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INTERACTIVE ARCHITECTURE
EXTENDING THE KANSEI ENGINEERING APPROACH TO REAL-TIME INTERACTIVE SPATIAL SYSTEMS

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ABSTRACT

This paper will elaborate upon the term Complexity in Architecture and present interactive design strategies as a possible approach to comply with current architectural demands. User emotions being one of these demands will be discussed in connection with the need for performance driven adaptability of current architectural constructs and will be exemplified by presenting test cases in the form of student projects where evoking specific emotions is the main focus of the design. The design assignment of a SPA (Hyperbody interpretation: Sensory Performing Architecture) starting from reinterpreting the classic idea of a SPA and incorporating the interactivity into the building's behavior shall thus be presented as an applied research project.

Subsequently the relation of emotions and interactive architecture will be discussed and the Kansei method will function as a possible linkage to enhance the emotive performance of interactive architecture. Ongoing research projects will give an indication of further research questions and possible interconnections of emotion design and complex interactive architectural systems.

Keywords: *interactive architecture, emotive adaptive systems, real-time behavior*

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1. INTRODUCTION

Over the past few years there has been a continuous change in the demands of current architectural design. Due to environmental, technological as well as sociological changes next to functionality and design aesthetics, the performance and the adaptability of architectural environments have become the focus point for designing, constructing, and maintaining contemporary architecture.

The demands for a new building are comprehensive and change during the lifecycle of the architecture. A building has to comply with sustainability standards, be energy efficient, and multi-functional. At the same time the position of the user in architecture has become more and more important, which results in a strong focus on usability, pleasant environments, and individual user experiences.

In order to be able to perform and adapt to these multiple contextual (human, environmental, cultural, economic etc) parameters new technologies have become crucial to the field of architecture resulting in the development of new design techniques. Interactive architecture, one such contemporary design technique, enables architects to account for multiple contextual parameters simultaneously in real-time. Especially for the user in architecture this offers great potential to the architect, allowing for adaptability of the architectural structure and programming reactions of its subcomponents according to action patterns of the user. This gives one the possibility to present a variety of stimuli aimed at evoking specific emotions within the users and change and adapt the stimuli in real-time.

2. EMOTIONS

According to Scherer, emotions can be considered as "an episode of interrelated, synchronized changes in the states of [...] organismic subsystems in response to the evaluation of an external or internal stimulus event as relevant to major concerns of the organism". [1] Based on this definition we can distinguish between at least three main components involved in the process of creating an emotion: the appraisal of external/internal stimulus, the cognitive process and the user action pattern. As shown in Figure 1 these three components, based on the neurological processing abilities per individual (also governed by internal stimulus such as past associations etc) can result in variable user action/response patterns thus making every individual and his/her emotional state a dynamic phenomenon.

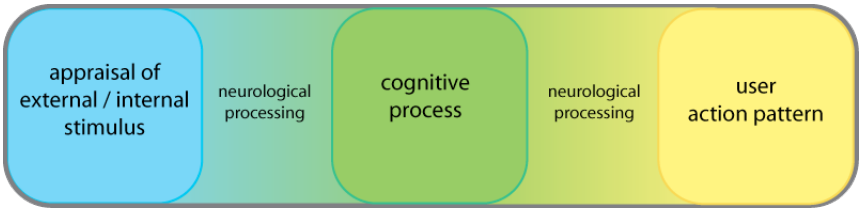

Figure 1: Neurological processing per individual as a fundamental link between the three emotion creating components

Arguing that every emotion starts with the appraisal process (appraisal theory), it does not matter anymore whether the emotion is generated as response to a perceived stimulus, remembered, or imagined event. An individual subjective emotional association is therefore as effective as an external stimulus to create an emotion. [2]

For the designing of products and with respect to this paper of architecture, this points out the main difficulty: every user is different and does not only have a different reaction to the surrounding than another user but every time he is confronted with the same stimulus a different reaction/ emotion can occur.

2.1. user emotions

Taking color as an example, Meerwein, Rodeck and Mahnke talk about biological reactions and the collective unconscious. Both valid for every human being since the biological reaction is a purely physiological connection between the stimulus, the eye and to the metabolism and organ functions and the collective unconscious is a part of our psyche that is the product of millions of years of the human evolution which reflect predispositions of responding to the environment. Both apply to every human being because they lead to a similar psychological or physiological interpretation of the stimulus and result in a similar expression of emotion due to genetic precondition although individually evaluated. [3]

However, while designing architectural constructs, addressing such basic human behavior, though important, is not sufficient, and although every user is different there has been an extensive research conducted about standard values aiming at providing a guideline to which psychological and physiological effect a sensorial stimulus can have. For these tests a product is either designed with specific sensorial qualities assuming a user action as a result which is then proven right or wrong or different variations of a product are presented to analyze which sensorial quality combination evokes the aspired reaction. [4]

The goal is to connect from the appraisal level – in this case with the physical product qualities (material, color, etc.) - to the cognitive level by evoking a psychological response (surprise, association, etc) or to connect directly to the action level by engaging the user in a specific activity, for example playing to induce a physiological or behavioral change. All adjustments should contribute to the creation of the desired emotion.

The Kansei engineering method starts from an aspired user experience and systematically tries to translate these psychological phenomena into physical product qualities. The emotion is therefore divided into subcomponents which are subsequently assigned to the physical product qualities.

2.2. user emotions in architecture

Architecture is mainly occupied with the first part of the emotion creation process.

Having identified architecture as a multi-sensory experience [5], architects are addressing the perception of space foremost via the visual components of the spatial experience. Compositions of color in combination with light, materials and form language are the most used tools to create a specific atmosphere (with a variety of stimuli). Visual perception research calculates the chances of architecture to succeed by the feeling of relevance of the

architecture that is created for the user [6]. This relevance does not only indicate the appraisal of the structure but implies also a connection between the user, the built structure, and the function of the building

Therefore the desired setting should be strongly connected to the function of the building. Whereas for functions as an office building, a schools or a hospital the experience goal is limited to designing a pleasant, function-stimulating environment other functions such as a church, a spa or a restaurant aim at evoking a deeper emotion at the user. Supported by the nature of the function an emotional setting is created that seeks to address the mental state of the user. Merleau-Ponty writes perception is sensation as a state of consciousness and the consciousness of a state [7]. One can argue that sensation in this case stands for the user's excitement including positive or negative feelings about the perceived, and consciousness indicates not only the awareness of the perceived space but also the awareness of oneself in it.

Clearly the attempt of architects is to design a positive sensation. To identify the preferences of the user is therefore a crucial part in the design process. Looking at the VIKE project the design process is partly handed over to the user in order to build an environment that fits the individual user demands [8]. The outcome should be an environment that is functional and pleasant to the user at the same time. In this way the emotion the Kansei of the user is main driver for the design. Although this is a promising approach for designing in this case a family home, some aspects remain to discuss.

The Kansei engineering process ends once the building is produced and built. The user Kansei nevertheless might change at a certain point. The possibility to change and adapt the architecture is limited to smaller adjustments without changing the structural shell.

Another question is how this approach could be extended to a larger scale: Public buildings have a bigger user group, which makes it impossible to let all of them participate in the design process. Still it is desirable that these buildings can address the user emotions, preferably for individual user groups and supporting the inhabited function.

3. INTERACTIVE ARCHITECTURE

Interactive architecture is an approach to satisfy the increasingly complex demands of architectural performance. It does not only enable a building to adapt to its surrounding, but to engage itself actively in a dialogue with the user. By the use of sensor technology the building collects data constantly. By understanding the demands and designing the possible adaptive configurations of the building components the designer can set forth the behavior of the building.

Sheizaf Rafaeli defined interactivity as "feedback that relates both to previous messages and to the way previous messages related to those preceding them" [9]. For interactive architecture this means that the building is able to use the data it gathers through different channels to adapt accordingly and to analyze the changes in the data received after that in relation to the adjustment it made.The building remains programmable, thus adjustable and is able to interact in real-time according to changing demands.

3.1. multi-relational design method

In current architecture the problem is that user oriented design is not the only demand. Questions of sustainability, flexibility, usability, cost-efficiency, and many more build up a complex construct when it comes to the task of designing good architecture. To visualize and weigh these demands against each other dynamic relational networks can be used. The advantage is that the user can be rated as very important which has instant impact on many other relations without excluding or neglecting them completely. The notion of dynamics in this case does not only indicate the adjustability of the composition or rating of the individual parameters but refers in the same way to the importance of time as influence for the relation network and the actual built architecture.

4. INTERACTIVE ARCHITECTURE – AN OPPORTUNITY FOR EMOTION DESIGN IN ARCHITECTURE

Interactive architecture solutions incorporating the afore-mentioned design strategies and real-time adaptation ability can gain considerably by specifically giving attention to the user and user emotions. In several projects on the border of art and architecture the user forms the centre of attention and the programmed interaction is concentrated on that relation. In other architectural examples the attempt to effect or stimulate a user emotion stay merely at the level of providing different stimuli without verifying if the aspired emotion is realized.

Still interactive architecture has the potential to establish this validation method. Coming back to the different phases of emotion, interactive architecture can not only provide different stimuli by adapting its configuration and spatial qualities but it can also react on the third phase, the result of the internal cognitive process of the human being by analyzing the users' action patterns as a result of this processing. Observing the human behavior in the architecture in the form of navigation, grouping proximity to architectural components, etc. and measuring individual user specific information such as heart rate, facial expressions, or body heat, latest technologies can help to identify connections between desired emotion, building adaptations and user reaction as a result of actual experienced emotion. In this way not only instant user reactions can be addressed but also emotion episodes which Weiss and Cropanzano explain as a series of emotional reactions presented over time as response to one underlying theme. [10] The creation of the appropriate stimuli is then a matter of the "learning process" of the system to improve. This process still has to be further developed and needs to be systemized.

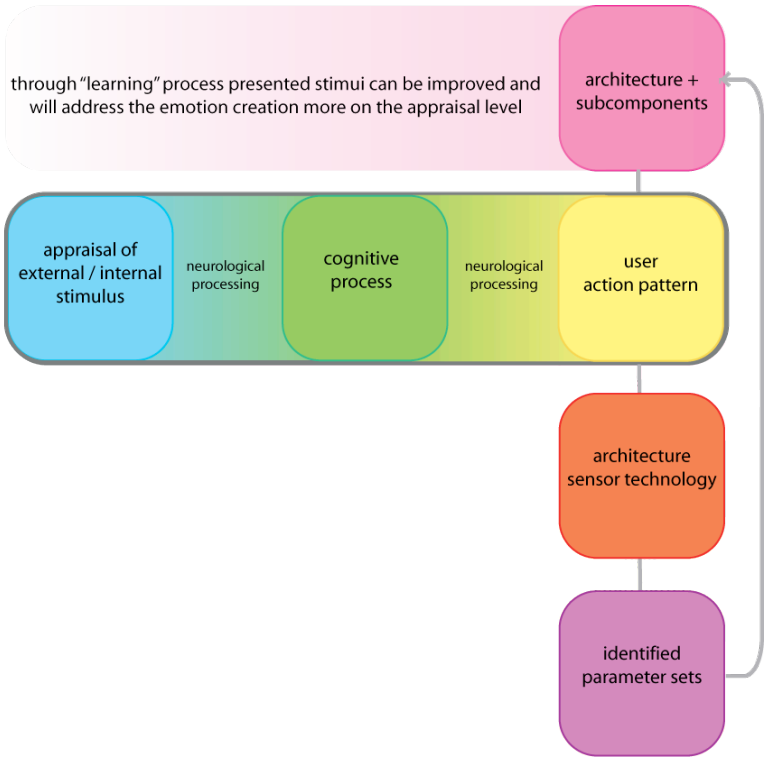

Figure 2: Principle of interactive architecture incorporating emotion creation process

4.1. Kansei engineering for designing interactive architecture

The Kansei engineering approach can provide this structural framework. The Kansei method splits up an aspired emotion into smaller subsets of the emotion until they can be translated into physical design features. This can be combined with a design approach in interactive architecture that deals with the complexity of a building structure, swarm systems. The main assumption is that a building is not one entity but the sum of its smaller subcomponents. These smaller components perform as individuals and by clearly defined relations to the other components build up a very complex group behavior.

There is an apparent overlap in the component based design approach. Connecting the two systems and starting from the emotions, subsequently breaking down these emotions to sensorial qualities in order to control the adaptation of spatial components (dealing with regulating light, sound, temperature, smell, structure) constituting an architectural space can result in multi-sensory spatial experiences as well as performance based architectural and interior articulations (interactive building skins, multiple usability of space via real-time interior augmentations etc). A promising step for the domain of interactive architecture would be to extend this process to a perpetual feedback loop relying on real-time contextual data to control performative components which adapt in real-time. This real-time interaction process can be seen as a design process involving a continual dialogue between a building, its users, its surroundings, and all other factors which would have an influence in defining emotive and performative aspects of the space under consideration.

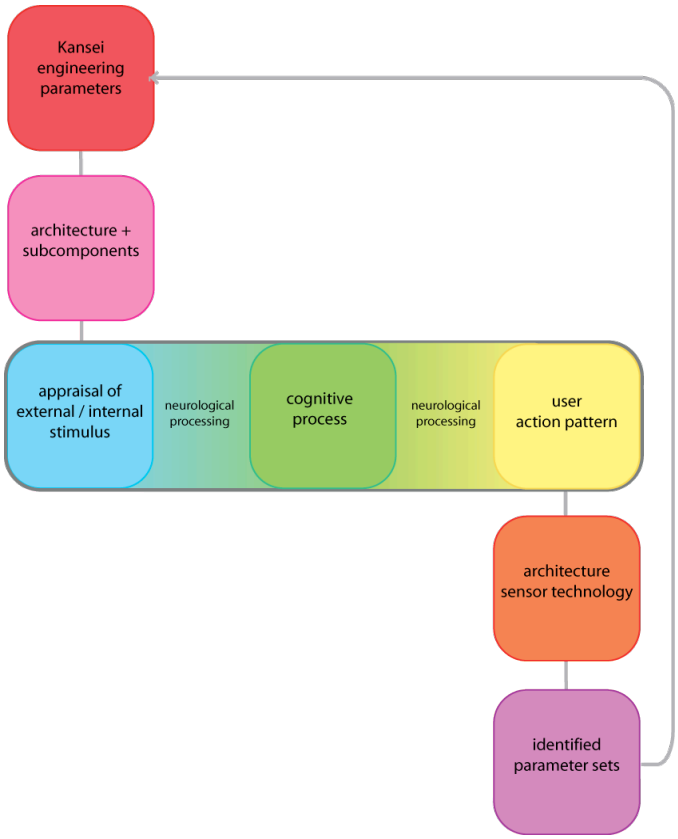

Figure 3: Kansei method to directly address appraisal part of emotion creation

The Kansei science should in this case help to both extract information of user emotions and to assign the subsets of the emotion to the correct architectural components in order to create the correct stimuli. The technology embedded in the architecture will then provide actualized data about the changes in user action patterns and for instance biomedical information to give an indication about the new prevailing user emotion which closes the loop to the Kansei part.

4.2. SPA student project as an example of interactive architecture aimed at emotion design

A student project at Hyperbody at the Delft University of Technology was set-up to make an attempt to address the topic of user emotions in the domain of interactive architecture. The design assignment was to re-think the idea of a spa building and to re-design it into a SPA (sensory performing architecture) focusing on the interactivity with the user. 20 students were divided into four groups. They were free to choose a location and a user group according to their new idea of a spa building. Next to the common design parameters from environment and functionality they had to focus on the designed experience for the user and interaction possibilities between the architecture and the user.

Case 1: "meeting at the Maas – a multi meeting SPA" by Dennis Cloppenburg, Penghan Wu, Wenjing Han, Yang Shi

The group decided to design a meeting spa mainly for stressed business men. The aspired design should be attractive and distracting from the daily stressful environment, and at the

same time exciting and inviting stimulating the usage for business meetings. Looking at built spa examples they identified parameter sets that were the reason for a space to have a relaxing character. In a second step they investigated the site to find back these parameter sets. Most dominant were light, sound, and view. The prevalence of these three factors in the environment determined the configuration of the different business spa spaces on the site.

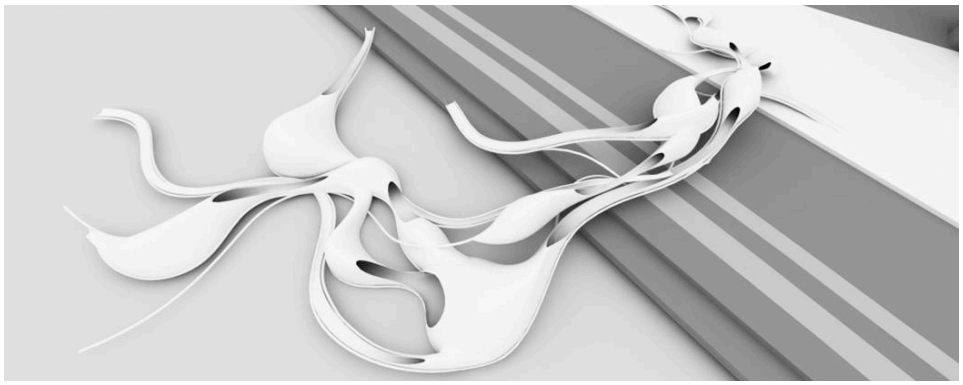

Figure 4: Overall design "meeting at the Maas – a multi meeting SPA"

The routing between these locations within the building should happen by a more ambient user interaction. Following the analogy of a water stream the guidance, choice of path, and speed of the people should happen naturally playing with curvature and size of the paths. To control this and other processes an interactive façade was introduced to further control the reaction on site parameters, stimulate interaction inside and support actual meetings.

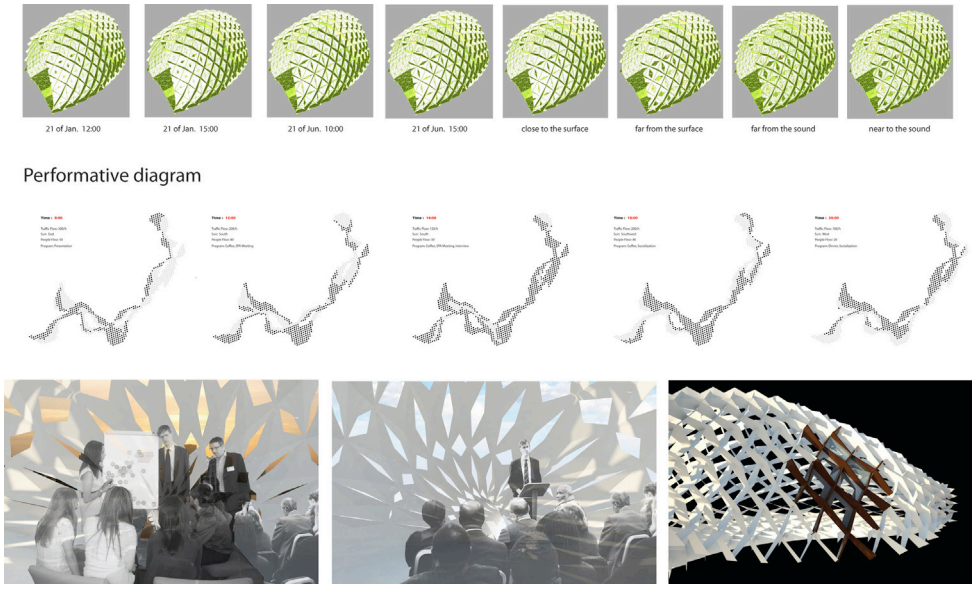

Figure 5: Interactive façade, performance to environmental and functional parameters

Case 1 incorporates partly the Kansei methodology and partly an interactive feedback loop. The aspired emotion is examined in built examples and physical parameters are identified to address emotion subsets (light, sound, view). Accordingly the architecture is composed on the site. In the interactive layer architectural components can adjust the

intensity of these parameters by adapting architectural components (façade) based on user actions and changes in the environment. In this project the Kansei approach leads to a fixed organization of the architecture. Furthermore there is no learning process involved in the interaction loop. Desirably also the Kansei parameters were still adjustable and would be included in a complete interaction loop, where in this case the façade would learn how to adjust to multiple parameter sets including the environmental conditions and behavior patterns of the user in order to provide the correct external stimuli.

Case 2: "SPARK" by Nicolas Fabre, Tieme Zwartbol, Pauline Durand, Ruzbeh Ghofranian

Main goal of the SPARK group was to create a place where the combination of awareness of the environment, the designed object and the individual would stimulate a change of mental state of the user towards the spiritual state of contemplation. Located in France, next to a main highway and in view distance to the famous bridge over the Tarn valley at Millau, they identified different user groups according to the time of stay and the purpose of their visit: For example a truck driver who would stay for only 15 minutes to take a break and a tourist who would come to see the bridge and would stay longer for that reason.

The SPA itself follows the idea of the chakras. Starting from very basic needs such as drinking and eating, there are six chakras which have to be experienced before coming to the last seventh and final step, the contemplation. To create awareness of the environment they populated the site with a variety of components, each parametrically differentiated according to site characteristics and chakra function. The result is a maze of objects that stimulate the user to reorient and to actively choose a path through the site, where each component provokes the user to think about the way of using it due to its unique dimension, material, environment, and proportion.

Figure 6: Design components populating the site

Each activity is supposed to create a different experience. After extensive research in material and structure possibilities, the group designed 6 material catalogues with function specific material capacities and fabrication benefits. The material and structure have to be strictly coherent with the experience designed for each chakra.

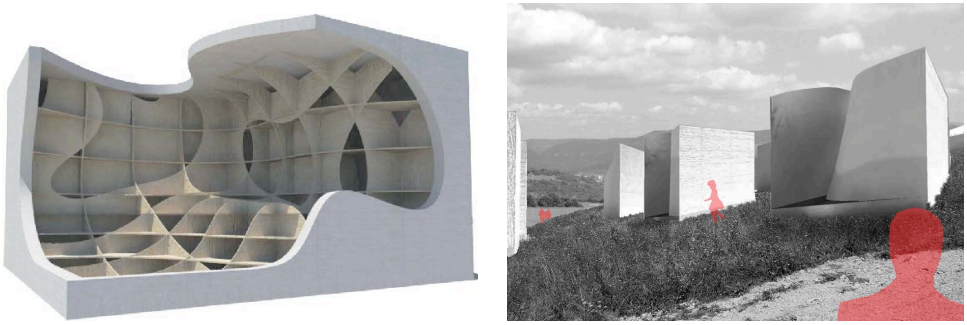

Figure 7: Materialization of one of the components and an on site impression

Case 2 does purely address the Kansei approach. Based on an aspired emotion the materialization and shape of an object is determined. If a feedback loop would have been introduced the adaptability of the structures would have been possible in relation to user action patterns or measureable physiological or psychological changes. Interesting in this project is the relation between time and emotion. The intensity of the emotion is meant to be controlled by the user (time of stay). Measured in time assuming that the user is willing to undergo the changes of the mental states to reach the level of contemplation this case could be further developed to look specifically at emotion episodes.

Case 3: "the XGR-SPA" by René-Paul Lokhorst, Geert-Jan Bijl, Xinyi Guo

XGR designed a SPA system for a spa in an urban setting with busy city citizens as target group. As an example they picked the city centre of The Hague. The design consists of two elements: an urban element - the "coral" and an actual spa "cocoon". The coral has several functions and is build up as a three layer tube system. It provides the possibility to transport the cocoon through the city and is an addition to the urban landscape in the form of streetlight, water management, sun and wind energy, and "art of the city".

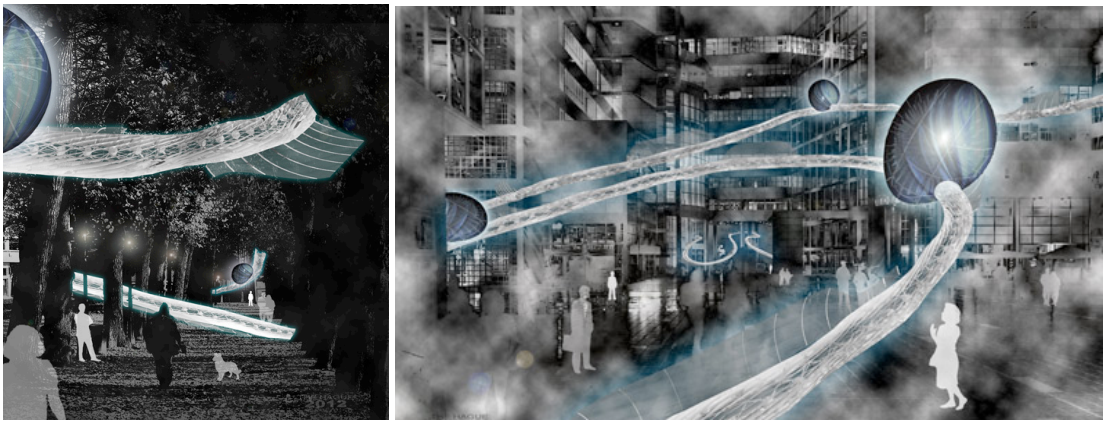

Figure 8: Coral structure carrying cocoons through the urban environment

The cocoon is a SPA design for one person. It has to be ordered by cell phone and is inserted in the coral structure on several spots in the city. Starting from an analysis of the mood of the user via several sensor technologies such as face recognition, voice analysis, and body temperature, the cocoon will make a selection of three different treatments aiming at relaxing this specific user.

Figure 9: Ordering scenario for a cocoon

The structure of the cocoon is designed that it can easily adapt and reconfigure according to the selected treatment. The project is designed in a way that it can be inserted in any city regarding the city specific environmental and urban conditions. Over time the coral will grow in the city construct and according to the user community the amount of cocoons can de- or increase.

Mood	Color	Mindstate	Structure Facade	Sound	Interior	Temperature	Humidity
Happy	White	Heaven	Elastic	Whale	Lay down	20 degrees	40%
Passionate	Pearple	↑	↑	Birds	↑	↑	↑
Relaxed	Blue	↑	↑	Waterdrops	↑	↑	↑
	Green	↑	↑	Forest leaves	↑	↑	↑
	Yellow	↑	↑	↑	↑	↑	↑
	Orange	↑	↑	↑	↑	↑	↑
	Red	Earth	Hard	Didgeridoo	Lay down	30 degrees	60%
Oxygen							
Mood	Color	Mindstate	Structure Facade	Sound	Interior	Temperature	Humidity
Anxious	Blue	Heaven	Hard	Seawater	Lay down	17 degrees	50%
Stressed	Green	↑	↑		↑	↑	↑
	Yellow	↑	↑		↑	↑	↑
	Orange	↑	↑		↑	↑	↑
	Red	Earth	Hard		Lay down	45 degrees	45%
Weather							
Mood	Color/Material	Mindstate	Structure Facade	Sound	Interior	Temperature	Humidity
Happy	Sun	Heaven	Elastic	Seawater	Sitting	40 degrees	40%
Passionate	Growth tree	↑	↑	Didgeridoo	↑	↑	↑
Relaxed	Rain	↑	↑	Rain	↑	↑	↑
	Moonrise	Earth	Hard	Silence	Sitting	20 degrees	60%

Figure 10: Cocoon adaptations according to data retrieved from body scan and treatment choice

Case 3 addresses both the Kansei method and interactivity, not in parallel but as two subsequent circuits. The treatments, which are supposed to evoke a specific emotion is enabled by great adaptability of the architecture. By direct input of and data extraction from the user the architecture is informed, resulting in a rather linear process (user informs architecture -> treatment evokes emotion -> standard configuration of architecture -> new user). Whereas the interactivity is limited to an elaborate user interface the adaptability of the architecture is split up in subcomponents where each one is adjustable to stimulate a specific emotion according to the chosen treatment. The treatments are fixed and there is no learning process incorporated to refine either the interface or the treatments for the next user.

Case 4: "get well soon" by Bernadette Luger, Martin Schorn, Christopher Tan

The group developed an everyday SPA, to be used by regular office workers. Intention was to fight the LOBO-syndrome (lack of break opportunities –syndrome).

Their Spa was a parasite building that could be attached to any given office structure. As an example they attached it to an office building in Delft, the Torenhove. After analyzing the work conditions they defined activation by extremes as the main goal for their SPA (Speed Power Activator). In order to take an activation break the user has to follow certain pathways through the parasite undergoing different activities from one extreme, for example sleeping to another extreme for such as climbing.

Figure 11: SpeedPowerActivator exterior and interior impressions

In order to keep the break situation exciting and refreshing the group designed three different flexible interior-modules all based on the same system; all of them are about changing space, changing experience, and changing sensation! Every day, every break can be different. Furthermore those elements give the possibility to the user to create his/her own space and at the same time give the spa the possibility to set some constrains on the user (e.g. after 20 minutes it can indicate that the break time is over)

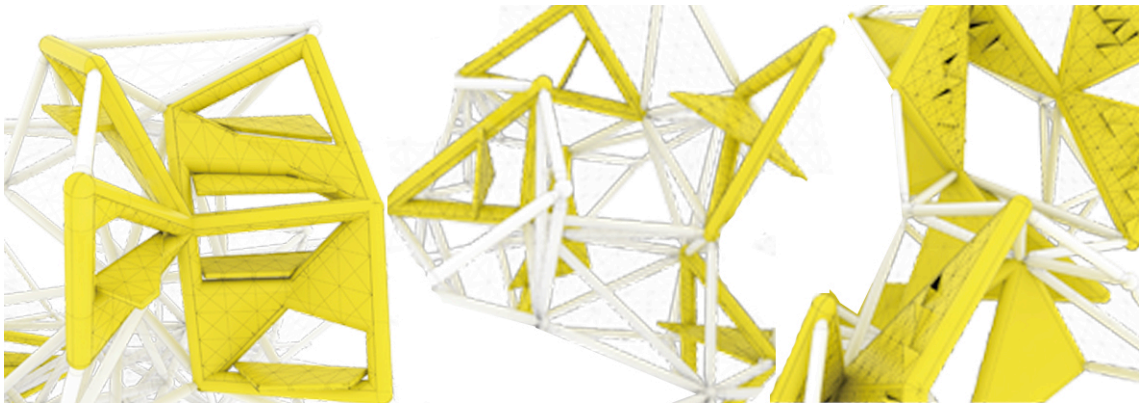

Figure 12: fractional space changer, space changer, and climber element from the SpeedPowerActivator

The interesting point of case 4 is that the students prescribed a specific user action with the architectural subcomponents in order to evoke the aspired emotion. The interactive loop

controlling the subcomponents does react to the user behavior not only on the appraisal level by changing the space and stimulating a psychological response but also on the action level by directly engaging them, even dictating a physical activity.

4.3. Evaluation

Because of the studio set-up the linkage to the user is very dominant in all the projects. Due to the nature of the function of a spa the desired change of mental state – the emotion to be created at the user – was similar. All the projects address very interesting aspects of the emotion creation and the performance of the architecture in real-time. Most of the projects have also investigated the possible connection between user emotion and interactive architecture and although the Kansei methodology to assign emotion subsets to different architectural subcomponents has not been extensively been researched all the interactive concepts address very specific parts of the architectural construct and were assigned to different parameter sets.

Given the complexity of the task and the completely architectural background of the students all the projects are interesting explorations to the topic of emotions in interactive architecture and they all demonstrate the potential and the necessity for enhancing the emotive performance of current architecture.

5. ONGOING RESEARCH

At Hyperbody many prototypes have been built to examine the topic of interactivity. The installations are controlled in real-time and adapt according to different parameter sets.

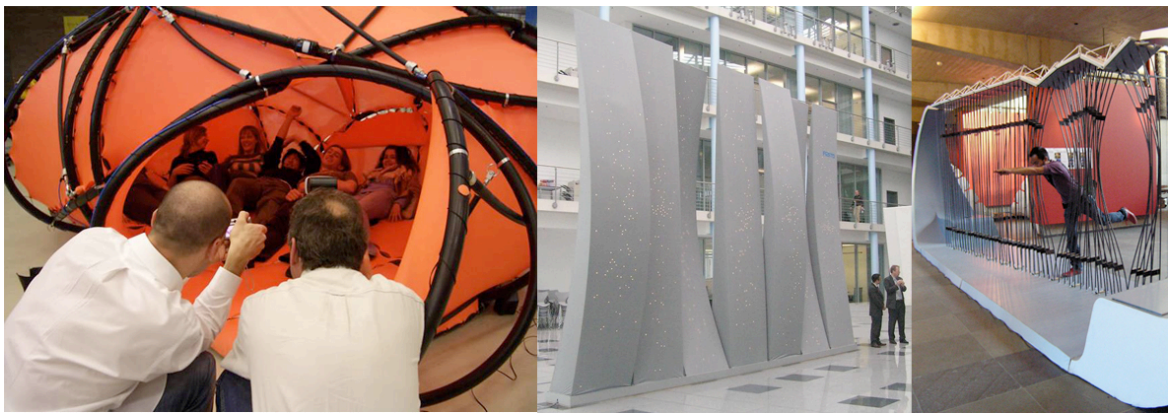

Figure 13: Realized Hyperbody Prototypes: a) MuscleBody, b) InteractiveWall, c) interactive portal

In these cases an emotion parameter is not yet formulated in the design process. Nevertheless user reactions imply a strong affection towards the interactive structures. An "emotion parameter" could be of great help to specifically design these stimuli and incorporate them in the emotion creation and interaction system.

Further research projects will aim at verifying this hypothesis. More iterations of student projects will help to conduct research for this purpose and interactive/ emotive prototypes and installations will be designed, produced, and examined.

6. CONCLUSION

The topic of emotions when dealing with architecture stays very complex because of the very subjective interpretation of space and due to difference in scale and technological limitations. Still, cross-industrial approaches such as Kansei engineering also in combination with new technologies and new architectural design approaches should be further implemented and tested in the field of architecture to deal with emotions in architecture not in a subjective almost artistic way but to conduct scientific research about emotive architecture and the effects of the relation between architecture, user, and environment. To build up this research architectural installations can gather helpful indications for later full scale operational architecture and bring up subsequent research questions.

The fact remains that user emotions will proceed in finding their way into the field of architecture and will become an important factor evaluating design in terms of performance and sustainability.

REFERENCES

Scherer, K.R.., What are emotions? And how can they be measured?, Social Science Information, Vol. 44, No. 4, DOI 10.1177/0539018405058216, pp. 695-729, 2005.

Scherer, K.R., Schorr, A., Johnstone, T., Appraisal Processes in Emotion: Theory, Methods, Research; Oxford University Press; p. 7, 2001

Meerwein, G., Rodeck, B., Mahnke, F. H., COLOR – communication in architectural space, Birkhäuser, Basel, Boston, Berlin, 2007

Fenko, A., Schifferstein, H.N.J., Hekkert, P. (2008) Factors contributing to product experience: the cases of 'warmth' and 'freshness', *In the proceeding of the Design and Emotion Conference 2008*, Hong-Kong, 2008.

Pallasmaa, j., The eyes of the skin – Architecture and the senses, Academy Editions, Great Britain, 1994

Bruce, V., Green, P. R., Georgeson, M. A., Visual perception – physiology, psychology and ecology, Psychology Press, Hove, 2003

Merleau-Ponty, M., Phenomenology of Perception (Routledge Classics); Routledge, 2002

Nagamchi, M., Kansei engineering as a powerful consumer-oriented technology for product development, Elsevier Science Ltd. - Applied ergonomics, Vol. 33, PII: S0003-6870(02)00019-4, pp. 289-294, 2002

Rafaeli, S.., Interactivity-From new media to communications, In Advancing Communication Science: Merging Mass and Interpersonal Processes (eds Hawkins, R.P., Wiemann, J.M., Pingree, S.), SAGE publications, Thousand Oaks, pp. 120, 1988.

Weiss, H.M., Cropanzano, R., Affective Events Theory: A Theoretical Discussion of the Structure, Causes and Consequences of Affective Experiences at Work, Research in Organizational Behavior, Vol. 18, p.p. 1-74, 1996

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