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Paper: **Constant Redefinition of Relations in Responsive Environments: Unpredictability and Boredom as Generative Impulses**

Topic: Architecture

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Abstract:
This paper focuses on the new experiences in architecture provided by the introduction of new technologies and advances in the computational paradigm, which have given way to the design and building of dynamic and flexible environments called responsive environments. Being dynamic and flexible, responsive environments are able to respond to changing conditions in the environment and the user actions. Their capabilities, extending from capturing the information from the environment to providing real-time outputs illuminate interesting opportunities for designers and users.

This emerging experience of responsiveness defines new experiences for the user, where the notion of responsiveness goes beyond that of a computer responding automatically to a given input and denotes a continuous redefinition of the boundary between the users' embodied self and its' computed representation. In the constant redefinition of this boundary neither the responsive environment nor the user can be regarded as passive receptors. Instead, they act as dynamic and active entities evolving and redefining the mutual relationship in-between constantly. This paper focuses on this relationship, where the environment and the user can be intertwined in such a way that each one acts like an extension of the other and propose new experiences. In order to attain this continuous redefinition, the relationship between the user and the responsive environment should sustain its continuity and open up new experiences and relations.

In this paper it is argued that introducing generative impulses that can help to continue the interaction between the responsive environments can be considered as a generative approach that produces variation. Concepts of 'unpredictability' and 'boredom' are conceived as motivating and generative impulses that can help to continue the interaction between the responsive environment and the participant and generate new experiences and relations. The paper also exemplifies a design-research experiment that was implemented as a portable digital screen to test and discuss the conceptualization of 'unpredictability' and 'boredom' as generative impulses in responsive environments.

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Constant Redefinition of Relations in Responsive Environments: Unpredictability and Boredom as Generative Impulses

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1.Introduction

Architecture and the built environment have close relationships with several research fields such as technology, science, engineering and philosophy and are directly or indirectly affected by the developments in these fields. Advances in communication and information technologies, as well as recent developments in computer technology, material research and sensor networks influenced the definition of built environments and hence altered the architectural design practice. In the light of emerging progresses in these fields, built environment has been redefined to address dynamic, flexible and responsive qualities that bring forth new reflections on architecture. The idea of responsiveness is one of these reflections on architecture, which calls for the participation of the human and the machine in the definition of the responsiveness of the environment.

Parallel to the technological advances, the changes in social, economic, cultural, and technological contexts have also affected the experience of the environment. They resulted in intellectual transformations, and have altered the way participants experience the environment, which led to the conception of responsive environments as a design and research field in the recent decades. These environments enable to share and exchange information between different parties such as machines, participants and environment and introduce a new mode of communication and interaction. Experience of this updated interaction defines new experiences for the human and challenges the design of built environments.

2.Responsiveness and the Experience of Responsive Environments

The idea of responsiveness and being responsive to the changing circumstances has significant reflections on built environment and hence on architecture. The ability of the environment to alter its form and reflect the environmental conditions is related with the concept of responsive architecture and has gained significant importance in the last decades, especially with the application of computational tools and strategies in the design and construction of built environments. [1] Nicholas Negroponte provides the initial definition of responsive architecture and states that responsive architectures are ‘‘a class of architecture or building that demonstrates an ability to alter its form, to continually reflect the environmental conditions that surround it.” [1] Parallel to the definition of Negroponte, recent examples of responsive architectures make use of computer technologies to reflect the changing relations and conditions. Through the use of computers and computational theories, the proposed environment/system becomes sensitive to changes in the information and responds to the data received from the participant and the environment.

Definition of the responsiveness through computer technologies gives the environment the ability to trace and respond to the changing conditions or stimuli from different sources: the participants, environment, and system. Computer technologies are made use of to include the computational behavior at any phase of the interaction process such as gathering information from the environment, processing the gathered information or providing a response to the environment.

Through the use of sensors, actuators, processors and various control theories, the environment gains the ability to simultaneously scan, process and provide the already defined counteraction of the data that is present at the environment or sent to it. [2] This advanced communication between the participant and the environment defines new spatial experiences and provides the desired compatible, effective and dynamic performance of the environment. The advanced communication enabled through the use of machines equipped with real-time processing technologies allows the environment to attain the desired adaptability and harmonious interaction between different parties, which is called the responsiveness of the environment. The responsive systems also enable the interaction between the participant and the environment and define the response of the environment to the changing conditions, social interactions and behavior of the participants.

The interaction between the participant and the system has evolved into a reciprocal relationship in the emerging examples of responsive environments, where each party involved in the interaction process respond to each other and redefine themselves. In their reciprocal relationship both the human participant and the system are considered as active and dynamic entities rather than passive receptors. They participate in the interaction process, affect the other parties and are affected from them. Through the spatial and technical systems employed in the system, the responsive environment acts like a translator and provocateur of certain experiences of feelings, emotions, behaviors, or states. In this manner, the experience and response of the participant and is detected and delivered both to the environment and to the other parties involved in the interaction process.

Engagement of the parties in the interaction process alters and redefines the relationships in-between and affects the definition of the environment. In this redefined environment, the participant can be considered as proactive parties as they are affected from the others and also from the environment. Extended into the responsive environment, these proactive parties enable the definition of more dynamic environments, which trigger the interactions between the machines, participants, their environment and wider networks of relations affecting them.

3.Extension of Relations into the Environment

The search for responsive environments that search for the extension of the parties on each other can be traced back to 1950s and 1960s, where Cedric Price and Gordon Pask provided the initial examples. However, in the last decades there is a remarkable increase in the number of studies that aim to attain the responsiveness through the use of technological advances such as ubiquitous computing, sensor systems, smart materials and textiles. These tools and strategies contribute to the definition and experience of the changes in the environment through the use of different interfaces, operating systems, and sensor-network technologies and enable the extension of the participants into the environment in different ways. [3]

Equipped with these systems and network technologies, these environments enable the interplay between the parties of interaction. Since the participants are interlaced

with the responsive interfaces and do not conceive the location and the working principles of the responsive interface at first sight, the proposed experience becomes unpredictable for the participants.

In the recent examples of responsive environments, the participants do not only interface but rather interlace with technology as they interact with the responsive systems and network technologies embedded into the environment. [4] As the participants and the technology are weaved together, the relationships between the participants, physical and social environment and the responsive system can be projected and extended into the environment. The interaction between them provokes the network of relations, defines new experiences for the participant and promises new concepts of built environment.

In this interplay, the participant can also be equipped with these systems and network technologies, which are integrated into the environment or located on the human body. Wearable technologies such as of head-mounted displays, digital technology, auditory displays, and body tracking technologies or smart textiles add computational and communicational capabilities to the parties of interaction and enable their active participation. [5] In the interaction process making use of wearable technologies, the coupling of the technology, human and the environment is defined through the responsiveness of the environment. Their coupling allows the participant and also the responsive environment to affect and be affected from the information provided through the interaction process. The connectivity between the parties and the responsiveness of the environment leads to a composite experience, where each party is affected by the experience of the other. Therefore, it can be claimed that, conception of the human participant as being interlaced with the environment through computational devices introduces new experiences for the participant and influences the formation and definition of the built environment.

In this reciprocal relation, both the human participant and the environment are defined as being in continuous transformation as the relations redefined during the interaction affect them. The relations defined between the parties are extended into the environment and the mentioned technologies are refolding the embodiment of relations and sending back into the interaction process. [6] The refolded relations redefine and/or transform the participants and initiate new data input to the interaction process. In order to attain the continuum of this process, in the recent examples of responsive environments, it is focused on multiplicities of participants and relations rather than single and static entities, where each party is coupled with the other through the relations. The experiences of the participants alter simultaneously as new relations are defined between the environment, the participants and the responsive interface. This calls for the active involvement of the participants and the interface in the definition of responsive environment, which enables the continuum of the interaction.

4.Boredom and Unpredictability as Generative Impulses

In order to experience the aforementioned transformations, the data exchange

between the participant and the environment as well as the type and process of interaction has to be defined in a competent and effective manner. This harmonious relation can be possible through the continuous transformation of the interaction between the participant and the environment and the data. Besides providing continuous data flow and responding to the interactions according to the relations embedded in the system, the responsive environment provides new expansions and experiences. However, when the responsive system responds to the similar data inputs with similar outputs during the interaction process, it acts as a passive element instead of a provoking one. In such a case, the continuous interaction between the environment and the participants may blur and lead to predictable and similar experiences, which do not inherit variation of experience and relations. Therefore, it is possible to claim that predictability and similarity of the interaction between the environment and the participants may define a monotonous relation for both parties and disrupt the continuity of the interaction.

The contribution of the unpredictability of the interaction to the responsiveness of the environment is the possibility of defining the variability of experiences and relations. It is the unpredictability of the variations in the interaction process, not the situation of the interaction and the environment that is out of control. In the design and definition of responsive environments, the concept of unpredictability can be conceived as a motivating aspect and a generative impulse for the variability of experiences defined by the responsive environment.

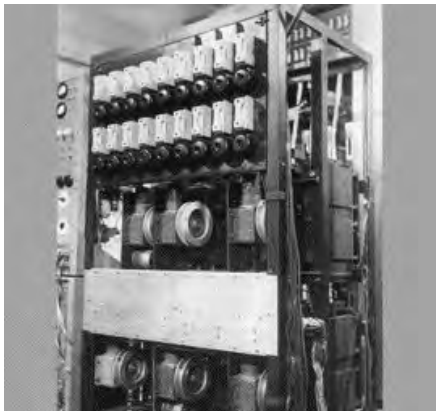
Since responsive environment is sensitive to the data received from the participant and the environment and reorganizes itself accordingly, the participant is provided with momentum, change and flow of action. Although, this circumstance seems to lack the experience of boredom at first sight, when highly intuitive systems were proposed or the interactive experience is repeated constantly, the participant may take a passive role. This passive condition may lead to boredom and loss of stimuli from the participant, which may result in the diminished or even totally disappeared continuity of interaction. However, boredom factor can be taken into account as a generative impulse for the responsive environment, which may trigger the relations and provoke the participants and the responsive system to actively participate in the interaction process.

The concept of boredom is commonly correlated with monotonous or repetitive activities [7] and with the dominance of unpleasantness, constraint, and repetitiveness. [8] Emphasizing its negative aspects, most of these definitions and descriptions underline that it is an individual experience and perception either of a situation or time interval. Susan M. Shaw defines boredom as ‘a state of under-stimulation, under-arousal, lack of momentum, or a lack of psychological involvement associated with dissatisfaction in the task situation’. [9] Psychoanalyst Ralph Greenson emphasizes the dependence of boredom on the experience of time and relates this feeling to the existence of a sense of emptiness, a passive attitude and a distorted sense of time in which time seems to stand still. [10] In fact, the correlation of time and boredom is a common approach in the studies about defining and describing boredom.

Another approach that emphasizes the relation between boredom and time is claimed by Heidegger. Heidegger defines boredom as a special fundamental mood related to the relationship between being and time. [11] Considering the relation between time and boredom, Heidegger differentiates between the experiences of boredom considering the individuals' elapsing the time, and provides three different levels of boredom; *becoming bored by*…, *being bored with*... and *profound boredom*. [11] These three different levels of boredom the time is not identified as the actual length of the time, but instead the individuals' experience of that specific time.

All these definitions underline the characteristics of a primarily negative state, which can be considered as an important factor affecting various aspects of a person's life. However, even though boredom is certainly associated with several negative effects, it can also provide positive motivation for experiencing new possibilities. Since boredom is considered as an indication of insufficient concentration or failure, boredom can provide signal for revising the situation, performance or concentration and have an adaptive role on the individual. [12] Therefore, boredom condition can be welcomed at certain circumstances as it inherits a potential of positive reinforcement and impetus. In responsive environments, the relation between the boredom proneness level and the continuity of the experience can also be approached with a similar attitude and the boredom factor can be considered as a generative impulse that triggers the relations defined between the parties of interaction and the responsive environment.

An early example of responsive environment that conceptualizes the experience of boredom as a provoking input is the MusiColor machine designed by Gordon Pask. Constructed in 1953, MusiColour machine was designed as a performance system reacting to the auditory input from the human performer in a concert. [13]



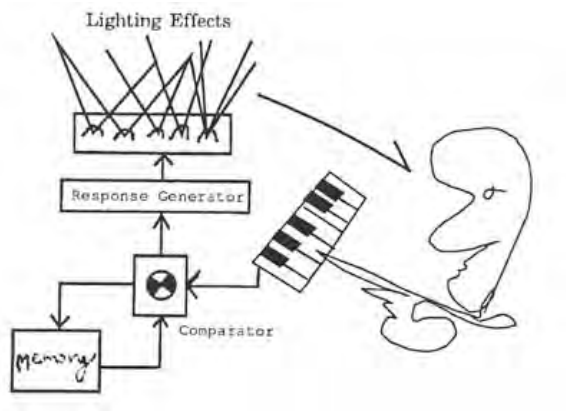


Figure 1 (Left): The control system of MusiColor Machine. [13]
Figure 2 (Right): Diagram of MusiColour machine. [14]

The machine that actively participated in the performance sensed the sound produced by the performers (musicians) and regarded them as inputs from the environment. [15] Processing these inputs, the machine responds to the environment

and the performers with lights in different colors flashed with different rhythms. [15] However, if the machine recognizes that it responds (flashes lights) in the same manner for a specific period of time, it gets bored and changes the flashing-pattern. In doing so, it alters the mode it determined for reacting the input (sound) driven into the environment and machine by the performers. [15] It is assumed that, these alterations in the flashing pattern will stimulate the performers with strange and unexpected experiences, which may encourage them to change the way they performed. [16]

In addition, if the rhythm and the inputs gathered from the environment are too continuous, or the frequency range is too consistent, the machine again gets bored and searches for other frequency ranges. It only responds to the performance when it traces those desired frequency ranges or a change in the inputs provided by the performer. [13] Therefore, through responding to a certain frequency range until it gets bored and searching for other possibilities for different interactions or rearranging and changing its flashing-patterns for increasing the stimulation, the MusiColour is regarded as an on-stage participant for the performance. [13]
In relation to the research on responsive environments and the concept of boredom, a test platform is proposed, which enables to discuss the interaction process between the participant and the responsive system. The proposed structure is a surface that is composed of several panels having groups of LEDs. These LEDs are activated through the interaction of the participant with the surface, which provides data for the system through the sensors embedded in the surface. The sensors are sensitive to the existence of an object, which provides visual and aural outputs. Each sensor controls a group of LEDs, which are affected by the movement of the object in relation to the proposed surface structure. The processed data gathered through the sensors creates different lighting patterns and aural responses.

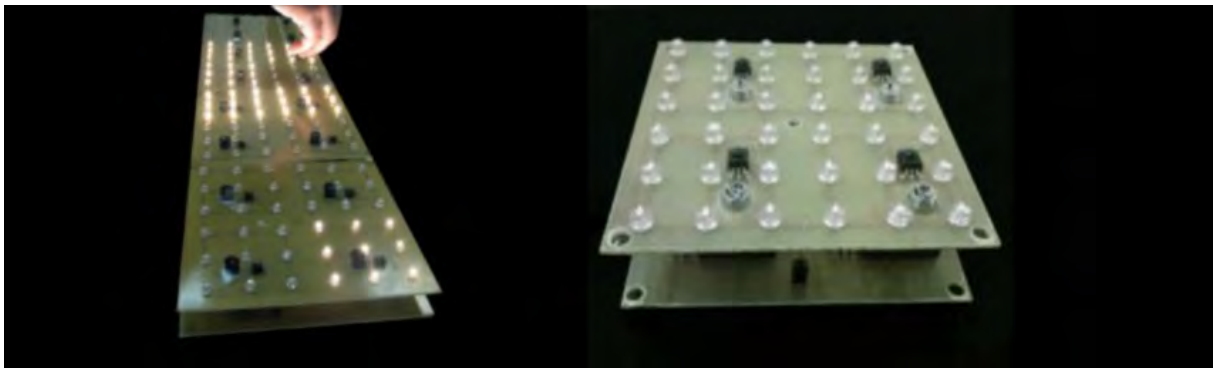


Image 3: The modular panels used for the responsive surface structure.

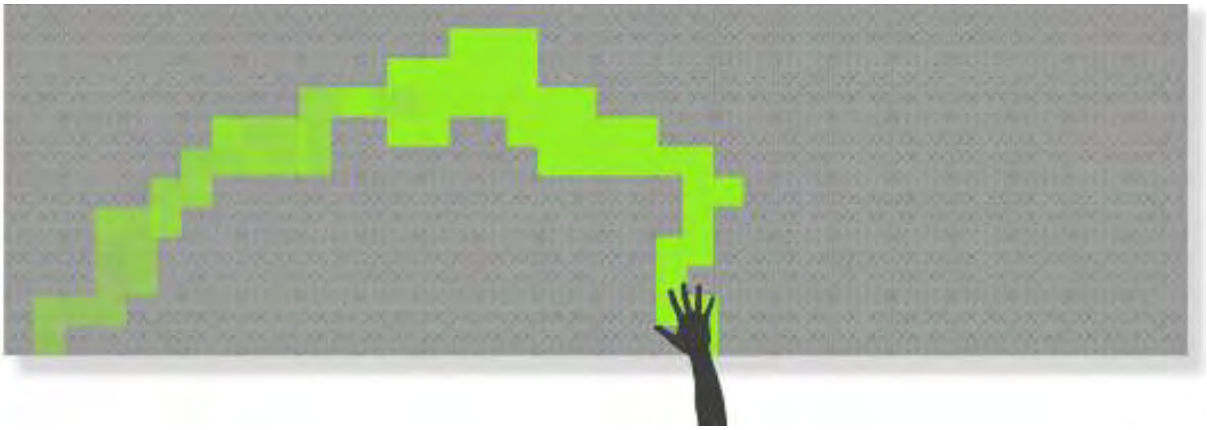


Image 4: Abstract representation of the interaction scenario of the responsive surface.

The proposed surface was tested through a group of participants and the interaction processes were recorded and analyzed. Besides, a questionnaire was applied to the participants, which guided the documentation of participants' experiences and comments. Analyzes of the interaction process enabled to reveal the activation frequency of each unit by the participant. After analyzing and documenting the experience of each participant, the data gathered were juxtaposed and several graphical representations were provided (Image 6).

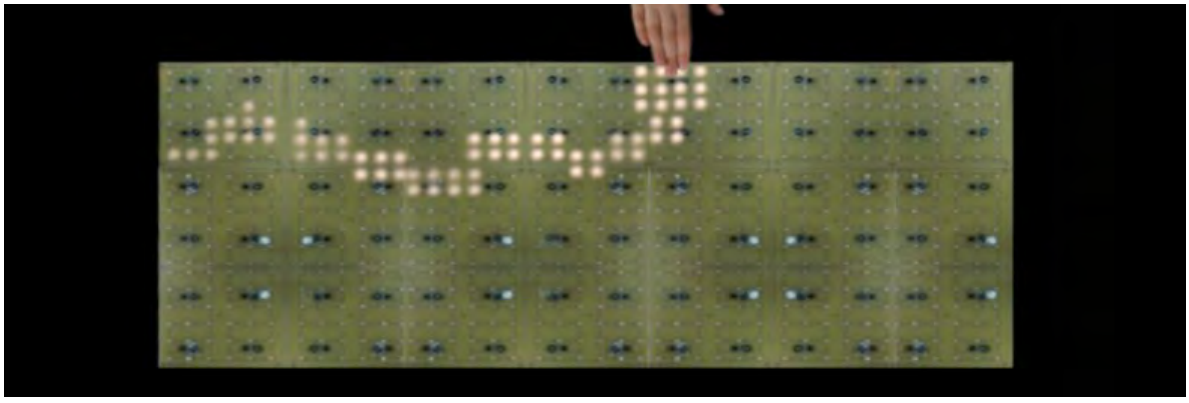


Image 5: Snapshot from the interaction process between the participant and the responsive surface.

Referring to these analyses displaying the activation frequency of the units, it was concluded that, some units were activated frequently, while some were never activated. Moreover, the analyses revealed that the units located at the middle of the model were the mostly activated ones. On the other hand, the passive condition of the units located at the upper left and right corners (A and B axes) was considered as a significant indication.

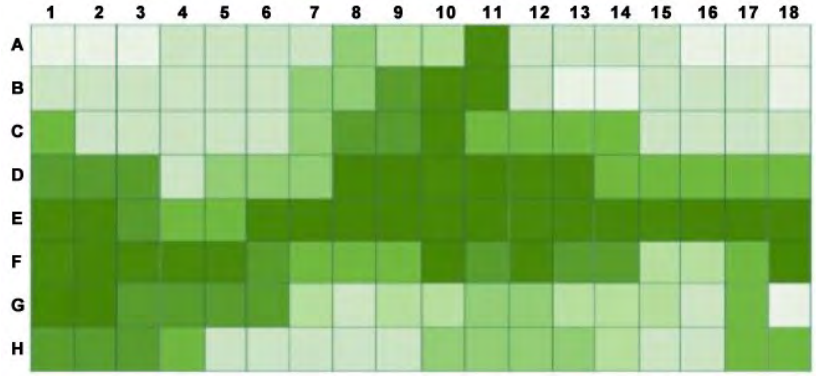


Image 6: Graphical representation of the activation frequency of the units in first model application.

Considering the results and evaluations of the first application, diversifying the interaction inputs/outputs between the participant and the surface was proposed as a way of satisfying the continuity of the interaction. Besides, unpredicted interaction scenarios was considered to be another factor that may trigger the relations between the parties of interaction. Therefore, a second model was provided and both visual (light) and aural (buzzer) outputs were included in the interaction process. In the second model, the activation frequency of the units was challenged by the inputs provided by the system to the environment and the participants. According to the activation scenario provided, if the participants activate the same group of elements more than 5 times in 10 seconds those units fall asleep and are inactivated for 5 seconds. Even if the participants try to activate those units they do not respond to the inputs provided by the participants. Moreover, if the participants activate the same units for more than 5 seconds without any interruption, the system gets bored and provides an aural response of buzzer sound. After the tests performed with the same participant group, the screen captures and questionnaire forms were analyzed with a similar approach that is used in the analyses of the first model application.

Referring to the graphical representations about the activation frequency of the units (Image 7), it was concluded that second pre-model application provided a more homogenous distribution. It was noticed that the frequency of activation that was concentrated at the middle part and central axes of the first model was diffused in the second model application and concentrated mostly around the units that provide an aural output. In addition to this, the analyses revealed that when the participants realized that the sensors are sensitive to a certain distance, they searched for other ways of interaction and used different parts of their bodies (their arms and faces) to activate the system.

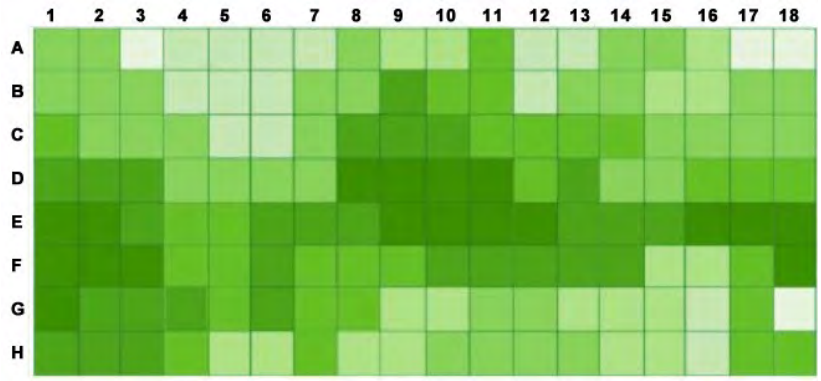


Image 7: Graphical representation of the activation requency of the units at second model application.

In the questionnaires the participants indicated that the aural response (buzzer) of the system had challenged their interaction with the system and they defined this condition as “unexpected”. Analyzes of the interaction processes reveled that the unpredicted experience of the aural response of the system guided the participants to search for new ways of interacting with the surface. Therefore, introduction of generative impulses that is unpredicted by the participant can also be considered as a way to provide the continuity of the interaction.

5.Conclusion

In reference to these analyzes it may be claimed that in the synergetic correlation of the responsive system with the participant and the environment, the interaction between the parties may lose its continuity. Interruption of the continuity may lead to similar experiences and obstruct the participation of the human and/or the system in the definition of the responsiveness of the environment. Unpredicted input to the environment inherits the potential of transforming the interaction between the participant and the system/environment that has already lost its continuity. The unpredictability of the experience may generate diverse interaction scenarios and new experiences. Besides, in the design and experience of responsive environments boredom can also be considered as positive stimuli for attaining the variety in experience and continuity of interaction. The experience of boredom may act as a drive for change, where both the responsive interface and the participant affected each other to satisfy the continuity of the interaction. Therefore, the search for the continuity of interaction can be considered as a generative approach that potentially defines dynamic and complex relations and able to generate variation in the interaction process, definition and experience of the built environment.

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