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Performative Architecture as a Theatrical Performer: A Technological Extension to Dancers' Movements

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Performance is perceived as a harmonious interplay between the performer and the space. Many elements at work contribute highly to an artistic act. History has witnessed the efforts made to activate the role of performance spaces towards interactivity and adaptivity, including more advanced stage designs that respond to the changing needs of the performer. However, architecture today frequently remains static rather than offering an immersive foreground experience to enhance audience engagement actively. With the advent of soft robotics and its required computation, architecture can input real-time performance data and generate form-changing movements, creating new sensory experiences that inspire and enrich subject-agent feedback. This article explores innovative means to enhance engagement by foregrounding architecture. Through social and design investigations, the study hypothesised the performativity of spaces as a spectrum ranging from immaterial sensory experiences to shape-changing adaptive systems. A case study was developed around two live performances in London, with user surveys focused on impacts, immersivity, and engagement. Principles were then abstracted and applied to propose the design of novel robotic spatial systems, where architecture becomes another layer of skin in an innovative theatrical experience - space, subject, and agent becoming a new trilogy of performative events.

1. Introduction

1.1. Vision

Imagine this scenario: you immerse yourself in a dance performance, where the boundaries of the space around you come alive, shifting, and adapting in harmony with your choreography. As you gracefully execute each movement, the architectural elements that comprise your surroundings become responsive, mirroring and supporting your dance with seamless synchronicity. In this remarkable exchange, the envelope itself becomes a performer, evolving alongside you.

The architectural components extend and enhance your movements, connecting you with the audience as an invisible bridge. As you navigate this dynamic relationship, the space opens new possibilities, inspiring you to explore dance sequences. This mutual exchange of creativity and expression between you and the architectural elements profoundly impacts those who resonate with your performance.

In this transformative experience, architecture ceases to be a static backdrop and assumes an active role, becoming a collaborator and co-creator. Together, you and the adaptive space transcend traditional

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boundaries, offering an immersive and unforgettable performance that blurs the lines between performer, environment, and audience.

1.2. Objectives

In an ever-changing society, new technological mediums present the art of performance with the critical opportunity to evolve, transporting spectators into heightened immersion (Murray 1997). Embracing this emergence can potentially revolutionise how we perform and engage with performances, offering novel sensory experiences through adaptive structures.

Adaptive architecture, sometimes called responsive or dynamic architecture, encompasses design principles and systems that can assume multiple configurations over time while adapting to evolving conditions and user requirements (Schnädelbach 2010). This approach involves incorporating technology and responsive mechanisms to construct buildings and spaces that can dynamically alter their shape, purpose, or environmental conditions in real time (Sumini et al. 2009). As such, spatial form-finding is not merely a quest for the most efficient shape but a source of insight into agency distribution (Ng et al. 2021). However, the research gap between changing spatial quality and audience experience limits our understanding of adaptive performance space design.

This article explores the shift towards interactive design in architecture, emphasising the rationale through questionnaire analysis and presenting a catalogue of extracted environment sets, which envision the aesthetic aspects of robotic structures and propose design strategies. The objectives are a) to examine various types of performing spaces, centring on the spectrum of ‘Space as a Performer’; b) to draw insights from live performances and develop a case study of the performing areas; c) to understand audiences’ varying experiences through questionnaires; d) to explore the potentials and significance of physical space as an adaptive and active participant in performances, moving beyond a static backdrop. The outcomes and experiences documented contribute to integrating soft robotics systems in constructing the envelope of performance spaces for enhanced theatrical possibilities.

2. A Closer Look at Spaces as Performers

Artists typically showcase their talents in traditional performance spaces but venture into unconventional or informal spaces like streets, squares, parks, metro stations, and tunnels (Ault 2002). From the lineage of performing spaces over time, many elements contributed highly to its sensory and immersive experience advancements. These elements are divided into the subject and the agent. The subject is the free independent element that is the performer, whereas the agent is an additional yet essential element dependent on the subject. By delving into the diverse ways space can evolve into a performer, designers may begin to understand their impacts on the audience. Four observable approaches to conceptualising space as a performer emerge through precedent analysis: subject removal, immaterial agents, interactive elements, and adaptive robotic systems.

The first approach removes the subject simply. Usually, the performer and the spotlight become the agent of the space (Kipnis 2002). We can find examples where the architecture or design of space takes

precedence over traditional subjects. The Wexner Centre by Peter Eisenman removed paintings from the gallery, shifting focus to the spatial form such that the architecture becomes the foreground (figure 1). By removing the subject or shifting focus to the agents, these approaches challenge traditional notions of performance and spectatorship, where architecture becomes an integral part of artistic expression. They encourage active participation and exploration, creating immersive and multisensory experiences.

In a performance setting, we could see this type of 'Space as a Performer' in digital arts (Saddler 2023). The Now Building is nestled beside the Elizabeth line entrance of Tottenham Court Road station, which hosts a 23,000-square-foot immersive wonderland. It features floor-to-ceiling digital art, providing a vibrant escape where the space transforms into a captivating spectacle of immersive digital art.

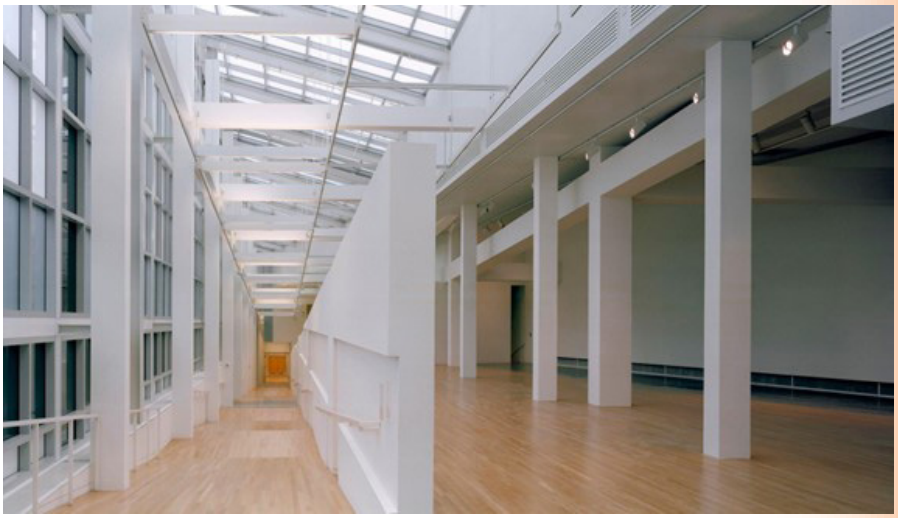


Fig.1. The first approach: subject removal, exemplified by the Wexner Centre. Image credit: Brad Feinknopf.

The second approach is to manipulate space through agents, either through articulating light, shadows, and colour variations to meld the form of the interior or using visual effects with display movements to create a sense of change and mobility (Petridou 2024). Borderless by TeamLab exemplified the approaches: all the different performative spaces have no performer (figure 2). The agent, the visual projection, becomes the main spectacle. The space caters to an immersive experience using interactive screens displaying a moving landscape that blurs the physical and digital boundaries. Space became an interactive and transformative entity, engaging the audience through visual, auditory, and sensory elements while they actively explored the environment.

Further exemplified in the exhibition Synchronicity at 180 by Strand, London, the electro-artistic collective United Visual Artists skilfully uses light and sound to question the fabric of our perception (figure 3). In this latest showcase, they adeptly transformed the sublime into an occasionally ominous experience, using light to transform the perception of space or the reality of the person in space and giving a sense of change and movement not from the space itself but from the perception inside. Pieces like Polyphony and Chromatic highlight the interplay between light and sound, while others such as Our Time and Edge of Chaos create tension by manipulating an unsettling emptiness, a cautionary

exploration that underscores our dependence on light, inducing a sense of unease and intended objective.

Fig.2. The second approach: immaterial agents, exemplified by Borderless. Image credit: TeamLab.

Fig.3. The second approach: immaterial agents, exemplified by UVA. Image credit: Synchronicity by UVA.

A third approach is having interactive elements within the space, but the overall boundary of the space remains static (Wiseman et al. 2017). Within the domain of stage design, there exists a dynamic and adaptable landscape where various elements beyond the stage itself are ingeniously manipulated to suit the evolving demands of performances. This includes introducing movable components such as set pieces, props, and even suspended elements from the ceiling. Additionally, the ground may feature openings or platforms that can rise or descend, creating new dimensions and levels for performers to engage with. These dynamic features contribute to a rich and immersive theatrical experience, enhancing the performer's interaction with the space and captivating the audience's imagination.

Translating and expanding concepts of adaptive stage design to the architectural realm, one example is the dynamic roof exemplified by BO18 in Lebanon (figure 4). Situated underground beneath a parking lot, the nightclub BO18 features a roof that opens during sunrise, allowing sunlight to permeate the space—a symbolic closing gesture to mark the golden sunrise in Beirut. While not a continuous interactive feature, this transformation occurs at a specific moment, introducing a distinctive experiential attribute that contrasts the before and after states.

Fig.4. The third approach: interactive elements, exemplified by a Beirut nightclub. Image credit: BO18.

Yet, a less commonly observed fourth approach takes a more literal route, employing robotic systems to facilitate shape-changing within the overall boundaries of the space as an integral aspect of the performance. Adaptive architecture facilitated by such autonomous systems are classified into two main categories: soft robotics and rigid robotics. The former employs flexible and compliant materials like elastomers, textiles, or pneumatic systems, allowing for deformations and adaptability in the system's structure (Stepanyuk 2023).

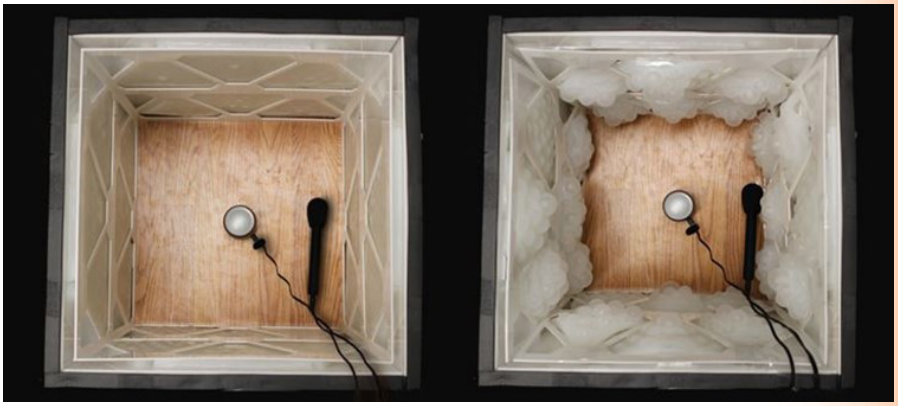


Fig.5. The fourth approach: Adaptive robotic systems, exemplified through project *Soft Acoustic Tile*. Image credit: MDL, Ryan Berg, Paulo Guerreiro, and Jesus Vasquez.

The central approach for their actuation depends on material intelligence using pneumatic and/or bending active systems to create the transformable element (Alici 2018). Pneumatic systems can change form by applying air pressure that can deform the form state - material intelligence - how the material behaves through manipulation and sealing techniques. Unlike rigid bodies, soft systems can deform more delicately. For example, consider the *Soft Acoustic Tile*, which employs a pneumatic, silicone-based soft robotic design activated through sound sensors. This innovative approach harnesses air as the means of actuation and as the medium for modulating the system's acoustic characteristics (Fig. 5).

Rigid robotics typically uses rigid structures and materials such as metals, plastics, and composites. These materials provide stability and rigidity to the robot's design. Also, they use stiff joints and linkages to achieve precise and controlled movements. Doria's paper on interactive pavilions presents an analogous case study (Doria 2016). The spatial design dynamically alters its internal form based on sensors and the user's location, providing a detailed technical approach, and exploring the feasibility of adaptive structure. This study aligns with the broader theme of developing interactive architecture to shift the traditional passive-reactive relationship between users and buildings. The envisioned outcome is a continuous exchange of influence and actions, challenging the conventional closed nature of architectural objects.

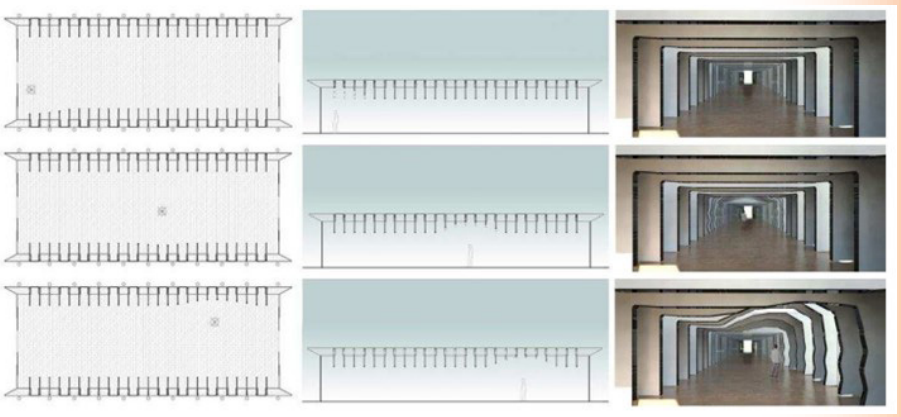


Fig.6. *Interactive Pavilion* Storyboard Concept. Image credit: David Doria.

3. A Compass of Performative Architecture

Drawing from these insights, a compass of performative architecture is formulated, with all elements representing a continuum between these extremes (figure 7). The compass referenced Janet H. Murray's (Murray 1997) theorisation of immersive realities and performative agents. Immersivity refers to being contained in a space or a state of mind through assumptions and actions. In contrast, the agency was defined as the aesthetic pleasure that arises from skilfully leveraging the procedural and participatory elements within digital environments.

The horizontal axis transitions from immateriality to complete adaptability. The vertical axis points to the quality of agents curated within a space — "space as performer" foreground architecture as the primary agent, whereas "space as immersion" discusses the interplay between the static and the installed to create a state of mind.

Together, the compass facilitates four areas of design approach for adaptive performance spaces. "Subject removal" foregrounds architecture by removing entirely the human performer, a form of immateriality. "Robotic systems" do the same but differ by focusing on adapting spaces to human agency. "Immaterial agents" immerse audiences by manipulating atmospheric quality and environmental parameters, whereas "interactive elements" rest on articulating physical structures.

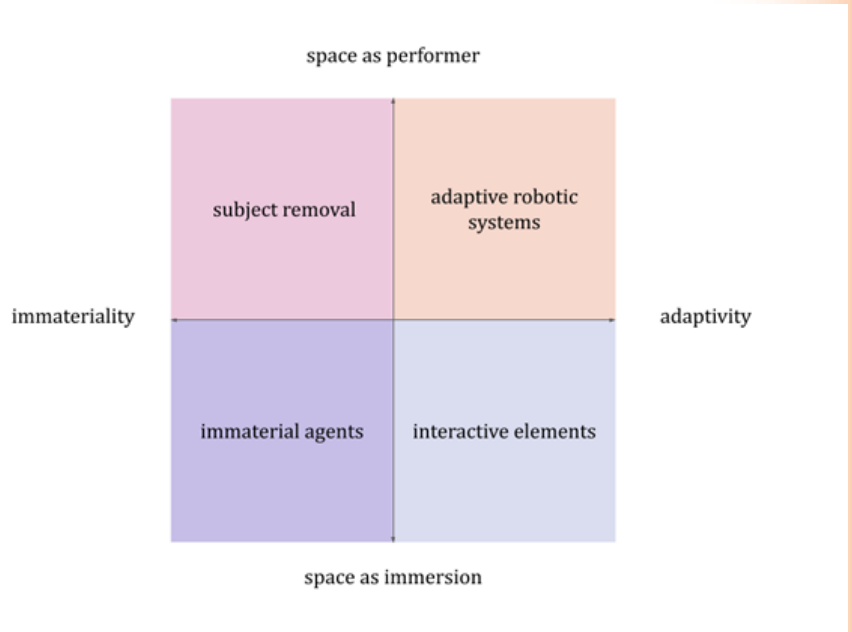


Fig.7. A compass of performance architecture, formulated from precedent analysis.

Curation is achieved when the agency of space is synchronised with that of the subject, resulting in a more captivating and interactive experience. One common factor between the approaches is the increase in interactivity as agents increase, for instance, shifting from a fixed viewpoint to a 360-degree field. Also, both axes transition from a limitation on the role difference between the space and the audience, reaching a no-boundary system between them. The axes signify a shift towards greater user engagement through interactivity. Although the domains differ, some focus on physical spaces, while others focus on media experiences, all coordinates share the underlying principle of progression. The performative effect resulting from such spatial transformation contributes to subject-agent feedback.

4. Methods

The study approach combines methods of case study, social survey, and design experiments. The goal is to understand how audience experience can be enhanced by foregrounding performative architecture as a theatrical agent, deriving a set of design principles.

4.1. Comparative Case Study

Two live performances in London were chosen for the case study for their differing levels of interactivity, providing insight into how individuals engage with varying degrees of interactive experiences. The authors attended the music show in-person; the process was recorded via field notes detailing the qualities, hand-sketch illustrations, and photo documentation.

- Case study I tried to understand the relationship between subjects and agents in the two performances, labelled A and B.
- Case Study II studied two performance spaces, labelled X and Y.

Our overarching objective is to construct a new trilogy that integrates these components into a design system, with strategy to enrich the audience experience.

In framing our design approaches, it is imperative to highlight the challenges surrounding audience experience, supported by results of social survey analysis. These challenges will serve as the focal point, driving our research forward and guiding our efforts to enhance engagement.

Finally, all is consolidated into a set of four strategies. By comparing parameters between performances, strategies and techniques that can contribute to a more satisfying, immersive, and engaging experience, the strategies were identified to inform future performance spaces and practices.

4.2. Social Survey

A survey was tailored to explore the impacts, immersivity, and audience engagement of performative spaces (refer to appendix). A questionnaire was structured to encompass various parameters, specifically in enjoyability, performance rate, connection, resonation, engagement, experientiality, and overall satisfaction to capture participants' experiences and perceptions effectively.

Participant Sampling

Participants of Case Study I were convenient sampled from audiences immediately following the end of performances A and B. In Case Study II, participants were recruited via social media platforms, targeting individuals who had attended the Thin Air exhibition.
There were thirty-two responses from participants for Case Study I, and fifty responses for Case Study II, who were asked to reflect on their overall experience separately, describing the atmospheres to establish a baseline measurement. This summarises participants' overall impressions concisely and provides a quick snapshot of their feelings.

Questionnaire Design

The questionnaire was sectioned for Case Study I to thoroughly evaluate participants' experiences and perceptions of performances A and B. The design of the questions prioritised clarity, conciseness, and impartiality. The sections of the questionnaire were as follows:

- ***Performer Comparison***: Participants were prompted to compare their performances.
- ***Satisfaction Ratings:*** Participants rated their overall satisfaction with each performance on a scale of 1 to 10, enabling quantifiable feedback.
- ***Engagement Assessment:*** Participants assessed their level of engagement using a Likert scale ranging from "Not engaged at all" to "Extremely engaged," offering insights into their connection with the performances.
- ***Experimental vs. Traditional Perception:*** Participants categorised each performance as experimental or traditional, reflecting their perception of the performances' innovative or conventional nature.
- ***Overall Impression:*** Participants indicated which performer's live electronic sounds left a stronger impression, capturing the lasting impact of the performances.
- ***Audience Resonance:*** Participants identified which performance they believed resonated more with most of the audience, providing insights into audience preferences and collective experience.

For Case Study II, the questionnaire was structured to comprehensively assess participants' experiences and perceptions of Spaces X and Y at Thin Air. The design of the questions emphasised clarity, conciseness, and impartiality. The sections of the questionnaire were as follows:

- ***Immersivity Comparison:*** Participants were asked to compare the immersivity of Space X and Y at Thin Air.
- ***Satisfaction Ratings:*** Participants rated their overall satisfaction with each space's performativity at Thin Air on a scale of 1 to 10.
- ***Impact on Audience:*** Participants were prompted to identify which space they felt had a more substantial effect on the audience.
- ***Resonation:*** Participants indicated which space resonated more with them.
- ***Engagement Assessment:*** Participants assessed their level of engagement with space X and Y at Thin Air using a Likert scale ranging from "Not engaged at all" to "Extremely engaged."

The questionnaire's design aimed to facilitate clear and concise feedback while maintaining impartiality. Likert scales were employed to allow for quantifiable ratings of satisfaction and engagement, standardising the assessment of satisfaction, engagement, and perception and enhancing the reliability of the responses. These structured questions were intended to provide comprehensive insights into participants' experiences and preferences regarding the immersive performances. Electronic distribution through social media platforms maximised accessibility and participation efficiency.

5. Comparative Case Study I: Agents and Subjects

5.1 Performances: Live Music

Performance A featured two DJs who crafted their acoustic percussive with analogue instruments using bolts, strings, carbon, steel, and electronic devices to produce sound. They controlled the sound by manipulating the bolts and machinery, adjusting knobs for specific volumes and frequencies. The performance occurred in an outdoor venue arranged in a loose interpretation of a proscenium typology, with an elevated wooden stage for the DJs and parallel seating providing a clear view of the performers.

In contrast, Performance B, led by a composer and performer, employed a more interactive approach using robotic integration to generate electronic music. The artistic practice revolves around designing hybrid instruments, developing software, repurposing hardware, and manipulating improvised vocalisations. Collaborative efforts with dancers, visual artists, and instrumentalists are also integral to the compositional process. Motion sensors were attached to the arms in the performance, translating hand gestures and body movements into electronic sounds. This work was imbued with a dynamic element where sound was generated through motion rather than direct control. A wearable collection of motion sensors was created using a microcontroller system known as Arduino. Each movement detected by the sensor was coded to a different generation of sound worn on the performer's hand. Each specific movement generated a corresponding sound intricately linked to the movements' swiftness, speed, or angle.

Table 1. Summary of the comparison between the two performances.

PERFORMANCE A	PERFORMANCE B
Electronic Music	Electronic Music
Created their own instrument	Created their own instrument
Analogue Control	Digital Control
Sound was controlled	Sound was generated by movement
Performance outcome focused on sound	Performance outcome focused on Sound and Movement
Loose Proscenium Layout Typology	Loose Proscenium Layout Typology
Outdoor Setting	Indoor Setting
Around 50 viewers	Around 50 Viewers
Same Audience of Performance B	Same Audience of Performance A

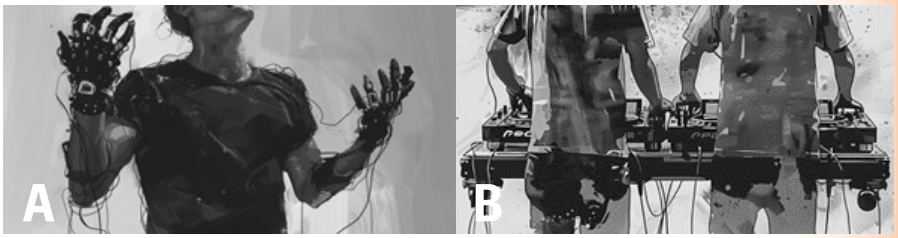


Fig.8. Performances A and B, respectively, live music performances, illustrated from field observation.

5.2 Social Survey on the Performances

For case study I, questionnaire results show Performance B has a higher overall score than A in all parameters (figure 7).

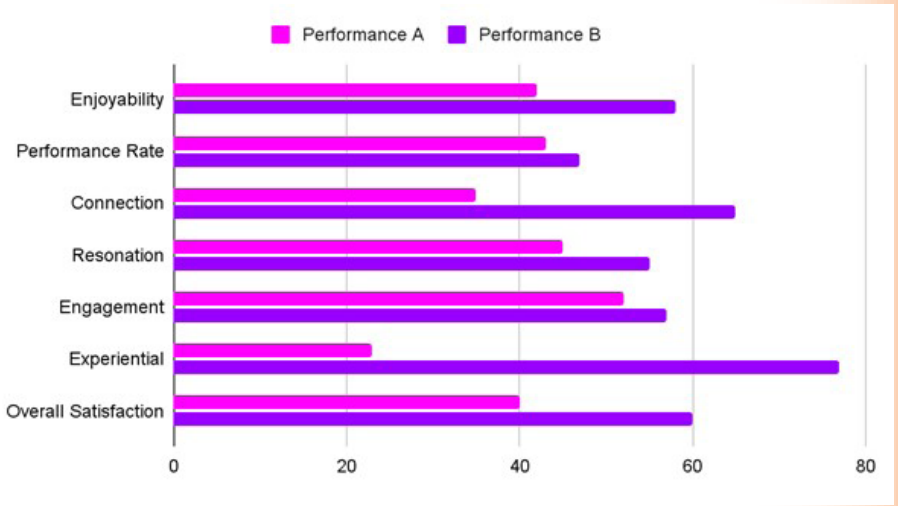
Upon closer examination, a critical disparity was observed: “experimental” and “connection” resulted in the greatest difference in audience scoring. However, the “performance rating” and “engagement” came close between the two shows.

Considering that Performance B included movement, while Performance A did not, it gave the audience a greater sense of connection to the performer. However, this feeling of connectedness does not necessarily affect audience engagement.

Although performer B’s music was not generated from precision, through spontaneity and free expression of bodily movement, it successfully aroused in the audience group a sense of exploratory excitement. Keep in mind that both performances enjoyed a similar level of quality regarded by the audience; B resulted in a significantly higher score in overall satisfaction.

This distinction rendered the performance with two focal points—sound and movement—where both elements assumed equal importance. Consequently, extreme expression or sensation, as emphasised in performance B, was heightened. It engendered heightened audience connection by adopting a curatorial-specific approach where movement and sound coalesce as subjects.

Here, the focus on movement, interactivity, and feedback exemplifies an immaterial approach and demonstrates the exceeding strength in building connections between subjects and agents. At the same time, the multi-modal art form provoked a sense of experimentativeness and satisfaction.



Graph 1. Survey results of case study I from thirty-two participants.

6. Comparative Case Study II: Space

6.1 Performative Architecture

Case study II was conducted on two spaces, X and Y, exhibited at Beams in London in 2023. All spaces were without performers; however, they showed a variety of research on sound, light, and space.

Space X specialises in real-time, generative, and code-based art, showcased through music, performances, and intricate installations. The objective was to elicit visceral and inspirational responses. By seamlessly merging noise with randomised algorithms, it harnessed digital technology to confront the political and power structures of the Anthropocene era, unveiling them as covert yet profoundly entrenched elements of contemporary society. Space X was a vast rectangular room, similar to a hangar, with a steel frame present every 3 - 5m. Connecting the frames are other steel beams, creating a grid. A continuous LED light source is linked with high sounds within each frame and beam. The light and sound moved together such that the volume and frequency of the sound changed with the brightness of the light. The darker and more intense the sound was, the more the light shaped the room.

Space Y, by Setup, is an internationally renowned studio that combines multimedia art, lighting and stage design, and performance programming. The team is motivated by its goal to investigate the expressive possibilities offered by emerging digital technology. Space Y also showed an interplay of lights and sounds where when one light is seen, a direct sound is associated with it. Its space was divided similarly to Space X. However, it was smaller than Space X.

Table 2. Summary of the comparison between the two spaces.

SPACE X	SPACE Y
Bigger space	Smaller space
Movement of LED Lights in straight lines	Movement of LED Lights in straight lines
Flashing of Thin light in grid location	No flashing of thin light
Flashing of Spotlight	No Flashing of Spotlights
High light strobe effect	No light strobe effect
Presences of Haze	No Haze
Presences of fans	No fans
Presence of speakers	Presences of speakers
Moment of emptiness	Low to no moments of emptiness

Fig.9. Space X and Y, exhibited in London, demonstrated different performative spaces with no performer.

6.2 Social Survey on Performative Architecture

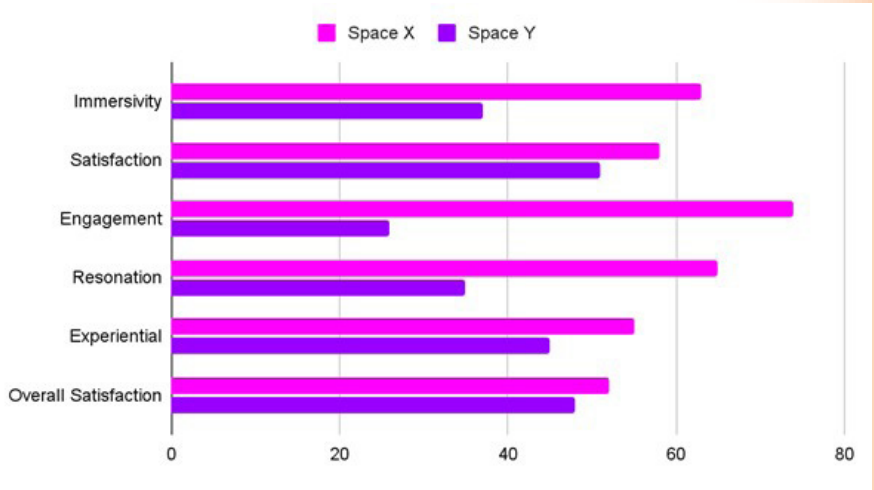
For case study II, Space X has a higher overall survey score than Y in all parameters (Figure 8). Space X exhibited differences in spatial manipulation, featuring more agents, such as light strobes, haze, and fans, resulting in a more pronounced lux effect and a more significant variation from darkness to light in a shorter duration.

By comparing the survey parameters, it can be observed that the most significant disparity in scoring between the two spaces resided in “engagement”. Both venues transformed the physical perception of space by integrating light, programming, and sculpture, creating an illusion of shifting boundaries and dimensions. However, the visual manipulation of space through extreme light and dark conditions in X fostered a perceptual shift in spatial proportions and form.

The second greatest disparity between the scoring of the two spaces lies in “resonation” and “immersivity”. A few differences could be evident when comparing the two design intentions. The immersive effect was accentuated in Space X by having more agents transition into subjects. A high light strobe effect dominated the space, with X having a vast ceiled space much more significant than Y. Also, X had moments of emptiness of light that weren’t as (in)visible in Y. Consequently, the perception of a shape-changing space in X contributed to a heightened resonation and immersive experience.

Despite the disparity in most parameters, the overall audience satisfaction came quite close between the two spaces. Also, both were regarded by most audiences as “experiential”. Noting that these venue designs involved an interplay of lights, sound and shadows, which fashioned the perception of dynamically changing spaces. The amalgamation of visual perception, auditory (a)synchronicity, and space operated harmoniously as a unified element.

These contributed to the space’s success in integrating subject removal and interactive elements approaches. Although the designs intentionally removed any human performer through automation to foreground architecture, it simultaneously reinforced human agency, as audiences who navigate between spaces, reflected and refracted by light and shadow, added to the theatrical presence. The navigation concurrently adds to the complexity of the rhythm and sound, orchestrating a spontaneous interaction and feedback between agents and space, resulting in high satisfaction of the performance.



Graph 2. Results Percentage of case study II from fifty participants.

7. A Proposal

7.1. Four Approaches to Performative Architecture

Based on the results and experience documented, four design strategies are formulated to create performative spaces to enhance audience experience and engagement.

Strategy 01: interactive elements: The design strategy for crafting a fully immersive performance space involves dynamically allowing the space to move alongside the performer. This approach is implemented by integrating sensors and actuators. Sensors detect the performer, while actuators facilitate the spatial adjustments. The technical intricacies of soft robotics can be explored through pneumatic or bending active structures like rods. Air compressors or a dynamical motor can manipulate these structures to effect the desired spatial transformations. Figure 11 depicts a diagrammatic example. The space exhibits particular behaviour at a specific distance from the performer and the sensors. If the distance exceeds a certain threshold, the sensors and actuators recalibrate to maintain proximity, allowing the space to move synchronously with the performer.

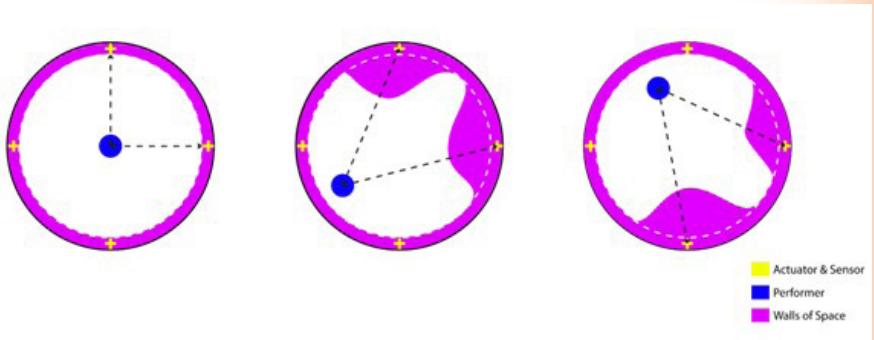


Fig. 10. Diagrammatic plan of strategy 01: interactive elements.

Strategy 02: subject removal: The second strategy involves accentuating the architecture by temporarily excluding the performer at specific intervals, redirecting attention to the architectural form and making it the focal point. Removing the performer puts the automation and controller of performative space in question, accomplished through a design approach that shifts the space from a monolithic structure to one with internal subdivisions. In such instances, the compartment can, at specific points, create situations where the performer is absent.

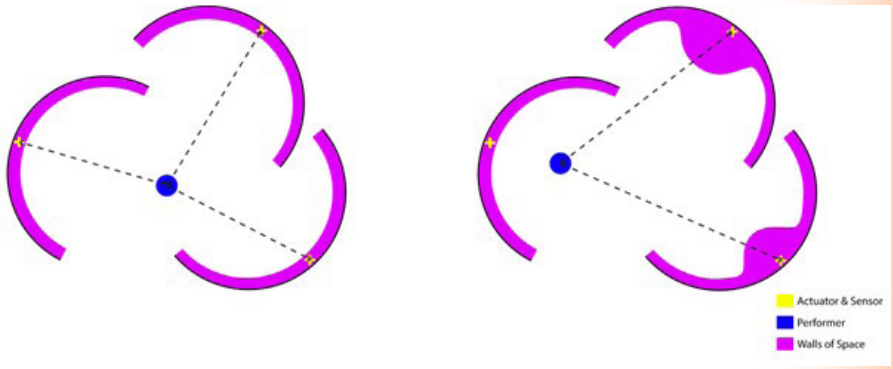


Fig. 11. Diagrammatic plan of strategy 02: subject removal.

Strategy 03: immaterial agents: For a more dynamic and curated experience, an approach involves drawing inspiration from museums and guiding participants through various spaces during a tour. This navigation simultaneously introduces the concept of multiple performing spaces, engendering excitement and anticipation through envelopes and discoveries, unifying spatial efforts to generate a progressive experience.

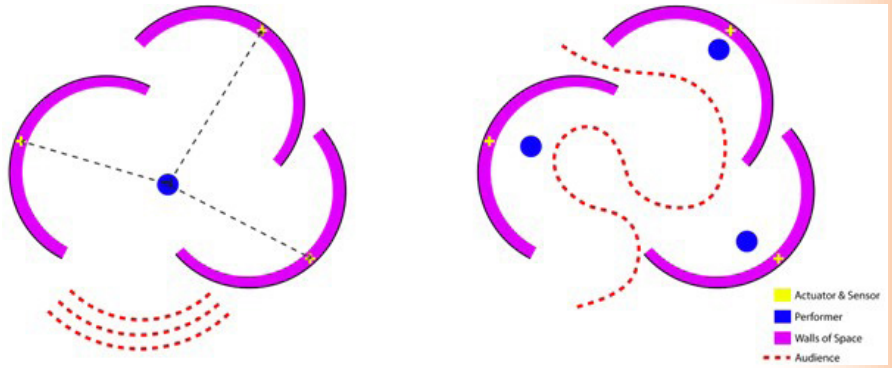


Fig. 12. Diagrammatic plan of strategy 03: immaterial agent.

Strategy 04: adaptive robotic system: The approach merges the spaces, creating an intermediary space between two performers. In this scenario, the intermediary space emerges as the focal point of architectural significance. It assumes the role of a performer within the spatial context. Figure 14 illustrates the convergence of these two spaces, giving rise to what we recognise as a full adaptive robotic system.

The interplay between architectural elements and the performer's presence in this space dynamically shifts focus. At times, the architectural design dominates the scene, drawing attention to its form, structure, and spatial qualities. Conversely, there are moments when the performer becomes the focal point, captivating the audience with their presence and actions within the space, assigning value to the spatial experience. By alternating between architectural prominence and performer engagement, the space is imbued with a sense of dynamism and narrative, inviting viewers to engage with it in a multifaceted manner.

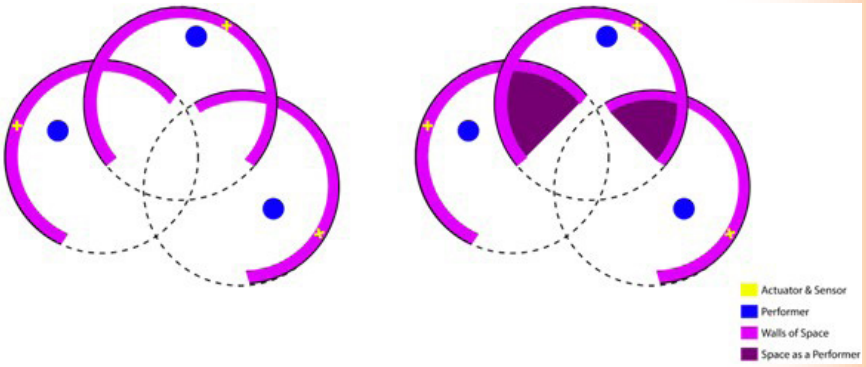


Fig. 13. Diagrammatic plan of strategy 04: adaptive robotic system.

7.2 Strategies Applied on a Merged Proposal *Soft Acoustic Tile* and *Interactive Pavilion*

We envision creating a pneumatic silicon space by fusing the design principles demonstrated in the material composition of the *Soft Acoustic Tile* and the inventive system employed in the *Interactive Pavilion*. This space is characterised by its dynamic inflation and movement towards

the performer once they surpass a defined distance threshold. Conversely, it deflates as it senses the performer's proximity to a designated pneumatic sensor. This synthesis introduces an architectural performer that seamlessly integrates with the theatrical performance, transforming into a technological extension of the dancer's movements. This symbiotic relationship between technology and performance enhances the immersive experience, blurring the boundaries between the physical space and the artistic expression.

The depicted sequence illustrates the conceptual framework of the initial strategy: Adaptive Robotic System. State 1 shows an unoccupied space, characterised by its inert state resulting from the absence of any activating force. Moving to state 2, a person is positioned within the space, strategically placed centrally at an equidistant specific distance from sensors A and B. Despite this arrangement, no inflation or activation is observed. However, in state 3, the performer shifted further away from the central point, causing sensor A to detect an increased distance. This alteration triggers the inflation mechanism, thereby instigating the activation of the space and demonstrating its responsive functionality.

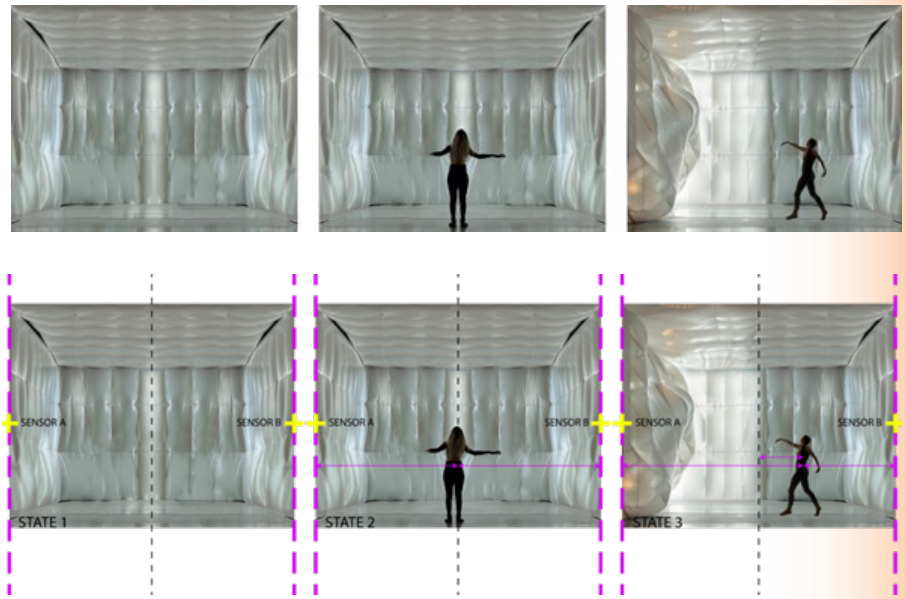


Fig. 14. Strategy 01 of the merged proposal showing three states.

The other strategy of having the space as a performer can be seen In figure 16, three distinct spaces are labelled A, B, and C. Both A and C contain performers, with B serving as an intermediary space where the walls shift in response to the movements in A and C. As individuals move away from the central space (resulting in increased distance between them and the sensor), the corresponding space expands proportionally to the detected distance. Hence, space B metamorphoses into an active performance area even in the absence of a performer within, thereby asserting itself as the foreground focal point.

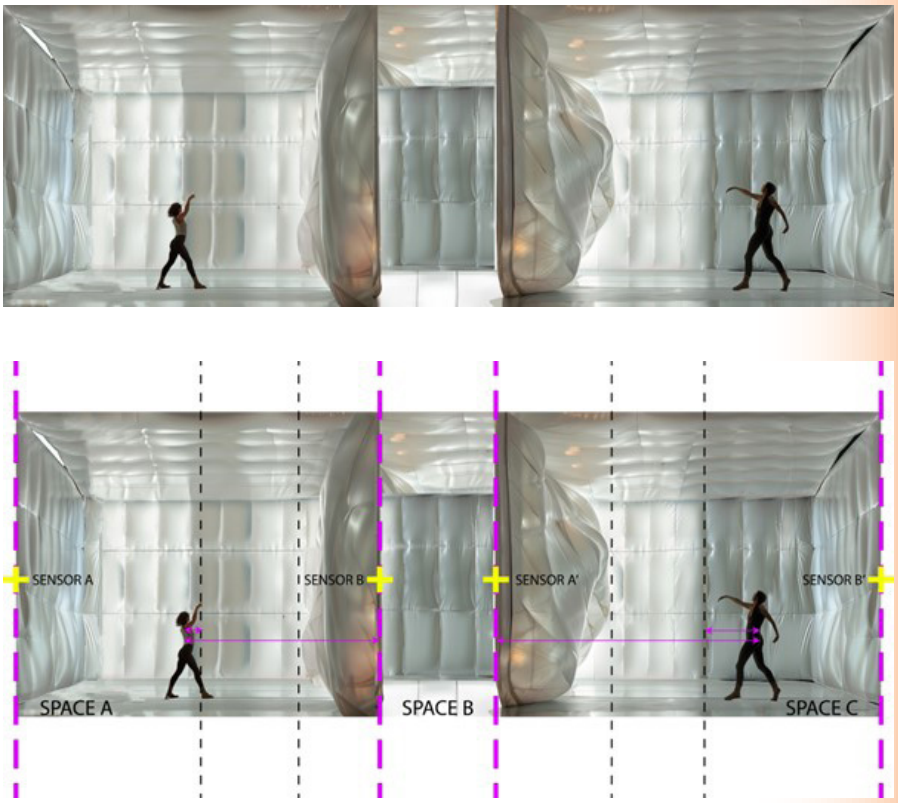


Fig. 15. Strategy 04 of the merged proposal.

8. Limitations and Next Steps

Upon reflection, the survey captured and agglomerated participants' experiences and perceptions; however, limitations were noted during the process.

First, potential response bias and the absence of open-ended questions for qualitative insights were noted. The study's next steps will be to conduct pre-testing and behavioural mapping validation to enhance reliability and triangulate results.

Second, questionnaires rely on self-reported responses, which may need more depth in exploring nuances to capture the spectrum of immersive experiences fully. The decision to begin with a formal survey approach was based on establishing a basic understanding. A future project iteration will involve informal responses from participants with a more participatory approach to cross-compare insights.

Third, a notable limitation is the need for demographic data collection. This step is vital for understanding the diversity of participants and gaining insights into how different social groups perceive and engage with performative spaces.

Finally, it is essential to note that with any dynamic performance, many variables beyond the architectural aspect contribute to the marvel. As these variables are often dependent and instrumental, it is essential to read the insights generated from the study as a reference for design aspiration.

The prospect of the four approaches guiding a systemic reading of performative space beyond stage design to the larger architectural realm is recognised. Still, applying them to experiment and progress

would need further effort. We hope this can lay the first foundation stones to provoke future work in the area.

9. Conclusion

This paper delves into the transformative potentials of integrating shape-changing soft robotic architecture into performance spaces. By endowing traditionally static architectural backdrops with dynamic capabilities, a new dimension of experiential design emerges, enriching the immersive journey for spectators.

This adaptability not only enhances the versatility of spaces but also lowers the marginal cost of mass customisation for individual performances. The infusion of dynamism can captivate and stimulate new bodily-sensory experiences and a deeper engagement with artistic narratives unfolding within material spaces.

As performance arts are increasingly challenged by growing digital engagement, behavioural change in audience habits post-pandemic, and a shrinking ticket market due to deflection, it calls for a paradigm shift in the way we curate, generate, and communicate the value of physicality.

Through a comprehensive analysis of four design approaches: subject removal, immaterial agents, interactive elements, and adaptive robotic systems, the study serves as a first step in uniting greater efforts, bridging dialogues, and sailing further expeditions on the shifting role of physical spaces in an increasingly digitised landscape.

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Appendix I

The following survey on case study I was asked:

1. Which performer's live electronic sounds did you find more enjoyable?

a. Performance A
b. Performance B

2. Rate your overall satisfaction with Performance A performance on a scale of 1 to 10.

3. Rate your overall satisfaction with Performance B on a scale of 1 to 10.

4. Which performer do you feel had a stronger connection with the audience during their live electronic performance?

a. Performance A
b. Performance B

5. Which performer's style of live electronic music resonated with you more?

a. Performance A
b. Performance B

6. How engaged were you with Performance A?

a. Not engaged at all
b. Somewhat engaged
c. Moderately engaged
d. Very engaged
e. Extremely engaged

7. How engaged were you with Performance B?

a. Not engaged at all
b. Somewhat engaged
c. Moderately engaged
d. Very engaged
e. Extremely engaged

8. Did you find Performance A more experimental or traditional?

a. Experiential
b. Traditional

9. Did you find Performance B more experimental or traditional?

a. Experiential
b. Traditional

10. Considering the overall experience, which performer's live electronic sounds left a stronger impression on you?

a. Performance A
b. Performance B

11. Which performer's live electronic performance resonated more with most of the audience?

a. Performance A
b. Performance B

Appendix II

The following survey on case study II was asked:

1. Which room did you find more immersive at Thin Air, Beams?

a. Space X
b. Space Y

2. Rate your overall satisfaction with Space X's performativity at Thin Air Beams on a scale of 1 to 10.

3. Rate your overall satisfaction with Space Y's performativity at Thin Air Beams on a scale of 1 to 10.

4. Which room do you feel had a more substantial impact on the audience?

a. Space X
b. Space Y

5. Which room resonated with you more?

a. Space X
b. Space Y

6. How engaged were you with Space X at Thin Air, Beams?

a. Not engaged at all.
b. Somewhat engaged.
c. Moderately engaged.
d. Very engaged
e. Extremely engaged.

7. How engaged were you with Space Y at Thin Air, Beams?

a. Not engaged at all.
b. Somewhat engaged.
c. Moderately engaged.
d. Very engaged
e. Extremely engaged.