other spheres and the relationship with them on their experience. Participants overall agreed with the assertion that the presence of the other amplified their movements and creativity (A22, m=3.7, sd=1.8).
In the interviews, a variety of relational experiences were shared:

"Here, I discover this great satisfaction of being followed or chased around. This is the main thing that I learned about myself." (P47)

"This 'innocence' makes me say (to myself), be careful, in your relationships, be vigilant." (P13)

"[I found out] That I'm a very solitary person because I didn't notice the movement of my partner and I was happy being on my own." (P27)

"I took it as a game, where the balls ask me for things I have to give, and then I realized it was the other." (P31)

For some, the minimal body representation of the partner limited their ability to 'read' them and interact:

"It is very difficult to interpret the behavior and intentions of the other subject only through the movement of the three spheres." (P15)

"It is by the direct experience of a body that I can represent it independently of any other virtual parameter (space, volume, temporality, movement)." (P46)

For others, the absence of self visual feedback enhanced the interaction:

"When losing our spheres, we feel like we have fewer gestural options, we are kind of more obliged to follow the other." (P37)

"When i no longer see my spheres, there is a shift from global attention and awareness towards the other [person] " (P37)

Overall, the combined feedback from the questionnaires and interviews suggests that participants were immersed in, receptive to, and inspired by the minimalist design of the environment. This extends to

the 'minimalist' design of the scenarios. The absence of a specific goal, explicit task or instructions of 'what to do' did not inhibit the movement or creativity of the participants but actually enhanced it. While the minimalist avatars made it more difficult for some to interact with their partners, they did alter body perception in interesting and novel ways, destabilized perceptual 'habits' and increased awareness to one's own movement and to that of the partner. In particular, many participants did not recognize the avatars as their human partners at least for some of the experience, and as a consequence could experiment relationality outside the habitual social sphere. Importantly, we found that the relation had an impact on the experience of the virtual environment in a subtle but significant way.[4]

4.2 A research-creation installation

As a research creation project, Articulations focuses on the collaboration between artists and scientists as a means of discovering new questions pertinent to each of them. For scientists this means learning how, e.g., dancers engage with and explore the embodiment potential of VR in ways that scientists and most pedestrian participants do not (the latter are more semiotic/signaling in their practice) - leading to the creation of new forms of measurement (Deleuze and Guattari 1994). At the same time, artists explore platforms like Articulations in order to develop new practices of artistic expression, including designing new sensations, through the creation of artworks. The collaborative participatory design brings about the creation of new concepts that answer these emergent questions.

In the process of designing a performative version of the Articulations project we proposed to two performers and a choreographer to explore the possibilities offered by this new paradigm, in search of new forms of mediation and gestural creations through the dematerialization of bodies. The resulting performance was presented to the public twice, once during the Artec "portes ouvertes" presentation in the Center of Arts at Enghien-les-bains and the second time alongside of other performances presented in the scope of the "Virtual Creativity, Collective Realities" symposium which took place in the ENSAD in Paris.

As previously stated, our research and design processes included three interdisciplinary workshops as well as three residencies that nourished both the theoretical and artistic approaches to the Articulations platform. Some of these sessions included the participation of several guests who were affiliated with dancing in various ways, either as dancers themselves or as practitioners of other movement or dance related activities. It soon became clear to our research team that people with such a background not only perceive and experience the platform in another way, but also reveal a certain performative aspect to those who are observing them. Thus, the idea of creating a spectacular form of the platform through a performance emerged.

One of the values of the design process of a performance is that the artists push the scientific researchers to test the limits of the platform, while co-creating vocabulary for interaction for the various forms of engagement proposed by the platform. We came to realize that it is often these performative aspects of the platform itself, revealed through this process, that not only help guide platform innovations, but also create a common vocabulary between observers/researchers and the dancers/immersants. This allows for both scientific research design and performative design to converge towards a research-through-creation procedure, based on an ongoing interdisciplinary dialogue that ensures clarity for those members of the team unfamiliar with either design perspective.

[4] With respect to the concept of 'shared VR', one subtle but important finding in the analysis of the questionnaire regards the interdependence between one's experience of the virtual environment and the dyad. We looked for assertions for which the responses of the two partners correlated significantly. We found that that was the case for one assertion: "I found this minimalist and silent environment inviting" ($r=3.27$, $p=0.032$). A possible interpretation of this correlation is that one's experience of the virtual environment was affected by and/or affecting the experience of her partner.

Figure 11. Picture from the ENSAD Performance in Paris

The collaborative conception and design processes with the team and other researchers helped fuel ideas concerning the possibilities of the setup and interactions, as well as having feedback as to what they were seeing and sensing when watching the others in immersion. These experiences informed how we imagined the audience would react as the performance unfolded and how to best frame the actions so that they would best be perceived by the audience.

One important goal was conceiving a performance that was engaging, personable, accessible and that reduced the sense of distance that can occur due to barriers imposed by the elaborate technological setup. This was tackled through creating an experience that would be both entertaining and reveal the inner workings of our research.

Two of the performers, whose practice is based in hip-hop movement language, were outfitted with virtual reality headsets. They conversed at the beginning of the performance as if they were discovering the virtual environment and the possibilities of moving within it. This sort of low-key discussion invites the audience to understand the actions happening on stage and observe the performers and the setup without fear of a reciprocated gaze. The choreographic language was a mix of hip-hop and contemporary dance that moved in and out of unison movement accompanied by custom created music. In addition, we needed to decide the order of the execution and the effects that would be present in the video projection, while making sure this setup would work as a meaningful whole.

One fundamental difference in experiential design between the ”laboratory” installation and the ”research-creation” installation was that in the latter the audience had to be able to perceive the virtual space shared by the dancers and understand their actions and choices. The virtual reality experience had to become a mixed reality experience. Whereas in the ”laboratory” installation this virtual space was only addressed to the performer and therefore had no need to be perceived in the physical space, in the ”research-creation” installation it was essential to materialize their presence on stage for the audience.

Since the Articulations platform was originally conceived and developed to immerse participants inside a virtual environment, using it in the context of a public performance presented a number of challenges at many levels: technically, visually, scenographically and dramaturgically. Both the choreography

and the performance were then conceived in a way to address these challenges and produce a shared experience between immersants and audience. The technical platform itself was modified in order to present the performers executing choreography in the physical space, while sharing feedback from the virtual environment with the spectators, transforming their virtual experience into a shared one, by projecting the virtual world inside the performance's physical space.

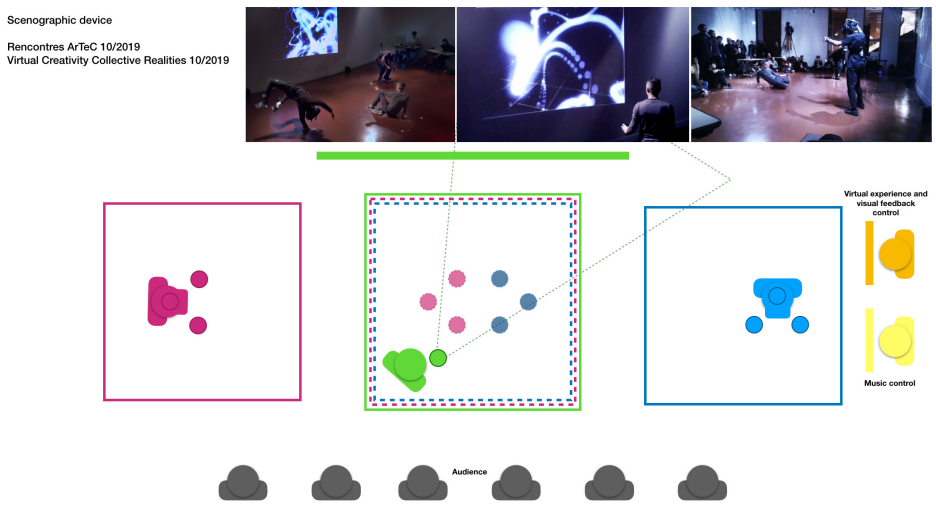

Figure 12. Research creation installation - The red and blue zones are the action spaces of the two dancers, whereas the green zone is the Mixed reality space - the mediator's action space superimposed on the virtual space merging the presence of the dancers.

Through the evolution of the platform's design the physical spaces of the participants became non-overlapping. In the first version, the participants could physically touch and collide (Figure 9). In the more advanced versions of the design (Figure 10, Figure 12), each of the dancers occupied a separate physical space. The physical space in between the spaces of each dancer (see Figure 12 - green square) persisted however as a fictitious interaction zone.

An important innovation that emerged through the collaborative process was the turning of this fictitious space into a mixed reality zone inhabited by the virtual presence of the two dancers and the physical presence of a third performer, a mediator embodied by the choreographer who was not wearing a headset, and who served as a bridge between spectator and performance space. In the version depicted in figure 6, the fictitious zone was geometrically located halfway between the zones of the two dancers. We realized this virtual space would remain an abstraction for the audience if it was not actualized by a presence on stage (Figure 12 - green figure). Thus, a "mediator" was necessary to make the link between these two realities: that of the real bodies of the two dancers on stage, and that of their fusional and dematerialized presence in the virtual space.

Working closely together with the choreographer, the designers added the ability to use a tracked VR sensor coupled with a virtual camera, as part of the performance, in which the mediator could simultaneously be on stage as a participant "filming" the avatars of the immersed performers and their interactions inside the virtual environment. The camera's output was then projected live on a screen behind the performers, directing the gaze of the audience to the performers movements in the live space, to their virtual interactions and to the emerging relationalities in space/time. At the same time, the mediator used light touch to provide the two immersed dancers a link to the physical reality.

This mixed-reality shared experience is formed by multiple elements deriving from different dimensions, the physical space that includes the performers and the public, and the virtual environment that is being actualized through the performers' gestures and interactions. Rather than conceiving the virtual and the physical as two discrete realities the mediator's presence turns them into a "continuum" along which he seamlessly moves to provide glimpses of the events happening in another dimension.

The notion of the continuum finds its origin in the work of Paul Milgram and his research team (Milgram and Kishino 1994). In their work, they introduced the concept of the reality-virtuality continuum. They proposed the concept of a virtuality continuum in the context of visual displays, but their ideas have since been adopted and extended to fit all domains of research around virtual and mixed reality, whether scientific or artistic (Georgakopoulou et al. 2019).

In their publication "Enabling a continuum of virtual environment experiences", Davis et al. (2003), inspired by Lewis Carroll's book, *"Alice's Adventures in Wonderland"*, attempt to extend the concept of the continuum. They are referring to the story as a metaphor for moving through various dimensions of reality. At the beginning of the story Alice meets the White Rabbit, a creature from another dimension. At this point, they propose, the rabbit is part of Alice's reality and at the same time it doesn't belong there, thus augmenting her reality. We argue that in fact, the rabbit is very much part of Alice's reality as well as part of another reality. He is able to inhabit and seamlessly move through the different dimensions.

The rabbit then acts as an interface, an inter-mediate, guiding Alice through immersion. Their meeting is a key point to the story, as it marks the moment where her reality becomes augmented by the presence of an element of another reality. Much in the same way in our case, during the performance, the third performer becomes the White Rabbit, assuming the role of a mediator between the multiple dimensions, while his presence augments the audience's reality.

In continuing the development of the performance, a new choreographic score based on feedback accumulated during the interviews and exchange sessions with the participants would be created. The score would unveil the various experiences as well as the underworkings of the process, and would embody and reflect the sensations and observations of the various participants. In addition, working together with a cast of dancers versed in improvised dance and somatic practices would add a dimension to the project that ties the performance and the research more closely together. The question of mixed reality and the white rabbit concept that emerged through the creation process has become a (scientific) research question that will be addressed in our upcoming research workshop in 2021.

5 CONCLUSION

The recent emergence of VR has challenged designers to conceive enjoyable and satisfying experiences of free, creative joint exploration. Interacting in space through movement offers new paradigms for interaction design. In this article we proposed the notion of Shared Diminished Reality as a design guideline for such development and presented a concrete project (Articulations) that instantiates this approach. Through our work on Articulations we observed how letting abstracted bodies move and interact in a minimal environment without a predefined goal can result in the creation of singular and intimate expressive patterns.

The design of the platform was carried out by the iteration of experiments: collective embodied hypothesis generation, prototype design, and experiential evaluation. A good example of the potential of this approach is the evolving mapping between the physical and virtual spaces. In the original design, bodies were partially dematerialized (only certain body parts were co-localized with the avatar). We then found that it was necessary to create a physical distance between users to avoid collisions between the parts of the

user's physical bodies not visible in the experience. Furthermore the partial dematerialization produced a strange sense of incoherence between the virtual physical copresence. The distancing resulted in a full dematerialization of the haptic presence of the other body during the VR experiment and a liberation of the users' gestures and imagination. The distancing of the subjects has also de-anthropomorphized the experience of the 'other', as they are no longer a priori aware that they are in the presence of the representation of another person.

The effect of de-anthropomorphizing was evaluated using movement quantification, and experiential reports as well as the mapping between them. In turn, the resulting mixed space (empty physical space inhabited by virtual movement) inspired the scenographic and dramaturgique development of a live-audience performance. Analysis of the kinetic data (Laroche et al under review) provides additional evidence for the impact of diminished reality on behavior. These results also point to the more general potential of SDR for scientific research on interaction.

In the post-experience questionnaires and interviews, participants reported finding the simplicity of the virtual environment calming, appealing, freeing, curiosity inducing, and socially creative. They were moving and co-creating their own interactional rules, even though the nature of the 'other' spheres was not alway clear as to whether it was human or digitally generated. The user's usual sense of self was altered by the minimalism of their own appearance while their visual similarity fostered a social encounter that made them improvise together.

Future studies by us and others should examine how these minimalist interactions reveal humans as storytellers, whose emergent behavior is not just connected to their perception but are connected to the stories they are telling themselves about what is happening. These can be seen in our initial interviews to co-shape their self and environmental understandings, suggesting the deep flexibility of cognitive mechanisms that may be missed in less open-ended experimental arrangements.
The participants' behavior and post-experience reports regarding their interaction with the minimalist design can inspire new forms of interfaces and virtual agents. By carefully attending to relational movement, immersive experiences can become more social, but without the overdetermination of typical anthropomorphic avatars.
In the Performative installation, the physical distancing allowed the dancers to explore new choreographic forms playing on the entanglement and fusion of dematerialized bodies in the VR space.
The dancers' distancing also had an effect on the scenography, creating a median space locating the virtual reality zone on the stage. This zone, inhabited and actualized by the choreographer, transformed the VR experience into a mixed reality experience for the spectators and dancers. The choreographer's role then became that of a mediator, an active passer between the virtual experience and the physical stage experience.

Interdisciplinary art-science labs are able to create innovative approaches to VR precisely by including multiple voices in all aspects of design, and by foregrounding play and performance as necessary aspects of this innovation. Our transdisciplinary approach offered us a way to conceive an experiment that is pertinent in each of these fields separately. Our platform, and its extension to the concept of Shared Diminished Reality is the very result of the workshops and residencies, where we tried to express and adapt our concerns through the language of different research fields.

One important value of the hybrid research creation procedures, such as the performance design of the Articulations platform, is in allowing for the emergence of a research through creation process. This particular form allowed for extended experimentation with features and ideas that have occurred through the

previous phases of the Articulations project. For example, the recording camera feature of the performative platform was an idea that has been put forth in the earlier stages of our project, long before the conception of the performance itself. In turn, the experience gathered through the performance will nourish the design of the Articulations project in its later phases.

By creating interdisciplinary art-science labs, practices of playful variation are brought into direct dialogue with both scientists designing experiments and designers creating virtual environments. Each participant brings not only new questions about what can be done with technology, but also brings their values, including different notions of fun, engagement challenge, and novelty. This is similar to the video game industry, where players often reinvent games through the ways in which they play creatively with glitches, "mod" the games, and play new games on top of the apparent game (Boluk and LeMieux 2017). These emergent practices often seed the next wave of games. Similarly, artists and dancers reinvent media such as virtual reality through engaging the technology within a frame of play and asking new questions (Kozel 2007).

The Articulations platform was developed with and for dancers. This was both a strength and a limitation. It emphasized the creation of an environment that invites interactive movement exploration without verbal language. Choreographers, for instance, noticed things about distracting environmental features, and interpersonal signaling constraints that no one else did. Similar contributions were made by visual artists, programmers, anthropologists and psychologists in the lab. The challenge of creating a performance tested the improvisational abilities of all the team members, while also providing a discrete goal to have a production-ready system. It sharpened the environmental design, the interactive formats, and the experimenters' awareness of the experience of being in diminished reality.

The way we shaped our experimentation protocol is also something that goes beyond our usual work habits. The questionnaires and interviews were designed based on how we, virtual reality designers, sociologists, anthropologists, dancers, and cognitivists, had each gathered behavioral data within our own disciplinary frames. Concepts such as presence, sense of self, bodying, worlding, each have their own literature and references in our fields, but this confluence allowed us to stand at the crossroads of them, allowing each of us to learn new things that we can return to our fields with, what Cohen-Cole describes as the interplay between interdisciplinary and multidisciplinary (Cohen-Cole 2007).

Shared Diminished Reality emerged from an interdisciplinary research creation process between the laboratory and performances. By aesthetically abstracting the gesture from other forms of communication, it highlighted and confirmed the semantic and emotional power of the gesture and its central role in interpersonal communication. Scaffolding shared experiences, built on users' emergent gestural vocabulary, seems to be an interesting lead to follow. Virtual reality is certainly an art of the gesture, of the act in becoming, and this new artistic form is fully in line with the continuity of living art such as dance or improvisational theater, as much as the arts of temporal storytelling such as cinema.

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Table 1. Categories and quantitative results of post-experiential questionnaires

Assertion ID	Immersion	Body	Relation	Assertion	Mean	SD
A9	x			I found this visual and silent space very appealing.	4.48	1.47
A10	x		x	I often (regularly?) forgot that some of the spheres represented another person.	3.62	2.15
A11	x			Real-world elements have often extracted me from my virtual reality experience.	1.24	1.56
A12		x	x	My attention was more focused on my own movements than on the relationship between our respective movements.	2.86	1.98
A13	x	x		In this virtual reality experience, I felt like I was more than my usual self.	2.76	2.03
A14		x		My movements were smoother and easier than usual.	2.83	1.86
A15			x	The connection and interaction with the other person was easy and very natural.	3.07	1.81
A16	x			I would have liked the experience to last much longer.	3.48	1.89
A17		x		I was more aware of my body than usual.	2.71	1.92
A18			x	I didn't feel that the other person was responding to the suggestions I was making.	2.95	1.71
A19	x	x		I find that the virtual reality installation limited the potential of my movements.	2.36	1.79
A20		x	x	My movements were motivated by what I thought the other person was perceiving.	2.52	2.06
A21	x		x	My partner didn't like the experience	1.79	1.84
A22		x	x	My movements and creativity were amplified by the presence of the other person.	3.79	1.85
A23	x			The simplicity of the virtual reality environment made me all the more curious and explorative.	4.38	1.61
A24			x	I was often the one who initiated interactions with the other person.	2.88	1.52
A25	x	x	x	When we could see our spheres in the mirror, I had the feeling that our movements were one.	3.19	1.92
A26	x		x	I didn't pay attention to the reflection of our movements in the mirror.	1.83	2.13
A27	x		x	When our spheres had different colors, I felt more separated from the other person.	1.98	2.14
A28	x		x	I had the feeling that the other person was absorbed by the mirror.	1.31	1.7
A29	x	x	x	When I could no longer see my own spheres, I found that I interacted more with the other person.	2.38	2.17
A30			x	The other person's way of moving made me feel that they were seeing things different from me.	2.86	1.98
A31	x	x	x	When I couldn't see my own spheres anymore, I felt closer to the other person.	2.48	2.12
A32	x			Not having any specific instructions or goals confused and misled me.	1.83	1.79
A33			x	Co-habiting the virtual space with the other person created a feeling of intimacy.	3.14	2.09
A34		x		I had a pleasant feeling of lightness	4.29	1.57