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FROM HAPTIC PERCEPTION TO MOVEMENT: A PHENOMENOLOGICAL STUDY ON SOUND AND TECHNOLOGICAL MEDIATION IN DANCE PEDAGOGY

DA PERCEPÇÃO HAPTICA AO MOVIMENTO: UM ESTUDO FENOMENOLÓGICO SOBRE A MEDIAÇÃO SONORA E TECNOLÓGICA NA PEDAGOGIA DA DANÇA

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ABSTRACT:

It is well known that, interactive media have become a major issue in both academic research and artistic practice. During the last years, motion sensing technologies have been proven to be a useful mean for movement's analysis in relation to dance and music performances. Different domaines ranging from artistic creative process to pedagogical applications have been involved. Within this context, many scholars pointed out the crucial importance of sound agency in developing sensorimotor awareness. A phenomenological approach seem to be taking an increasingly prominent position in informing such theoretical framework. Multimodality and embodiment have been revealed to be the main features in order to understand the relation between movement, sound and mediation technologies. The case study presented is part of a research project that involves dance pedagogy and new technologies at Nice University. This paper focus on description of an interactive experience based on motion sensing/bio-signals technologies allowing dance students to explore the sense of touch in connection to objets' manipulation and sound production. The goal of the experience was to analyze how multimodal connection between haptic and auditive feedbacks can be incorporated trough gesture and how, this relation affects perceptual organization of movement. As it emerges from this study, sound feedbacks seem to facilitate the transition from manipulation gestures to dance movements. Moreover, the arise of a "sonorous presence" enhances both proprioceptive awareness and corporeal imagination thereby affecting the movement composition process.

Keywords:
Interactive Technologies. Dance Pedagogy. Sound Feedback. Multimodality. Embodiment.

RESUMO:

Como é sabido, a mídia interativa tornou-se um problema importante tanto na pesquisa acadêmica quanto na prática artística. Nos últimos anos, as tecnologias de detecção de movimento provaram ser um meio útil para a análise do movimento em relação à dança e as performances musicais. São envolvidos diferentes domínios que vão do processo criativo artístico às aplicações pedagógicas. Nesse contexto, muitos estudiosos apontaram a importância crucial da agência de som no desenvolvimento de conscientização sensório-motora. A abordagem fenomenológica parece assumir uma posição cada vez mais proeminente na informação desse quadro teórico. A multimodalidade e a corporificação[1] são reveladas como as principais características para entender a relação entre movimento, som e mediação tecnológica. O estudo de caso apresentado faz parte de um projeto de pesquisa envolvendo pedagogia da dança e novas tecnologias na Universidade de Nice. Este artigo concentra-se na descrição de uma experiência interativa baseada em detecção de movimento e tecnologias bio-eletrônicas que permitem aos estudantes de dança explorar o senso de toque em conexão com a manipulação de objetos e a produção de som. O objetivo da experiência foi analisar como a conexão multimodal entre feedbacks hápticos e auditivos pode ser incorporados por meio de gesto e como essa relação afeta a organização perceptiva do movimento. Como resulta deste estudo, os áudio feedbacks parecem facilitar a transição de gestos de manipulação para movimentos de dança. Além disso, o surgimento de uma "presença sonora" aumenta a consciência proprioceptiva e a imaginação corporal, afetando assim o processo de composição do movimento.

Palavras-chave:
Tecnologia Interativa. Pedagogia de Dança. Retroalomentação Sonora. Multimodalidade. Corporificação.

1 NT: no idioma original: *embodiment*.

INTRODUCTION

DURING THE LAST three decades, digital media gain an overwhelming importance in performing arts and, especially, in dance practices. Motion sensing technologies, in particular, played a crucial role in innovating contemporary dance's expressive codes. From Troika Ranch and Palindrome company's multimedia performances to William Forsythe's interactive CD-ROMs, from Yacov Shavir's virtual environments to Klaus Obermaier's audiovisual reactive systems, from Susan Kozel's telematic-based choreographies to Sarah Rubidge's participative installations, dance has been deterritorialized into multiple hybrid forms (DIXON, 2007; SALTER, 2010). Furthermore, an increasing interest in analytical application of motion sensing technologies emerged at the beginning of 2000's. Two main tendencies can be observed with regard to dance. A fundamentally computational approach and a more phenomenological one. The first focuses on the development of specific algorithms and motion capture systems able to analyze the relation between movement qualities and expressiveness (CAMURRI et al., 2000, 2004). The second is more interested in the way interactive feedbacks can allow a re-organisation of movement (FORSYTHE, 1999; MENICACCI; QUINZ, 2006). Other important researches on

movement and technological mediation point out the straightforward connection relating sound, perceptual organisation and sensorimotor integration processes. Several researches on this subject have been developed in last years focusing on gesture-sound interactions in technological mediated contexts: gesture's expressivity in relation to emotion (CAMURRI et al., 2008), gesture modeling for interactive sound computing (BEVILACQUA et al., 2012), ecological approach to mapping strategies (MIRANDA et al., 2014), embodiment theory in relation to music perception (LEMAN; JAN MAES, 2015), relation between effort and biosignals in musical performance (TANAKA, 2015). All of these studies seem to agree on the importance of audio technologies as a means to enhance our corporeal awareness.

Moreover, several scholars and artists started to investigate the relation between interactive media, music, dance and learning. In this context motion capture systems can be used to devise new movement analysis models involving professional performers practice and motion learning methodologies (CAMURRI et al., 2016). Furthermore, interactive technologies are proved to be a useful pedagogical tool also for a non-expert audience. Some recent researches stressed the importance of musical interactivity in stimulating motor creativity and physical participation of children (MAFFIOLI; ANELLI; KÄLLBLAD et al., 2008). Similar results came from interactive sound technologies application in the context of motor and psychological rehabilitation (BERGSLAND; WECHSLER, 2016). From this angle, digital interactive technologies seem to be an important tool to enhance of our bodily involvement into sound experience.

EPISTEMOLOGICAL FRAMEWORK

New perspectives on dance and technological mediation are also informed by interdisciplinary studies of perception. A good understanding of how humans perceive the world is quite essential in order to figure out the way how digital media affect and transform our kinesthetic sensibility. In this

regard, embodied perspective seems to acquire an increasingly importance in connecting cognitive and sensorimotor interactions in human beings. It is no coincidence that some "classical" insights of phenomenological tradition are actually inspiring different scientific fields, even in "hard" sciences. Some of the core-ideas of Merleau-Ponty's philosophy (MERLEAU-PONTY, 1961), like the dynamic role of sensation, the strictly connection between perception and sensorimotor activation, and, above all, the notion of multisensoriality, are now taken into account in different fields of scientific research. Unlike traditional epistemology, who claimed the passive nature of perception, several branches of neurophysiology seem to agree on the fact that active and passive functions are both present in sensory receptors (BERTHOZ, 2000).[2] The "activity" of our sensorial system also implies the interconnection between exogenous stimuli and muscular activation. To perceive something is basically "going to" : when I'm looking out the window of my room, I'm not just contemplating from a distance. I'm literally moving my virtual body in order to sensorially reach the environment out of the window. All perceptions are, indeed, motor projects or movement simulations. This is explained by the fact that the same areas in the brain are activated during imagined and executed actions (NÖE, 2004). Michel Bernard, elaborated the philosophical notion of *fiction* in order to describe this peculiarity of our perceptual system (BERNARD, 2001). Fiction implies virtualization of my actual body in a virtual one, capable of inhabiting a both physical and imaginary topography of the space. Dancers well know, although intuitively, this powerful faculty of our corporeality. Fiction of movement allows us to consider a second form of simulation (or chiasme[3]) which operates within our perceptual organization. When I perceive some richly expressive phenomenon, like a performer dancing or playing an instrument, I'm not just perceiving some isolated sensorial feedback. Close to my actual perception (ex. the acoustic stimulus coming from an instrument), other sensorial phantoms emerge: I can perceive both roughness and plasticity of the instrument's material, I can physically feel the muscular tension generating a musical gesture or a dance movement. According to Bernard's aesthetic reflection, a certain sensation (like for instance an auditive feedback) is capable of evoking other sensorial modalities (ex. somatosensory or haptic). This second sensation, is a simulacrum of the first one. This fictional sensation is not just an imaginary, unreal or mental image. It is a reflection of our perceptual system's multisensory organization. Furthermore, Alex Meredith and Barry Stein pioneering

2 From a physiological point of view, sensory receptors's operating principle comprises both active ands passive functions. Among active processes we can mention, for example, the predicative functions related to the measurement of derivatives (speed, acceleration, pressure variation, etc.). Moreover, sensors are able to modulate their own sensibility by modifying the "quality" of the information received. (BERTHOZ, 2000).

3 Notion of chiasme was first conceived by Maurice Merleau-Ponty (1961) in order to define structural reversibility of our perception. Michel Bernard re-elaborate this concept and identify three main typologies of chiasme : intra-sensorial (reversibility between active and passive fonctions in sensorial system), inter-sensorial (interconnection between different sensorial modalities), para-sensorial (relation between voice and sensorimotor system).

studies experimentally demonstrated the cross-modal convergence of sensorial stimuli in some specific areas of our brain, and in particularly in superior colliculus (Meredith, Stein, 1986). Recent researches on this subjects seem to agree about the fundamentally multimodal and interactive nature of our neurosensory system (CALVER; SPENCER; STEIN, 2004; GREEN et al., 2011; NAUMER; KAISER, 2010).

This new epistemological understanding of human perception also inspired, in recent years, the emergence of novel paradigms in musical gesture studies (GØDOY; LEMAN, 2010; GRITTEN; KING, 2011). The term "musical gesture" denotes a wide spectrum of musical descriptors ranging from metaphorical description in musical analysis to semiotic units in performance's studies. According to embodied music cognition theory, gesture (and more generally the body as a source of intentional and involuntary motion) is the real mediator between subjective experience (mental representation and sensorial response to music) and the environment (the music as physical phenomenon and cultural mediated behavioral system). This paradigmatic interpretation of gesture reflects three major features of the theory: music perception is embodied, multimodal and action-oriented (GØDOY, 2003; LEMAN, 2008). According to Leman, such embodied understanding of music allows us to reflect on how to rethink the technological environment. Further researches on this subject support the idea that an embodied understanding of musical gesture can inform mapping strategies, interface design and, more generally, reconfiguration of technological mediation (DONNARUMMA, 2016; JENSENIUS, 2013; VERFAILLE, 2006; VISI, 2017).

RESEARCH CONTEXT

Within this theoretical framework, it is clear that the understanding of sound-movement connection can be significant in order to formulate new hypothesis on perceptual organization in relation to dance. In this context, technological mediation is configured as a mean to enhance the level of corporeal involvement with music. Moreover, even in the field of artistic practice

a crucial esthetic shift has occurred. In contrast to earlier new media art and performance, that celebrated the immateriality and the ephemerality of the virtual (DYSON, 2009), contemporary performing arts are reconsidering the importance of presence and physical participation. In the dance works of Cindy Van Acker, Ginette Laurin, Isabelle Choinière and Wayne McGregor – among others – the use of audio technologies and interactive devices is conceived with the purpose of affecting performer's perceptual geography and thereby increasing his awareness of the internal physiological process of movement (PITOZZI, 2016). Such an use of real-time sound feedbacks allows dancers to renew their gesture compositional processes and their corporeal imagination.

Given this background scenario, this study aims to present some original reflections about gesture-sound relation starting form a practical-based investigation. The case study presented is part of a research project involving dance pedagogy and new technologies: "Corps sonore. Applications Interactives pour l'Analyse du mouvement et la recherche pédagogique" ("Sound Body. Interactive applications for Movement Analysis and Pedagogical research"). The project was co-developed with Federica Fratagnoli, dance professor at Nice "Côte d'Azur" University. The investigation involved two classes during the last two years (2015-2017). The main goal of this research was to describe how interactive sound feedbacks can enhance gesture awareness starting from enquiring both perceptual and imaginative organization of movement. To this purpose, interactive sound applications were been developed using different typologies of sensing technologies (optical detection, motion sensors and bio-feedback signals). Several exercices, inspired by movement analysis practices, were proposed to students in order to evaluate how acoustic feedbacks inform movement. Exercices focused on visualization, allocentric spatial representation and gestural compositional processes.

Unlike most other research studies in this domain, which focus on quantitative analysis of motion data, a qualitative approach was preferred. According to phenomenological perspective, we believe this method to be more exploratory and rich in explanation of subjective's experience. Moreover, a comparative analysis of the observation and participant's reports seem to be a powerful tool allowing us to understand the relation between movement perceptual organisation and imaginative processes. Therefore, data collection followed a combination of

these five methods: 1. Direct observations; 2. Discussion with students after each session; 3. Student's self-report; 4. Interviews; 5. Audiovisual documentation analysis. Above mentioned theoretical insights have been used, firstly, to devise pedagogical practices. Moreover, some key-concepts have been employed in order to formulate some hypothesis about experience.

TECHNICAL CONFIGURATION

The present study focuses on the description of an interactive experience based on motion sensing/bio-signals technologies allowing the user to explore the sense of touch in connection to sound production. This experience involved a class of nine dance students at Nice University. The session lasted two hours and half plus thirty minutes of discussion with students. The goal of the experience was to analyze how multimodal connection between haptic and auditive feedbacks can be incorporated trough gesture and how, in this case, imaginative processes affect perceptual organization of movement.

The starting point of the exercise was the manipulation of an object. In order to sonify this kind of haptic interaction, a specific Max application had been developed.[4] The interactive system was based on the use of two different interfaces: a Hot Hands controller and a Myo armband. Hot hands is a wearable midi interface enabling continuous control of musical parameters. This ring-like device uses a three-axis accelerometer to get data about finger's movement. Precisely it provides three continuous values based on 180 degrees rotations. Myo Armband is a quite sophisticated device containing different kinds of sensors. Only the EMG sensors were used in this exercise. EMG (Electromyography) is a bio-signals captation technique, normally used for medical purposes, enabling the recording of skeletal muscles' electrical activity. A specific algorithm was designed in order to detect not only arm muscular contraction but also fine electrical variations produced by tiny hands' movements.

4 Max is the most famous visual programming language enabling creation of interactive environnements for music, perfor-mance and multimedia with a strong emphasis on real-time generation of content. Cf. Lechner (2014).

The didactic aim of the interactive system was to enrich haptic experience by mean of sonorous feedback. Sound production shouldn't be the task of gesture but its "emergent effect".[5] Therefore, interaction has to be natural and intelligible for the user. In order to facilitate a spontaneous incorporation of auditive feedbacks, two main features are take into account: interdependency of parameters and sound's materiality. Interdependency of musical parameters reflects the natural interconnection of our sensory receptors. Basic functions of human physiology, like for instance the sense of balance, are the result of a complex system of interdependencies.[6] Similarly, in the interactive system we designed, musical parameters are interconnected at the low-level in order to produce an intelligible response to objects gestural manipulations. Three hand's rotations allow morphing[7] between three different audio samples. Each rotation is related to the others producing an effect of complete interdependency. Muscular contraction controlled two audio filters (a lowpass filter and a resonant one). Semi-total relaxation of the muscles was detected in order to produced silence. Audio samples were designed in the purpose of evoking a tactile experience. Sound texture was based on two electronic samples (issued from a digital additive synthesis) and an electroacoustic sound, realized by recording and processing different crackling materials (dry leaves and papers). Electroacoustic sounds, depending from their degree of materiality, can often stimulate tactile sensations or mental images evoking material textures. The use of crackling sounds as raw material aimed at producing a virtual connection between auditive and tactile experience. This interactive configuration allows student to experience rich audio-tactile feedbacks during haptic exploration of the objets' surface.

EXPLORING HAPTIC PERCEPTION : EXPERIENCE DESCRIPTION

Pedagogical experience's structure is informed by "Analysis of movement" practice. Starting from several verbal indications, students are invited to explore a specific movement in the space. Later, a second experience,

5 In philosophical terms, the word "emergent" denotes those phenomena arising from and depending on some more basic phenomena yet are simultaneously autonomous from that base. Cf. Bedau (2008).

6 « The discovery by Sherrington and his school of the mechanism that causes a muscle to contract when it is stretched led to a view of balance as the linking up of a multitude of local reflexes: when the body bends under the effect of gravity, muscle receptors as well as those of the joints, vestibular system, and even vision detect this bending and cause a muscle contraction that rights it. » (BERTHOZ, 2000, p. 216).

7 Morphing is a digital technique enabling to transform one sound source into an other. In this case I designed a MaxMsp patch based on FFTT technique.

providing integration of new sensorial/kinesthetic informations, is proposed. After this experience, students come back for the second time on the first movement experienced. In this phase a novel sensorimotor organisation is supposed to arise. Within this pedagogical model we elaborated a personal didactic structure involving mediation technologies. The exercise was, hence, divided into three parts corresponding to different levels of sensorial experience :

1. Haptic/movement experience with and without objects

2. Haptic experience with both objects and sound feedbacks

3. Haptic/movement experience without object but with sound feedbacks

First of all, students have to choose an object among a selection of different materials (plastic bottles, towels, scarfs, packaging materials, books, etc.). The first part of the session was articulated articulated in three different phases allowing students to intentionally connect somatosensorial stimuli, proprioception, and gesture. During this first phase, we asked them to explore with their hands the surface of the objects. This section of the exercise aimed at stimulating focus on haptic feedbacks issues from the object (shape, plasticity, weight, texture, dynamic qualities, etc.). In the second phase, students have to set down the object and try to reproduce the movements of manipulation without the support of the object. In this case, they have to reenact particular gestures of exploration starting from experienced haptic sensations. In the third phase, we asked students to incorporate object's haptic feedbacks and to transform these sensations in dancing movements. This section resulted very interesting because of the diversity of the objects and the variety of movements. Each student focused on different aspects of the gesture-object relation in order to compose movement. Someones converted object's weight in gravity, others transform object's plasticity in movement's quality. Broadly, students focused on some peculiar qualities of the objets in order to virtualize them trough the movement. Imaginative valorization of haptic feedbacks seems to be crucial in this phase. The body of the object became a virtual pattern enabling the composition of movement.

The second part of the exercice involved technological mediation. Students repeated the exploration of the object wearing the two interactive devices (Myo armband and Hot Hands ring). As we mentioned above, we did not ask students to intentionally produce sound. Acoustic feedbacks arouse as an echo of gestural manipulation of the object. This part of the experience was conceived to enhance multimodal experience of movement. Perceptive categorization of gesture-object interaction was based on, at least, three direct feedbacks : visual and haptic sensations issued from the object, digital sound feedbacks produced trough the use of interfaces (depending from the material, some objets also naturally produce acoustic sounds). Because of the typology of motion sensing/bio-signal devices, sound also stimulates, even if indirectly, the emergence of proprioceptive sensations. Particularly bio-feedback sensors helped us to be aware of our muscular tonus variation during the manipulation.

In the third part of the exercise, students have to continue gestural manipulation but without the object. In this section is quite evident that auditive feedbacks gain greater importance. In absence of direct haptic and visual stimuli, both sound feedbacks and memory of somatosensory sensations participate to the object virtual reconfiguration. It should be noted that also auditive sensations produce some kind of somatosensory images because of the material quality of sound. We have hence two levels of tactile “virtual” images: tactile sensations issued from the object and tactile images evoked by sound. Both are not actual sensations even if they are somehow presents in perceptual organization. In the last section of the session, we asked students to create dance movements starting from the collection of haptic sensation they had just experienced. Similarly to the first part of the exercise, students composed movement patterns by evoking structural qualities of the object (dimension, plasticity, etc.). Particularly, textural features of the object are incorporated in movement’s quality. Furthermore, sound feedbacks affect gesture execution. Several movements are, unconsciously, associated to their acoustic response facilitating the transition from gesture manipulation to dance movement. So, for instance, grasping gesture is associated to a particular acoustic response (based on both hand’s rotation and flexor muscles’ contraction). This kind of sound modulation can be reproduced in a wide movement involving similar kinesthetic organization. Although sound production do not represent the task of the exercise, multimodal connection between haptic sensations

and acoustic response, via proprioceptive awareness, allows students to virtualize object's body (with its shape, weight, dynamic qualities, etc.) within their corporeality. This new virtual body, situated at the convergence between the memory of haptic sensation, interactive sound feedbacks (and also tactile informations derived from acoustic qualities), proprioceptive awareness and imaginative valorization processes, is the root of the movement composition.

CONSIDERATIONS ABOUT THE EXPERIENCE

Video documentation, as well as student's reports, highlights the double function of the object. Both source of sensorial experience and movement's constraint, the object leads gesture and affects proprioceptive awareness. In student's comments, the object is not considered as a neutral element. Since first exploration, the object defines the limits of our sensorimotor involvement and thereby the borders of our *umwelt*.[8] Nevertheless, the object's qualitative proprieties are not simply received by students. These features are integrated within personal kinesthetic organizations (depending from cultural, existential and physical experience of each one). Also a simple manipulation is not a neutral operation but reveals a peculiar negotiation between our haptic sensibility and object features. This specific kind of interaction is amplified by mean of the movement. Object's proprieties are functionally selected (I chose to work just on the material qualities that make sense for me) and converted into gesture patterns with the mediation of both proprioception and imaginative processes. Despite the variety of individual responses to haptic exploration and movement composition, several constants in perceptual organization can be pointed out. Two main sensorimotor processes are activated during the first part of the exercise. After have set down the objects, students are invited to re-perform exploration gestures. As a great part of students noted in their reports, reproducing manipulation primary entail the recollection of movements involved in the exploration. In doing so, students are encouraged to deeply explore their

8 Notion of Umwelt, was elaborated by Jakob von Uexküll at the beginning of XXe century. It defines the organism's exis-tential milieu. From a biological point of vue, it denotes at the same time sensorial and pragmatic environnements embed-ding living being. (VON UEXKÜLL, 1957).

kinesthetic organization and become aware of physiological processes that compose gesture. The second process is activated when we asked them to expand these exploration gestures in the space around them. The achievement of this task implies a real incorporation of the object's material proprieties. Material's texture seems to be one of the most remarkable features allowing students to feel a new density for their body. Also object's dynamic proprieties and plasticity play a role in affecting gesture's quality, especially in movement's effort, while materials' weight have a direct and intelligible influence on gravity. As some students remarked, object's plasticity also reverberate in space perception. For instance, a rigid object allows to imagine a dense and resistant space. Movements become, hence, strong and sudden. All of these aspects imply a transfert of the haptic sensations to the proprioceptive level and thereby in perceptual organization of the movement. Also kinesthetic sensation is proved to be a primary source to built up movement in the space. Some peculiar manipulations, like for instance gesture of twisting, are reproduced in some wider movements (for instance vertebral column's spiral movement). In this case, twisting gesture become a model to compose movement patterns.

Let us now consider how technological mediation and sound feedback affect gesture execution and movement composition. All students agreed about that interacting with sound initially provoke a sort of shock. A sonorous image of their body emerge by means of digital interaction. Even thought exploration gestures are not sound-driven, interactive acoustic response imposes a new hierarchy in kinesthetic organization. Some movements trigger sound while other do not produce an acoustic response. Students had to integrate this new sonorous body in their habitual (and often unreflected) corporeality. This operation demands an expansion of the bodily borders and therefore a reconfiguration of our perceptual organization. It is important to remark that students don't know how interactive system works. This is crucial from a didactic point of view in order to not influence spontaneity of interaction. That is way this part of the exercise is characterized, as many students observed, by a gradual incorporation. This phase basically involve multimodal integration processes allowing to connect kinesthesis, proprioception and sound feedbacks. Interaction between muscle electrical signals and sound production is proved to be really outstanding in this regard. Sonification of muscular tension provokes a quite unusual sensation. As a student underlined during the

discussion about the experience: «it's like perceiving exteriorly something that is normally an inner sensation ». Unlike the first experience with the object, muscular sonification provokes a remarkable shift in the awareness from exterior dynamic of movement to proprioceptive involvement in gesture execution. Because of interactive feedbacks, perception of muscular tonus variations becomes a significant (and visible) feature of the gesture. This correlation between effort and sound generation has a direct outcome in reproducing gesture without objects. As we pointed out above, reenactment of manipulation gestures involves here not only the recollection of haptic experience. Specific gestures (and specific somatosensory sensations) are directly associated to a sonorous image (not only a mental representation but a real sound). This sound hallmark can be used as draft enabling manipulation reenactment. Some students highlighted that sound feedback helped them to recollect gesture more efficiently in comparison to the first part of the exercise. In absence of material objects, sound give presence to virtual objects evoked by gestures.

Other interesting observations emerge from the very last part of the exercise. In this section students had to expand their sensorial experience into wide movements within the space around them. It's a question of virtualizing perceptual informations into sensorimotor organization. Two fictional processes are involved in this kind of corporeal reconfiguration. Somatosensory sensations are used to define both space material density and gesture quality. In this case virtual reconfiguration of corporeality is rooted in the experience of object materiality. A second form of virtualization concerns movement patterns. Dance movements arise here as a variation of the gestural exploration. Object's body, no more actually present, resonates in the dancer corporeality. How technological mediation and sound interaction inform such a virtualization process? Students' feedbacks about their experience differ are significantly diverse. Very briefly, they can be summarized into two main positions. A great part of them highlights the difficulty to integrate somatosensory sensations with sound feedbacks. The richness of aural informations seems to limit the evocation of tactile experience. Nevertheless, we think that this difficulty does not reflects a real incompatibility between aural and somatosensory informations. Perceptive incongruence is probably originated within somatosensory system. As we already noted, the electroacoustic soundscape we designed is mostly made of material sounds (crackling, etc.). According to Michel

Bernard, we can affirme that this kind of sound materials elicits the emergence of tactile, physical, organic simulacra, that are virtual sensations evoked by my actual perception. It may be assumed that these audiotactile simulacra conflict with tactile sensations associated to the object. Furthermore convergence or incongruence between the two tactile sensations is also in relation to the effort. Given that sound production was significantly related to muscular tension, students that have experienced more dynamic efforts in gesture manipulation also came up to connect movement composition to sound generation. Indeed, this second group of students remarks that sound is proved to be essential in order to virtualize object sensations through the movement. In their performance, there is a straightforward connection between sound modulation during object manipulation and sound modulation in a danced final section. Here tactile informations, issued from the haptic exploration, are integrated with the sound production and expanded in the movement. After object manipulation, analogous sound textures are clearly re-performed in a new form of kinesthetic organization.

CONCLUSIONS

First and foremost, technology allows us to experiment new perceptual modalities. By transforming movement into sound we are not simply providing alternative forms of gesture-music interaction. Above all, motions sensing technologies permit conversion of kinesthetic organization's invisible aspects into audible processes. In doing so, our corporeality acquires a sonorous presence. As the present study shows, the use of such acoustic layer is proved to be a powerful mean of investigation for the pedagogical context. By connecting interactive sound feedbacks to gesture, students become aware of the micro-levels that compose movement. This allows them to rethink dance movement compositional process. Furthermore, motion sensing technologies allow us to devise novel insights within perception study. Providing a significant rearrangement of our perceptual geography, technological mediation highlights some fundamental mechanisms of sensorimotor organization. According to multimodal integration

principles, auditive feedbacks enhance, in terms of effectiveness and precision, our ability to accomplish a sensorimotor task. In our case study, students seem to be able to recollect manipulation gestures in a more easy way by interacting with sound. This occurs because memory of haptic stimuli is informed by and associated with audio manipulation. Somatosensory perception is hence enriched and transformed by sound. Their convergence seems to produce mutual adaptive behavioral resonances that facilitate reenactment of movement.

Other important considerations concern movement's virtualization processes. From an ecological point of view, we can say that the object elicits a variety of affordances (GIBSON, 1977). As we observed, different typologies of manipulation arise depending on the object constitution. The use of sound feedbacks radically transforms the quality of these interaction. By the use of motion technologies, haptic manipulation is strictly connected to audio manipulation. It is interesting to observe that such sonorous presence persists even in absence of the object. From a phenomenological point of view, the object continue to afford, by means of the sound, even if is no more actually in my hands. Fragments of these affordances are also visible in dance movements reproducing the same audio modulation. Sound interaction helps to virtualize the object in a wide movement. Therefore, affordance seems not to be just a mere "possibility of action" but a dynamic kinesthetic structure involving the entire sensorimotor apparatus. In doing so, interactive technologies highlight the role of virtualization processes in perceptual organization of movement.

In general terms, we can affirme that the imaginative valorization of the object proprieties play a crucial role in multimodal integration processes. As we noted, sound is not just perceived as an aural object. It also presents tactile qualities that can converge or conflict with object's materials features. Suches audiotactile informations allow to imagine a resonant body. The way how sound feedbacks can be transformed in concrete images is fundamental in order to understand why certain audio materials can be more appropriates to interact with a specific object. From this point of view, futur works have to examine in depth morphological relations between audio and tactile qualities. Such an understanding have to inform sound design strategies as well as pedagogical contents.

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