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'Move in Tempo': involving the audience through their movement in installation art

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Abstract: This article presents 'Move in Tempo', an installation performance designed to immerse everyone in a unique artistic experience blending dance performance, technology, and movement-based interaction. Through 'Move in Tempo, participants engage with the temporal dimension of movement from two perspectives, the experiences available to visitors of the installation. The first perspective allows visitors to act as performers of their own experience, engaging directly with the installation through their movements. The second perspective is that of a spectator, where visitors observe a performance within the installation space, choreographed specifically for 'Move in Tempo'. The installation invites each person to move within a rhythmic framework,

facilitated by algorithmic and machine learning techniques. Through this interactive experience, participants contribute to the creation of the artistic narrative, making them integral performers within the installation. Evaluation results from the participation of over 700 visitors highlight the impact of the interactive experience. Qualitative and quantitative assessments reveal increased visitor engagement, enhanced understanding of art and culture across various age groups, and enriched holistic experiences. By incorporating participant feedback and evaluation data, this article demonstrates the effectiveness of 'Move in Tempo' in bridging the gap between art and audience.

Keywords: interactive installation; algorithmic art; machine learning; performance; interaction design; audience participation; movement-based interaction; dance; technology; co-creation.

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1 Introduction

Contemporary art has witnessed a profound evolution in recent decades, particularly with the integration of technology into the artistic realm. As noted by Takala (2023), this fusion of art and technology has given rise to transformative changes at the intersection of artistic creation and digital innovation: interactive media art. The utilisation of digital tools, interactive platforms, and multimedia installations has opened new avenues for artistic expression, challenging traditional boundaries and redefining the artistic landscape, including in dance and performance. This intersection has birthed new avenues for exploration in performance, as highlighted in references such as Dixon (2007), where the fusion of art and technology offers novel approaches to creative expression. Through the utilisation of technology, artists are empowered to enrich the total imagery (Franklin, 2013), enhance the quality of movement (Dixon, 2007; El Raheb et al., 2018), and even contribute to the well-being of individuals through immersive experiences (Strassel et al., 2011). Central to our inquiry is the utilisation of the body as a mediator within interactive installations, aligning with Marcel Duchamp's advocacy for spectator involvement as an integral component of the artistic experience (Duchamp, 1994). According to Dixon (2007), in the 1960s, different artists began exploring mixed media arts, then bringing the public closer to their work.

Artworks such as 'Walk with Contrapposto' by Nauman (1968), 'Glass on Body' by Mendieta (1972), 'Pintura Habitada' by Almeida (1976), 'One Minute Sculptures' by Wurm (1997) are examples of a selection that profoundly impacted contemporary art at the close of the 20th century. Through their innovative artistic approaches, they successfully drew the public into closer proximity with their creations, exerting a transformative influence on the contemporary art landscape. Already in the 21st century, 'Deep Walls' by Snibbe and Raffle (2009), 'Eavesdrop' by Silva et al. (2021), 'Your Uncertain Shadow' by Olafur (2010), 'Ghosts' by Weis (2017), 'People Create Space and Time, at the Confluence of their Spacetime New Space and Time is Born' by teamLab (2019), 'Pulse Topology' by Lozano-Hemmer (2021) created artistic spaces for the artist to become part of the work.

In this article, we present 'Move in Tempo' an installation built upon previous research to explore how we can involve the audience in installation art. One of the main goals is the purpose of 'Move in Tempo' concepts', exploring body movement through the interaction with technology at different times. This capacity of the technological installation to construct a world that is not entirely real takes us all into another dimension of different narratives. For that reason, we have intersected dance performance and technology as an alliance that reflects the dimension of time as a

crucial element in choreographic creation, as well as in the human-computer interaction of the common visitor.

The structure of this article begins with an exploration of the *related work*, which examines the integration of the body and audience interaction in contemporary art from the 1960s to the present. Subsequently, we delve into the 'Move in Tempo' performance installation, tracing its inception from conceptualisation to the evaluation of visitor experiences at the Machado de Castro National Museum, designated as a *UNESCO Cultural Heritage*, please see Labadi (2013). Through 'Move in Tempo' our contribution lies in demonstrating how the integration of technology, which visually reflects the temporal dimension of movement, can enrich audience interaction and artistic expression. This artistic installation allows participants to move and interact in various temporal dimensions simultaneously, a concept encapsulated by the term 'Move in Tempo' (i.e., where *tempo* refers to time or temporal dimension in Portuguese). Acknowledging the pivotal role of visitor experiences in interactive installations, the final section of the paper investigates the qualitative and quantitative data collected, elucidating their impact on the evolution of 'Move in Tempo' and its contributions to the broader field of study.

2 Related work

Bruce Nauman discovered a new dimension in body deconstruction through video recording, leading to the creation of new compositions projected in installation. Nauman utilised a video camera as a mirror, as noted by Krauss (1976). It is important to note that Nauman's work should not be viewed through a narcissistic lens; rather, the artist sought to explore the distortion of his bodily experience, as exemplified in his piece 'Walk in Contrapposto'. According to Brandão (2016), "in his work, it doesn't even matter whether it is the artist's body or not." The artist actually used his body in a way uninterested in autobiography.

On the other hand, Mendieta explored an autobiographical subject-artist relationship in which she addressed social-political problems experienced by herself, see Mendieta (1972). She integrated photography and video records as an archive of her performances. Also using her body as the artwork object (i.e., 'Glass on Body', 1972), Mendieta aimed to sensitise the audience to political-social problems. While in Mendieta's performance, the use of her body was explicit, in Nauman and also Helena Almeida's work, the artist's presence sought to be a representation of anybody, not evidencing its identity. Helena Almeida found in photography and digital support a new dimension to explore the relationship between movement and time-space, as cited by Carlos and Phelan (2005). Her work makes the spectator reflect on the dimension of time-space and tries to find out in what space the human body is really located, inside the frame or outside it, distant or close to the spectator.

2.1 Exploration of audience participation in contemporary art

For instance, Erwin Wurm invites the spectator to be the performer of his work. Through 'One Minute Sculptures', Wurm provides written instructions on paper for the new performer to create an unusual performative moment with the space. This work, like Mendieta's work, uses the digital as a record of performance, but in this case,

a performance that combines traditional sculpture in a contemporary art perspective, according to Pembleton and LaJevic (2014). Within the artists already discussed, 'One Minute Sculptures' is the only work whose artist's body is not evidenced in the work. The emphasis is on the spectator's own lived experience and the result of their action in/with the space. Nonetheless, there is a common characteristic in all the artists' approaches: to mentally move the audience. The *Emancipation of Spectator* which Jaques (Rancière, 2021) addressed has become in contemporary art a real practice, intended by the artists. The spectator is no longer the passive spectator who solely observes; the spectator not only becomes part of the artwork, but his body, action, and movement define the narrative of the artistic experience.

2.2 The interaction of the spectator as an action of the artistic experience

At the beginning of the 21st century, interactive installations created the space that was required to fully engage the audience. The intention that Wurm was already exploring by inviting the spectator to the performance, here takes an interactive dimension with the technological medium.

In 'Deep Walls', Snibbe and Raffle (2009) developed an installation space for the audience to perform and see their movement in the installation. According to the author, 'Deep Walls' is an interactive installation that projects *cinematic stories*. In this work, *cinematic stories* are understood as the interactions recorded, in the form of shadows of visitors who performed in the installation. These records are repeated, over time, in the installation itself, allowing the participant to see himself again. Also in a cinematic exploration of the installation itself, in 'Eavesdrop' (2004), Pledger and Shaw engaged the spectator as the producer of the cinematic experience, as cited by **?**. In this 360° installation, the spectator could control the interactive narrative and find the sequential story of the installation. Here, the spectator's body is not requested in the interaction as a performer, but rather their decision-making interacting with the installation.

Already documenting the actuality of contemporary art, Olafur Eliasson the artist also asks the audience to be a co-producer of his work and thus places experience at the center of his practice, employing not only sight, but sound, touch, smell, and even taste, according to Kane (2019). The artist argued that one of the greatest responsibilities of artists is to help people not only to know and understand something with their minds but also to feel it emotionally and physically (Eliasson, 2016). The artist also believes that involving the spectator in this way can mitigate the numbing effect created by the information overload he faces today, and in this way motivate people to turn thought into action. In this way, we can verify that the involvement of the audience is no longer just about approaching the artist or the art, but creating an atmosphere that makes the spectator reflect and react. It is understood that the intended reaction is not only on the art experience but instead on a social reaction, in essence, an effect that was trying to achieve with his work.

2.3 Exploration through dance and performance

We address the work of Cathy Weis who brought dance as her performative background to the installation-performance environment, as cited by Parker-Starbuck (2006). However, the artist became involved through this form as an overcoming of her physical

and medical condition. Through the fusion between the body and technology, Weis explores the boundaries between living bodies and cyborg bodies. Her work comes close to Nauman's work, due to the bodily uncluttering she incorporates. But Weis also brings to the light of installation-performance the invitation for the spectator to dance and be a performer himself. In 'Ghosts' the different perspectives that the artist explores to make the installation ambiguous in relation to what is real and what is virtual, which is also related to Helena Almeida's intention.

2.4 Audience as performer in interactive installations

The next two artworks, similarly to Olafur Elliasson's work, put the viewer in the place of the performer. In the form of an interactive installation, visitors are invited to interact with technological art and see the evolution of the artistic experience through their own interaction. The artwork 'People Create Space and Time, at the Confluence of their Spacetime New Space and Time is Born' by teamLab (2019) it is an interactive digital installation which is continuously and eternally changing due to the behaviour of people. This work reflects time, through the life cycle of the cherry blossom trees. "Cherry blossoms are born, they bloom, then scatter, the cycle of life and death continues to repeat itself" cited by teamLab (2019). As an interactive installation, when visitors stop or place their hand against the wall, a circle is born and grows to radiate at a certain pace and at a specific interval. The circle is born and transforms only the light and dark of the background world.

On the other hand, the artwork 'Pulse Topology' by Lozano-Hemmer (2021) is composed of thousand of lights suspended at different heights that create an interactive landscape that visitors are invited to traverse. Each light bulb glimmers to the pulse of a different participant, which contributes to a connective arrangement. Custom-made pulse sensors record visitors heartbeats and when a new participant interacts with the installation, their pulse is added to the canopy of the recordings above them, with the newest recording replacing the oldest.

2.5 Moving from the artist's expression to the spectators' experience

In previous works within the realm of contemporary art, artists have consistently endeavored to bridge the gap between their creations and the audience, utilising various resources available throughout the history of contemporary art. For instance, Mendieta and Wurm employed cameras to meticulously document and preserve their work, capturing not only the essence of their performances but also their interaction with their audience. Similarly, figures such as Nauman, Almeida, and Weis utilised the camera as a means to explore a myriad of compositions and bodily transformations, enriching the narrative of their artistic expression.

Moreover, recent trends in artistic installations have emphasised the development of multisensory experiences, actively engaging visitors and transforming them from passive spectators into active participants. However, amidst these advancements, there exists a notable area for improvement: the absence of a cohesive conceptual framework. Many contemporary installations often lack a clear message, struggle to evoke genuine emotional responses and overlook the intended impact on the audience beyond the immediate sensory experience.

In our work, 'Move in Tempo', we endeavor to address this observed gap by introducing innovative concepts and approaches that set our project apart from previous endeavors in contemporary art. Our installation not only engages the spectator through technological means, as evidenced in the works of Snibbe, Pledger and Shaw, Eliasson, TeamLab, and Lozano-Hemmer but also incorporates a thoughtfully crafted conceptual framework. Through 'Move in Tempo', we aim to evoke profound emotional and intellectual responses from our audience, fostering deeper engagement and reflection beyond the immediate sensory encounter. By seamlessly integrating technology with conceptual depth, our work seeks to redefine the boundaries of contemporary art, offering a transformative artistic experience that transcends mere spectacle.

3 'Move in Tempo', concept and creation

The genesis of 'Move in Tempo' was rooted in a specific context, namely the isolation experienced during the pandemic that we endured from 2020 until the next years, please see Heyang and Martin (2020). The restrictions applied to prevent the spreading of COVID-19 have forced choreographers and performers to rethink their artistic creations. Within this context, our project sought to introduce a novel paradigm centered around two key premises: the repetition of performers as a departure from traditional choreographic methods, and the exploration of time as a central element in creating movement narratives across different temporal dimensions.

'Move in Tempo' is an interactive art installation designed to facilitate and enhance the creative process for performers, choreographers, artists, visitors, and enthusiasts alike. At its core, it enables everyone to engage with movement and visual composition through movement-based interaction; please see Figure 1. The project draws inspiration from the expressive nature of dance and performance, aiming to convey emotions, thoughts, and messages through the fluidity of movement, as highlighted by Levy (1988). Building upon prior research (Nogueira et al., 2021, 2023), we integrate the nuanced dynamics of choreographic narrative, emphasising the interplay of space and time as fundamental elements in documenting and evolving performative art forms.

Central to 'Move in Tempo' is the exploration of temporal dynamics, where the past, present, and future intersect through real-time technological interactions. Visually represented as an interactive virtual grid composition, the installation allows users to immerse themselves in a continuous dialogue between movement and time. In 'Move in Tempo', performers or visitors engage with the installation space, dynamically moving within it, thereby becoming an integral part of the artwork. This interaction unfolds as participants perform dance or casual movements within the installation space, fostering an inclusive experience for individuals of all ages, backgrounds, and physical abilities. By offering a simple user experience through movement-based interaction, 'Move in Tempo' ensures accessibility and immediate engagement for visitors, regardless of their artistic or technological proficiency, enabling a seamless and impactful encounter with the artwork.

In the context of 'Move in Tempo', the term 'tempo' encompasses more than just the pace of movement; it reflects the intricate relationship between time and movement within the realm of dance performance. Living within distinct temporal moments simultaneously is impossible, yet this interactive installation offers a medium to explore these complexities. 'Tempo' in this context encapsulates not only the speed

of movement but also the exploration of different temporal dimensions, synchronised or desynchronised, reflecting the scale of time through various elements of dance such as space, velocity, and intention. Thus, 'Move in Tempo' aims to provide participants with an artistic space to engage with and interrogate the concept of tempo, transcending mere physical movement to delve into the deeper nuances of time within the choreographic narrative.

3.1 The installation-performance

'Move in Tempo' is a site-specific installation that transforms an empty space into a dynamic realm of artistic exploration, embodying the essence of installation-performance through movement-based interaction, as previously explored in the authors' research and artistic works (Nogueira and Menezes, 2023; Nogueira et al., 2024). This innovative installation offers visitors two distinct yet interconnected experiences: the open installation itself and a live performance. In the open installation phase, visitors actively engage in a *kinesthetic* experience, assuming the role of performers as they interact with the space through their own movement. Here, they can explore the nuances of different temporal dimensions, feeling the passage of time through their bodily actions within the installation, and witnessing this relationship projected onto a virtual grid in real-time. During the live performance, spectators observe the convergence of these temporal dimensions as the dancer's movements are choreographed and executed in accordance with the concept of Move in Tempo.

Figure 1 'Move in Tempo' performance using a 'three times' grid mode (see online version for colours)

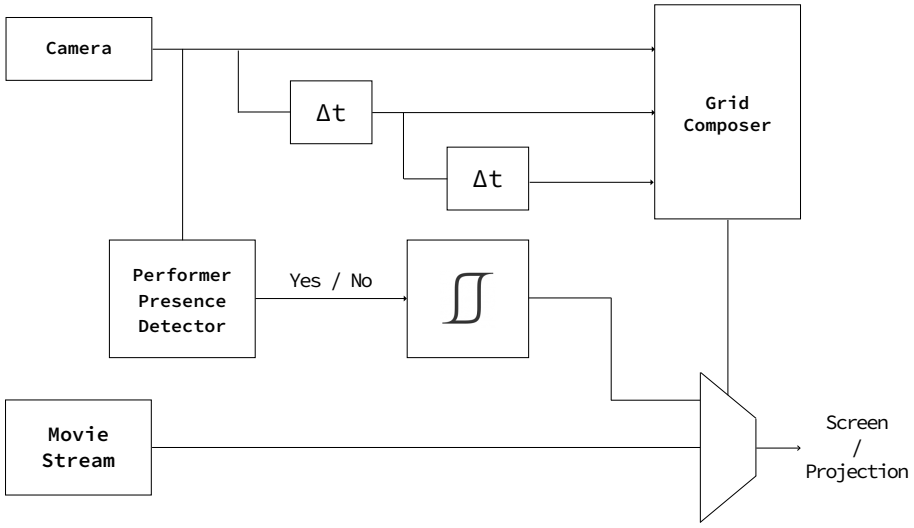
As shown in Figure 1, the projection enables everyone to observe not only the present moment but also past movements simultaneously, providing a multi-layered perspective on the choreographic narrative. To facilitate understanding and engagement, descriptive guides are strategically placed throughout the space, offering viewers insights into

the core concept of the installation. Additionally, signage directs visitors on how to navigate the space, guiding them to areas where they can interact, observe, and immerse themselves in the projections. From a spatial standpoint, the installation is typically divided into two zones: the performance/interaction area and the projection area, positioned closely together to enhance the immersive experience. Through the seamless integration of technology and art, 'Move in Tempo' not only invites the audience to engage with the installation but also promotes physical well-being and enriches their overall artistic encounter.

3.2 System architecture

The installation-performance 'Move in Tempo' integrates a technological component supported by different parts. As presented in Figure 1, the installation displays two main spaces, the interaction space (i.e., where the performer is in the image, right side) and the projection space (i.e., where the visual grid is observed, left side). The software responsible for building the visual composition runs in a computer machine which is connected to a camera in the facility to collect the images in real-time. A projector that outputs the resulting visual composition on a large scale (in real-time). Two spotlights are placed on each side of the performance area, creating shadows behind the dancer. A loudspeaker that plays the sound of the installation according to the presentation format. If it is a performance moment, the sound reproduced is the sound of the voice-over created for the art piece; if it is the format of an interactive installation open to the public, only the ambient sound is maintained. Signage and information are integrated into the installation to guide visitors. The human presence mediated by the visitors or the performers makes the installation come alive and be driven.

Figure 2 Visual scheme of the installation's architectural system



The software we developed incorporates an advanced machine learning algorithm, specifically human pose estimation (Heyang and Martin, 2020), to detect the presence

of individuals within the installation. This innovative mechanism seamlessly transitions between real-time capture and pre-recorded performance footage, enhancing the overall immersive experience. As depicted in Figure 2, the system promptly detects the human body upon entry into the installation space, utilising the 'performer presence detector' to trigger the display of the real-time visual grid. This integration is pivotal in maintaining the continuity of the performance narrative, ensuring its presence and impact even in the absence of live performers. By presenting excerpts of the performance when the installation is unoccupied, the system entices visitors to engage in an immersive exploration, facilitating a deeper understanding and appreciation of the installation's artistic concept.

3.3 Grid composition

To generate the grid composition, we started developing a virtual 8 × 8 grid model. Each square of the grid presents a camera capture, as presented in Figure 3. In total, 36 images (i.e., in the 6 × 6 model) are presented in the visual grid, each image within a square of the grid. Each black square corresponds to the image captured in real-time. The white squares will present the same image with an arbitrary time delay. In other words, the black squares correspond to the present performance, and the white squares represent the past performance. After the first exhibition of 'Move in Tempo' we realised that the installation was strongly dependent on some site-specific conditions. We considered that the grid should be adapted to each space, so it has been ranged between 6 × 6, 9 × 9, 12 × 12. At the moment, we present four grid models, as shown in Figure 3, and they are distinguished by the following characteristics:

- Three times – The grid is divided into three columns which show, each one, different temporal moments. The middle column is always showing the real-time capture (see Figures 3 and 4). The part on the left side of the grid shows the more distant past time, and the part on the right side of the grid a more recent past. In the center, the column in black shows the present time.
- Column model – The visual composition is divided into multiple columns, considering that the even-numbered columns have a time lag of the image capture. In this model we just have two temporal moments (see Figures 3 and 4).
- Row model – The visual composition is divided into rows, considering that the even-numbered rows have similar to the column model, a time lag of the image capture, and also a flip image (horizontally) which will create a mirror reflection effect (see Figures 3 and 4).
- Diagonal model – In this model, the visual composition is divided into a diagonal line that is drawn from the upper left corner to the lower right corner. This line which crosses through eight diagonally arranged squares defines which squares will present the captured image in a different time scale. Moreover, this model is that this same diagonal line splits the composition into two visual triangles will create a mirror reflection effect. In this model, there are three visual representations happening simultaneously, a real-time capture, a real-time capture that flips the image, and a capture that occurs in a time-lagged (see Figures 3 and 4).

4 'Move in Tempo' participants' experience

The 'Move in Tempo' installation was presented in three different exhibitions and visited by approximately 700 visitors. The first exhibition took place at the 'Criatech' Art and Technology Collective Exhibition, in Aveiro, where 'Move in Tempo' received more than three hundred visitors over four days (October 2021). The second exhibition 'Move in Tempo' was presented in a group exhibition, 'Motel Coimbra' at the University of Coimbra, and was seen by one hundred visitors (November 2021 to January 2022). The third exhibition was presented at the Machado de Castro National Museum, *UNESCO Cultural Heritage*, and received more than three hundred visitors (April and May 2022). The first and third exhibitions 'Move in Tempo' provided an open format for the public to interact living the art installation itself. Also at both exhibitions, there were performance sessions, in which the public could watch a contemporary dance piece created for the purpose of the installation, premised on the dimension of time in dance movement.

Figure 3 Grid models: 1 – 'three times'; 2 – 'column model'; 3 – 'row model'; 4 – 'diagonal model'

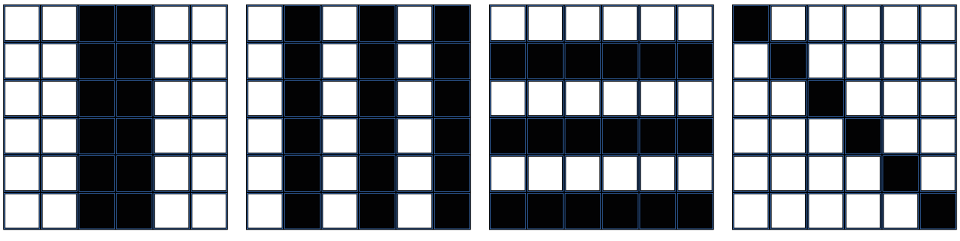


Figure 4 'Move in Tempo' performance in different grid models: 1 – 'three times'; 2 – 'column model'; 3 – 'row model'; 4 – 'diagonal model', 6 × 6 model (see online version for colours)

The format of 'Move in Tempo' provides the participants with two different perspectives about the installation art. The first experience is defined by the spectators' role – inside the installation, the participant could observe a contemporary dance performance, close to the performer. In the second experience, the participant is invited to interact with the installation through his own body movement, as shown in Figure 5. The participant switches the spectator role for the performer role. By experiencing both roles, the participant can better understand the artistic creation process of 'Move in Tempo' installation-performance.

From the beginning, 'Move in Tempo' has aimed to provide intuitive interaction through a simple artistic experience intended for anyone (including disabled people). During the different exhibitions, we observed that, regardless of physical and cognitive conditions, participants wanted to interact and experience 'Move in Tempo' installation-performance. Its inclusive facet was particularly remarkable when young people and children with motor and cognitive limitations that visited it, spontaneously started interacting and enjoyed it for some periods of about 30 minutes in some cases. These children and young people lived the experience in 'Move in Tempo' happily and without further interaction difficulties. The first time at 'Move in Tempo' exhibition, we received a study visit composed of thirty students who watched the performance and interacted with the installation. One of the students was a person who uses a wheelchair and asked to be helped out of it to experience the installation, in which she spent five minutes experiencing and enjoying 'Move in Tempo'. In the third exhibition, and after the performance, a class of children between 6 and 10 years old (i.e., all of them diagnosed as autistic, or deaf-mute) interacted and tried to reproduce the dancer's movements in the installation during twenty minutes. These moments lived in 'Move in Tempo' allowed us to understand that the installation has an inclusive component and that, regardless of physical difficulties or limitations, visitors want to see and live the experience because its *kinesthetic* character stimulates and encourages the body interaction and creative process, as well as new approaches to human movement.

These findings, albeit recorded on video, are only qualitative data through the behavioural observation of the participants. For this reason, in the last exhibition of 'Move in Tempo' at the Machado de Castro National Museum, at the end of the performance, the participants were asked to answer an evaluation survey, expressing their personal opinion and evaluating the performance of the installation. The questions addressed the participants' experiences within the 'Move in Tempo' installation, with the aim of collecting information about the understanding of the installation concept, opinions about the experience, the most/least performed actions by the participants, and suggestions. While these questions can be expected to receive very personal points of perspective, it was hoped that it would be possible to detect some trends raised from the overall analysis.

4.1 Participants' survey

During the exhibition period, we undertook a systematic evaluation comprising both qualitative and quantitative methodologies to assess the participant experience and art communication efficacy within the 'Move in Tempo' installation. Our evaluation focused on two primary dimensions: the physical manifestation of the installation within the museum space and the behavioural interactions of participants within the installation environment. The physical dimension scrutinised the specific design and

presentation of the installation, analysing its effectiveness in conveying artistic concepts and engaging viewers visually. Meanwhile, the behavioural dimension delved into participants' interactions with the installation, particularly their bodily movements and overall engagement with the artwork. Our objective was to discern potential areas for enhancement and optimisation of the media art experience offered by 'Move in Tempo'.

To conduct the evaluation, we formulated a series of hypotheses about target audience demographics, interaction dynamics, and art communication strategies. Participants were provided with access to a survey via a QR code displayed prominently within the exhibition space, supplemented by informational cards offering a brief overview of 'Move in Tempo'. This dual approach aimed to facilitate survey completion either immediately following the exhibition visit or at a later time, accommodating participants' preferences and schedules. Moreover, recognising the diverse linguistic backgrounds of visitors, the survey was made available in both Portuguese and English languages to ensure inclusivity and accessibility. A total of 74 questionnaires were completed in Portuguese, with an additional ten questionnaires completed in English, reflecting the multicultural nature of the exhibition venue and its diverse audience base.

4.2 Evaluation metrics

In the arts field, participation has always been a subject of discussion, the spectator is not always involved enough, as the author or artist intends it to be, as referred by different authors (Harland and Kinder, 1995; McCarthy and Jinnett, 2001; Fancourt and Mak, 2020). Nevertheless, we believe that when art is integrated into an installation art environment and engages the spectator's interaction in a relaxed way it can bridge this barrier. In this sense, through the experience of the participants in 'Move in Tempo', we sought to understand their interaction in the installation. We developed a set of hypotheses regarding the participants' experience and based on the confirmation or rejection of these hypotheses we reflect on future development.

Hypothesis 1	Using the body as an interaction device contributes to an easier understanding of art.
Hypothesis 2	The understanding of the installation art is influenced by age.
Hypothesis 3	Asking the audience to participate in an interactive and relaxed way contributes to the involvement of older age groups.

For the evaluation metrics, we established a correlation between data acquired through each survey and analysis behaviour during the exhibition of installation-performance.For the statistical and qualitative evaluation, we utilised the one-way and two-factor analysis of variance (ANOVA) F-test, as applied by St. and Wold (1989). In the following, we present some of the results to confirm or invalidate our hypotheses.

4.3 Participant groups

The survey was completed by 84 participants: 52 female (F) participants, 31 male (M) participants, and 1 participant whose gender was identified as other (O). The analysis of the results was conducted through four groups divided by the different age groups of the participants, each one composed of 21 participants. The four groups were due

into the following ages division: group 1, children between 9 to 14 years old; group 2, teenagers between 15 to 17 years old; group 3, young adults between 18 to 30 years old; group 4, adults between 30 to 74 years old.

Regarding all participants, each one out of the 84 participants signed informed consent before the anonymised survey. The age division for each group of participants is presented in Figure 5. The age range of the participants is between 9 years old and 74 years old, on average 26 years old (SD = 16.29). Each group has the following gender and age division:

- Group 1 (children) – 13.61 years old (SD = 1.24), F = 9 and M = 12.
- Group 2 (adolescents) – 16.28 years old (SD = 0.9), F = 17, M = 3, O = 1.
- Group 3 (young adults) – 23.23 years old (SD = 3.61), F = 14, M = 7.
- Group 4 (adults) – 52 years old (SD = 10.55), F = 12, M = 9.

There were significant differences in the age difference between Group 4 which presented a normal distribution of 10.55. Of the eighty-four participants almost half of the group, more precisely 43 participants went to the museum where the installation was located with the main purpose of visiting 'Move in Tempo'. The remaining 41 participants did not go there on purpose to visit 'Move in Tempo', that is, their experience was something that happened sporadically following their visit to the museum.

5 Results from the participants evaluation

Considering that one of the main goals of this work is to bring the public closer to the art and involve them as much as possible, we tried to devote some questions to the individual experience of each participant. We focused on understanding the main actions that the participants perform in this particular installation, as well as the causes for the lack of involvement of some participants.

5.1 Participants' experience

We divided 'Move in Tempo' into five types of interactions and actions that participants could experience:

- A – observing the installation
- B – observing the live performance
- C – interact with their own body and movement
- D – record photography and/or video
- E – reading the information provided throughout the installation.

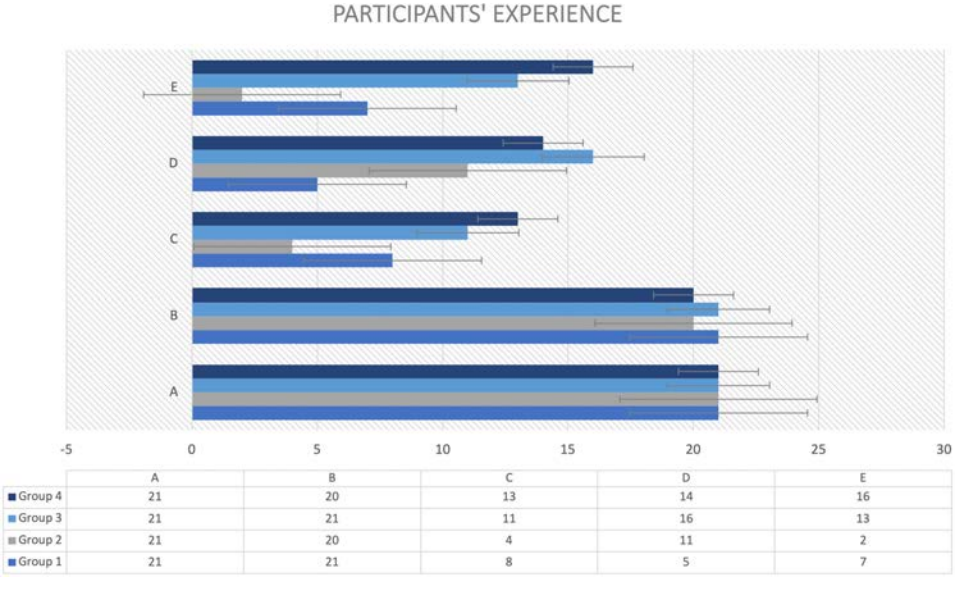
We believe that older ages are the most interactive and interested participants during the installation experience. For that analyses approach we applied the two-factor with replication analysis of variance ANOVA test, the F-value (F = 13.639) is larger than

F-statistic (*F-crit* = 3.259), which means we can reject the null hypothesis. The result of the P-value (p = 0.0002) is less than our significance level (e.g., 0.05), which means all our results are significant.

5.1.1 Observing installation and live performance

All participants who answered the survey observed the installation and the duration of the experience of the 84 participants had a total average of 33 minutes (SD = 23.3). Of the total of 84 participants who completed the survey, 82 participants observed live performance, as shown in Figure 5.

Figure 5 Participants' experiences were divided into groups and their actions: A – observing the installation; B – observing the live performance; C – interact with their own body and movement; D – record photography and/or video; E – reading the information provided throughout the installation (see online version for colours)



	A	B	C	D	E
Group 4	21	20	13	14	16
Group 3	21	21	11	16	13
Group 2	21	20	4	11	2
Group 1	21	21	8	5	7

5.1.2 Interact with own body movement

The average interaction within the installation, through the spectator's movement, was 9 (SD = 3.91). Albeit, if we analyse each group individually we realise that groups 1 and 2 (i.e., children and young teenagers) were the groups that interacted the least, with eight participants interacting in groups 1 and only 4 participants interacting in group 2. This situation could be explained by the short time which these two groups had available to visit the installation. In the case of groups 1 and 2 the participants were mainly students who were involved in a study visit, and therefore had a very restricted time to visit the installation. On the other hand, groups 3 had 11 participants interacting in the installation, and in the case of group 4, which was the group with more participants interacting, 13 persons from 21 participants, 62% of this group. Those who selected "I

did not interact with the installation through my own movement" were further asked to provide the reason why they had not performed that action. The answer to this question was an open-box response, and we got the following feedback: 20% of participants wrote *many people in the room* or *unknown people*, 30% *shyness* or *shame*, and 50% *I had no interest* or *I don't know*.

5.1.3 Recording photography and video

The total average number of participants who recorded photography and video was 11.5 (SD = 4.79), which gives 54% of the participants performing this action at the installation. Analysing each group individually, and as presented in the table, we can observe that groups 1 had 5 participants recording video and taking photographs, groups 2 had 11 participants, group 3 had 16, and group 4 had 14.

5.1.4 Reading the information in the installation

In general, 44.5% of the participants read the information displayed in the installation. Since there is very little written information, the interactive installations must have contributed to fulfilling the participants' needs for information. As the last action, the participants were asked to select the action (E), if they had read the information provided in the installation. This action had an overall average of 9.5 (SD = 6.24). Associated with this option was the question of whether the participants who had read the information found it useful for understanding the work. Associated with this option was the question of whether the participants who had read the information found it useful for understanding the work. The answer 'yes it was useful' had an overall average of 13.35 for each group (SD = 4.34). The response 'not applicable (didn't read)' had an overall mean of 5.25 for each group (SD = 4.71). And the response 'no' had a mean of 0.11 and only in group 1 was this selected-response presented.

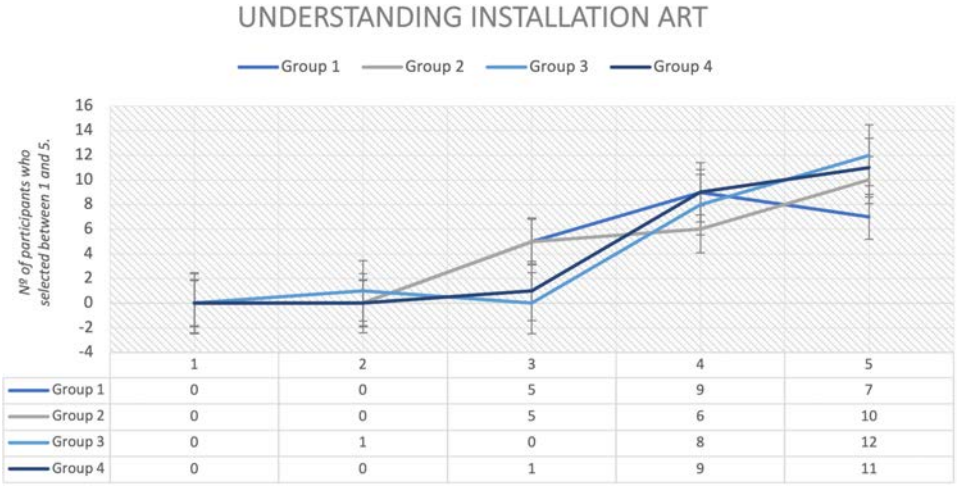
5.2 Duration of the participants' experience

The minimum experiment time was nine minutes and the maximum time was one hundred and twenty minutes. Dividing this analysis by the different groups, we have the following average length of each group experience: group 1, M = 25.43, SD = 19.26; group 2, M = 25.14, SD = 24.66; group 3, M = 42.01, SD = 26.78, group 4, M = 42.62, SD = 21.3. Applying the single-Ffctor analysis of variance ANOVA test, the F-value (F = 3.775) is larger than F-statistic ($F\text{-}crit$ = 2.718), which means we can reject the null hypothesis. The result of the P-value (p = 0.0137) is less than our significance level (e.g., 0.05), which means all our results are significant.

5.3 Perception of participants' number

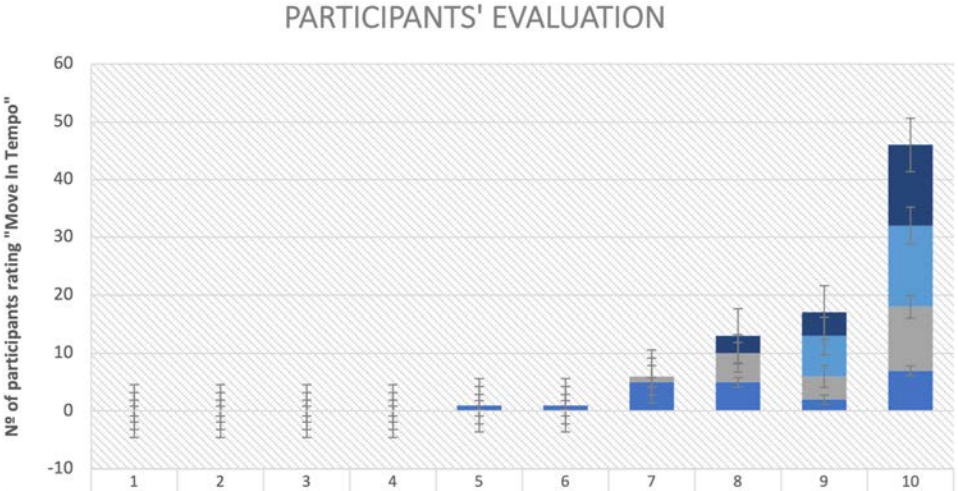
It was asked the participants to refer to the number of visitors during their experience. It was multiple choice and the options were: [1–5], [5–10], [10–15], [>15]. The last option, more than 15 visitors during the experience was the most selected option with 68%, and the experience visited by groups [10–15] was 15%.

Figure 6 Comprehension of the installation-performance 'Move in Tempo' by each group (see online version for colours)



	1	2	3	4	5
Group 1	0	0	5	9	7
Group 2	0	0	5	6	10
Group 3	0	1	0	8	12
Group 4	0	0	1	9	11

Figure 7 Evaluation of the individual experience in 'Move in Tempo' by each group (see online version for colours)



	1	2	3	4	5	6	7	8	9	10
Group 4	0	0	0	0	0	0	0	3	4	14
Group 3	0	0	0	0	0	0	0	0	7	14
Group 2	0	0	0	0	0	0	1	5	4	11
Group 1	0	0	0	0	1	1	5	5	2	7

5.4 'Move in Tempo' concept comprehension

To further understand the comprehension process of participants' at 'Move in Tempo', they were asked to select from 1 to 5 (i.e., 1 = slow, 5 = fast), how quickly the participants understood the concept and dynamic of the installation. *Were you easily*

able to understand the installation 'Move in Tempo'?. In all groups the average is 4, however the standard deviation ranges between each group: group 1, SD = 0.76; group 2, SD = 0.83; group 3, SD = 1.05; group 4, SD = 0.06. In the case of groups 1 and 2 five participants rated their understanding with 3, and while only one person rated their understanding with 3 in the case of group 4, and in group 3 one person rated their speed of understanding with 2. All other ratings ranged from four to five, as depicted in Figure 6.

The Hypothesis 2: "the understanding of the installation art is influenced by age" is answered by the analysis of variance. According to the two-factor without replication analysis of variance ANOVA test, the F-value (F = 6.824) is larger than F-statistic (*F-crit* = 2.758), which means we can reject the null hypothesis. The result of the P-value (p = 0.0004) is less than our significance level (e.g., 0.05), which means all our results are significant.

5.5 'Move in Tempo' rating evaluation

At the end of the survey, the participants were asked to rate their experience with the Move in Tempo from 0 to 10 (i.e., weak = 0, excellent = 10). Following the results shown in Figure 7, the total average was 9.166 (SD = 1.2). The report given by the participants varies among the four groups, considering also that the younger age groups gave lower scores than the adult age groups. Group 1 evaluated as an average of 8 (M = 8.29, SD = 2.31), group 2 had 9 (M = 9.19, SD = 0.96), group 3 gave 10 (M = 9.66, SD = 0.23) and group 4 evaluated 10 (M = 9.52, SD = 0.56). According to the two-factor without replication analysis of variance ANOVA test, the F-value (F = 7.937) is larger than F-statistic (*F-crit* = 2.718), which means we can reject the null hypothesis. The result of the P-value (p = 0.0001) is less than our significance level (e.g., 0.05), which means all our results are significant.

6 Discussion

Starting with the sample of participant groups, we can firstly refer that the great majority of participants from groups 1 and 2, children and young adolescents, experienced the installation during study visits, as their visit was not programmed. That is, these participants did not purposely go there to see 'Move in Tempo', but did so following a visit to the museum where it was presented. This also means that their availability of time to be able to visit the installation 'Move in Tempo' was less than the other groups, or not exclusively. This will explain the results in Subsection 5.1.2.

Regarding the hypotheses presented, we verified that Hypothesis 1, *using the body as an interaction device contributes to an easier understanding of art*, is true. Through the analysis of each sample group, we found that the visitors who interacted with the installation through their movement (5.1.2), were also the visitors who gave the highest evaluation to the understanding of the installation (5.4). Hypothesis 2, *the understanding of installation art is influenced by age*, as discussed earlier, is also true, as the results presented were significant. Finally, Hypothesis 3, *asking the audience to participate in an interactive and relaxed manner contributes to the involvement of older age groups* is true, as the highest number of interactions were found in the older groups (i.e., groups

3 and 4). Nevertheless, it is also observed that the younger groups did not have the availability to experience the installation longer.

As an art installation, this work intends to engage all audiences, regardless of age or knowledge, as well as to make the experience with art an inclusive one. The observations realised, throughout the exhibitions, were extremely positive, and we present some of the comments of visitors: "*I enjoyed the experience a lot!*", "*I loved it so much!*", "*Loved the performance, keep it up!*", "*I loved the way the dancer interacted with a spectator who was watching*", "*I look forward to one day seeing the integration of the future into the installation. It would be interesting for the performance to integrate other dancers, repeating and creating different moments*." In addition to the feedback from the surveys, throughout the exhibition, we received personal opinions from visitors, who always praised the intersection of live performance and technology. The integration of live performance and within an installation in which the spectator is very close to the artist aims to break the boundary that traditionally exists between stage and audience. In the same way, the performance contemplates a narrative throughout the choreography that translates the relationship of movement with the time dimension. Although the installation provides a hybrid format that allows the spectator to be the performer himself, 'Move in Tempo' brings different audiences closer to art through technology and humanises the concept of the machine through the performer's body in movement.

7 Conclusions and future work

'Move in Tempo' epitomises an enduring artistic journey, perpetually evolving with each exhibition and enriched by invaluable audience feedback. Our dedication to refining the artwork's message and concept is underscored by the insights gleaned from both qualitative and quantitative data, affirming the resonance of our hypotheses. Looking forward, upcoming exhibitions of 'Move in Tempo' will integrate local dancers, fostering deeper community engagement and broadening the spectrum of performers. To facilitate this collaboration, we envisage conducting 'master classes' where dancers can delve into the creative process behind 'Move in Tempo' and craft choreographic compositions inspired by the installation's concept.

We are steadfast in our belief that the fusion of dance movement and interactive technology, combined with community involvement, will further narrow the gap between society and the realm of art and culture. By offering participants dual perspectives – as both performers and spectators – within a rhythmic framework facilitated by algorithmic and machine learning techniques, 'Move in Tempo' transcends traditional boundaries, empowering each participant as an integral contributor to the artistic narrative.

As we embark on the journey ahead, our focus remains on refining and expanding 'Move in Tempo' to maximise its impact and accessibility. To this end, numerous avenues for future work beckon. Firstly, we aspire to explore novel pathways for community engagement by forging partnerships with diverse cultural groups and institutions. By tailoring 'Move in Tempo' to resonate with the unique cultural expressions and narratives of various communities, we aim to foster a more inclusive and enriching experience for all participants.

Moreover, we acknowledge the potential of 'Move in Tempo' as a conduit for therapeutic expression and wellbeing. In forthcoming iterations, we plan to collaborate

with experts in dance therapy to explore the therapeutic benefits of engaging with the installation, particularly for individuals confronting physical or mental health challenges. Ultimately, our future endeavors will persist in pushing the boundaries of interactive art, technology, and community engagement, guided by our unwavering commitment to bridging the gap between art and audience while enriching the cultural landscape.

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References

Almeida, H. (1976) *Pintura Habitada* [online] https://gulbenkian.pt/cam/works_cam/pintura-habitada-156660 (accessed 20 May 2025).

Brandão, M.V. (2016) *Passos em Volta: Dança versus Performance – Um Cenário Concetual a Artístico para o Contexto Português*, Doctoral thesis, Universidade de Lisboa, Faculdade de Belas-Artes [online] http://hdl.handle.net/10451/35505 (accessed 20 May 2025).

Carlos, I. and Phelan, P. (2005) *Intus*, in Português, Livraria Civilização Editora.

Dixon, S. (2007) *Digital Performance: A History of New Media in Theater, Dance, Performance Art, and Installation*, MIT Press.

Duchamp, M. and Dachy, M. (1994) *The Creative Act*, Sub Rosa.

El Raheb, K., Tsampounaris, G., Katifori, A. and Ioannidis, Y. (2018) 'Choreomorphy: a whole-body interaction experience for dance improvisation and visual experimentation', in *Proceedings of the 2018 International Conference on Advanced Visual Interfaces*, pp.1–9.

Eliasson, O. (2016) *Why Art has the Power to Change the World*, Vol. 23, Huffington Post.

Fancourt, D. and Mak, H.W. (2020) 'What barriers do people experience to engaging in the arts? Structural equation modelling of the relationship between individual characteristics and capabilities, opportunities, and motivations to engage', *PLoS One*, Vol. 15, No. 3, p.e0230487.

Franklin, E. (2013) 'Dance imagery for technique and performance', *Human Kinetics*.

Harland, J. and Kinder, K. (1995) 'Buzzes and barriers: young people's attitudes to participation in the arts', *Children & Society*, Vol. 9, No. 4, pp.15–31.

Heyang, T. and Martin, R. (2020) 'A reimagined world: international tertiary dance education in light of COVID-19', *Research in Dance Education*, Vol. 22, No. 3, pp.306–320.

Kane, A. (2019) *Olafur Eliasson interview with Mark Godfrey* [online] https://www.dazeddigital.com/art-photography/article/45262/1/olafur-eliasson-wants-you-to-see-hear-touch-smell-taste-his-art (accessed 3 June 2022).

Krauss, R. (1976) *Video: The Aesthetics of Narcissism*, October, pp.51–64.

Labadi, S. (2013) *UNESCO, Cultural Heritage, and Outstanding Universal Value: Value-based Analyses of the World Heritage and Intangible Cultural Heritage Conventions*.

Levy, F.J. (1988) *Dance/Movement Therapy. A Healing Art*, ERIC.

Lozano-Hemmer, R. (2021) *Pulse Topology* [online] https://www.lozano-hemmer.com/pulse_topology.php (accessed 20 May 2025).

McCarthy, K.F. and Jinnett, K.J. (2001) *A New Framework for Building Participation in the Arts*, Rand Corporation.

Mendieta, A. (1972) *Glass on Body* [online] https://hammer.ucla.edu/radical-women/art/art/untitled-glass-on-body-imprints (accessed 20 May 2025).

Nauman, B. (1968) *Walk with Contrapposto* [online] https://www.moma.org/collection/works/122032 (accessed 20 May 2025).

Nogueira, M.R. and Menezes, P. (2023) 'Movement-based interaction: an approach to visual and auditory stimulus and memory*', *6th Experiment @ International Conference (Exp. at '23)*, Évora, Portugal, pp.73–78, DOI: 10.1109/exp.at2358782.2023.10545965.

Nogueira, M.R., Menezes, P. and Patrão, B. (2021) 'Understanding art through augmented reality: exploring mobile tools for everyone's use', *9th International Conference on Information and Education Technology (ICIET)*, Okayama, Japan.

Nogueira, M.R., Simões, J.B. and Menezes, P. (2023) "FORMS' – creating new visual perceptions of dance movement through machine learning', in *ACM SIGGRAPH 2023 Posters (SIGGRAPH '23)*, Association for Computing Machinery, New York, NY, USA, Article 8, pp.1–2, https://doi.org/10.1145/3588028.3603673.

Nogueira, M.R., Menezes, P. and Maçãs de Carvalho, J. (2024) 'Exploring the impact of machine learning on dance performance: a systematic review', *International Journal of Performance Arts and Digital Media*, Vol. 20, No. 1, pp.60–109, DOI: 10.1080/14794713.2024.2338927.

Olafur, E. (2020) *Your Uncertain Shadow (Colour)* [online] https://www.tate.org.uk/whats-on/tate-modern/olafur-eliasson (accessed 20 May 2025).

Parker-Starbuck, J. (2006) 'Becoming-animate: on the performed limits of 'human", *Theatre Journal*, Vol. 58, No. 4, pp.649–668.

Pembleton, M. and LaJevic, L. (2014) 'Living sculptures: performance art in the classroom', *Art Education*, Vol. 67, No. 4, pp.40–46.

Rancière, J. (2021) *The Emancipated Spectator*, Verso Books.

Silva, B., Carrega, J., Lunenfeld, P., Tavares, M., Shaw, J., Giannetti, C., Koenitz, H., Costa, S. and Araújo, A. (2021) *The Forking Paths – Interactive Film and Media Editors*, CIAC – Edições Centro de Investigação em Artes e Comunicação, July.

Snibbe, S.S. and Raffle, H.S. (2009) 'Social immersive media: pursuing best practices for multi-user interactive camera/projector exhibits', in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, April, pp.1447–1456.

St., L. and Wold, S. (1989) 'Analysis of variance (ANOVA)', in *Chemometrics and Intelligent Laboratory Systems*, Vol. 6, No. 10, pp.259–272.

Strassel, K.J., Cherkin, C.D., Steuten, L., Sharman, J.K. and Vrijhoef, J.M.H. (2011) 'A systematic review of the evidence for the effectiveness of dance therapy', *Alternative Therapies in Health & Medicine*, Vol. 17, No. 3.

Takala, G.B. (2023) 'The interactive creativity of the digital era: exploring how media art redefines the relationship between audience and artwork', *Studies in Art and Architecture*, Vol. 2, No. 3, pp.28–44.

teamLab (2019) *People Create Space and Time, at the Confluence of their Spacetime New Space and Time is Born* [online] https://www.teamlab.art/w/people_create_space/ (accessed 20 May 2025).

Weis, C. (2016) *A Choreographer's Loft, Where 'There's History in the Walls'* [online] https://www.nytimes.com/2016/10/02/arts/dance/cathy-weis-soho-studio-has-history-in-the-walls-sundays-on-broadway.html (accessed 20 May 2025).

Wurm, E. (1997) *One Minute Sculptures* [online] https://www.tate.org.uk/art/artworks/wurm-one-minute-sculptures-p82013 (accessed 20 May 2025).