2021-08-30

Audio-visual instruments and multi-dimensional architecture in Visual Research Methods in Architecture.

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<CN>Chapter 23<CT>Audio-visual instruments and multi-dimensional architecture

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<H1>Introduction

<NP>By exploring multi-dimensional architecture as an extended repertoire for design, the role of perception becomes an integral aspect for architectural thought. This model of design foregrounds the performative relationship of space and its mediation with particular focus on the affective phenomena or 'triggers' that shapes the experiential qualities of an immersive act. However, these considerations require the need for a more sensitive range of tools that can record perceptual data, whilst anticipate new forms of spatial content. Thus by deploying multi-layered sensor technologies together with computational resources borrowed from cognitive science, architecture can evolve a higher-dimensional system for experimentation and testing. Multi-dimensional architecture can therefore transform the architect's role to that of a progenitor of causal effect, and by the origination of an enactive tool set, multi-dimensional considerations put the perceptual, cognitive and associative response at the centre of the discipline.

<TEXT>Multimodal interaction represents an opportunity for better understanding these potentials, and as perception implies interaction with the physical and virtual environment, situationally reflexive instruments must support and present navigational guidance in the recognition of the temporal and contextual cues whilst allowing for a 'fused' interpretation of visual, audio, haptic and kinaesthetic characteristics. It is not only a design problem to synthesize these instruments, but mappings between communication medium and content need attention to support the management of this data-rich environment.

The research set out within this chapter focus on the integration of an audio-visual approach whereby the user's interaction enables communication between percipient and the environment. This exchange produces computational abilities derived from site-specific dialogue-driven fusion of an agent interfacing with an external environment. Using this hybrid multi-level design tool set, the integration of perceptual modalities is distributed amongst the various recording or sensor technologies and are merged to create a hyper-vigilant spatial practice.

These instruments originate from a system-theoretic perspective and functioning as a supportive framework to extend the understanding of multimodal perception. The instruments are designed to operate both as a mode for hyper-vigilant sensing but also act as the conveyance medium for affecting perception through biasing and attention transference. Thus I argue for a greater level of human-environment cogency, whilst offering an architectural interpretation of situated cognition (Wilson and Clark 2009: 55) that merges the theory of multimodal fusion with strategies for design.

My research promotes an increased awareness of the causal and synergistic relationships of site-responsive stimuli. This in turn leads to increased granularity of spatial awareness – which I classify as spatio-sensory amplification. Spatio-sensory amplification is the tendency to perceive one's environment as being relatively intense and of a visceral nature, for example the inclusion of latent traces of historical affordance. These cognitive processes tend to indicate a spatial awareness characteristic of a long-latency, and are explored as phenomenologically driven data sets. The epistemological position here follows the mantle of 'practitioner as researcher' (Gray and Malins 2004: 21), whilst the purpose of the research is primed to evolve expert spatial practitioners including architects, spatial designers, composers and wayfinding specialists.

This enquiry opens up the domain of situated cognition as a performative framework for repositioning spatial practice comprised of affect-field feedback values that locate, inter-relate and make malleable, a non-Euclidian space. The research advocates a compositional role for multimodal perception by extending the psychophysical dimension of architectural space so as to yield the 'extra-existents' (Deleuze 1990: 42) for design. Situated cognition considers perception as active and predictive (Noë 2004; O'Regan and Noë 2001; O'Regan 2011); that is, we predict or anticipate the future sensory consequences of potential actions, thereby identifying the contents of perception in terms of our expectations and in terms of profiles of interaction. Therefore cognition cannot be seen as separate from the external environment; rather, knowledge is co-determined by the individual and the context. This position follows the enactive argument for cognition that arises through the dynamic interaction between agent and environment.

This theoretical stance intentionally makes problematic the mind-matter division of Cartesian dualism, by evolving an enactive model of situated cognition as a co-determined construct, mutually formed within the dependencies of feedback loops. Such an architectural model of space necessitates the need for specialized instruments that not only serve to record, measure and interpret this information, but also recognizes and anticipates the speculative question of a design methodology explicitly modifying the processes of cognitive extension.

Gilles Deleuze (1993: 187) contextualizes these mind-body dualisms as a sensation-affect contingent on modes of relationality and writes; ‘I become in sensation, and something happens through sensation, one through the other and one in the other’.
Expanding on this thesis my research focuses on the negotiation of space through the mediation and deformation of *becomings*, to use a Deleuzian term and infers compositional understanding of the perceptual processes that generate multiverse experiences as ‘phenomic environments’ (Cassidy 1997: 23). These instruments are therefore calibrated to penetrate the ‘dualism of bodies or states and effects or incorporeal events’ (Deleuze 1990: 9) by propagating the zones and intersections of agent-environment co-determinism whilst developing a transactional dialogue for propagating these inherent qualities – making perception open for experimentation and manipulation.

These theories expand the spatial territory of Neil Spiller’s (2002: 5) ‘hybrid sites’ by questioning perception as an emergent subspace of architectural geometry, insofar as considering situated cognition as a territory that is constructed through prediction and experience. By exploring Deleuze’s dualism as a ‘site of ecologies’ (Spiller 2002: 5) comprised of a dipole environment, charged between agent and environmental conditions, I evolve a hyper-vigilant praxis for amplifying and sustaining these reflexive continuums that lie ‘between the effects of the “structure Other” of the perceptual field and the effects of its absence’ (Deleuze 1990: 348).

These concerns operate in contrast to the style propelled, object-based, externally driven static forms of architecture commonly found today. In contrast, this research into multimodal perception explores the visceral dimension of space as an extension of three-dimensional space that is both fragile and non-linear and situated within an intense field of causation feedbacks. In doing so it bridges the gap between cognitive science and art practice. This approach appeals to the senses and is part of the spatial experience. The work functions as a strategy to unlock the visceral dimension as an affective multi-dimensional experience, evolving an architectural grammar for spatial agency. Further, the research establishes an inference forecasting model for predictive design, by establishing an audio and visual methodology more attuned to the ‘mutual causal connectedness’ (Harries-Jones 2002: 37) of agent-environment affordances.

This mode of operational practice speculates on the ability to manipulate the inter-relationships within these conditions and advances an extended, extra-dimensional realm of spatiality by means of inter-modulation tweaking, by manner of affective amplification, whereby situated cognition is re-sequenced to an enhanced state of 'spatial intelligence' (Schaik 2008).

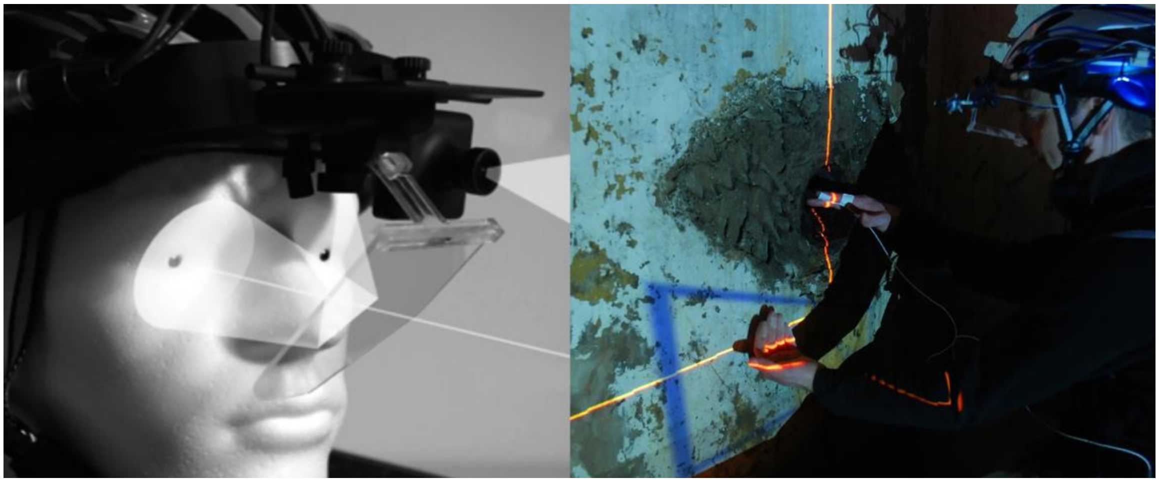
<H1>Spatial apparatus

<NP>Central to the research is the enquiry into the nature of spatial perception and the understanding of whether human emotional states have a measurable effect on our environments. The research seeks to determine methods to record and navigate these ephemeral qualities on the basis of affect, memory and anticipation. The spatial instruments made are designed to amplify these readings in the form of audio-visual feedback, whereby the various instruments are calibrated to externalize the point of exchange between the human-environment interface. In a state of animated affect and akin to forensic profiling, the audio-visual instruments record perceptual friction by calibrating the performative values of multimodal behaviour, including expression accent, physiological instinct, behavioural intuition, cognitive attention and experiential dynamics. These readings, entitled Cognitive-tope data, record where each value is configured between reality and a virtual experience. The premise for the research and the exploitation of these traces is to originate a new spatial language made up from the analysis of situated cognition that is formed by the constant breaching of boundaries between physical and virtual space in the realm of the audio and visual. The instruments thus interpret these agencies to determine the dimensional qualities between the 'felt reality of reality' (Massumi 2002: 16) and the external site effectors.

<TEXT>The instruments are made up of a series of organized interacting elements used for recording and triggering perceptional experience, namely audio-visual sensor technologies. These new corporeal technologies including Eye tracking devices; Bio-feedback systems; Cognitive-tope mapping; Arduino components and Human Computer Interfaces; Pure Data programming environments for audio, video and graphical processing; and Trigger projections.

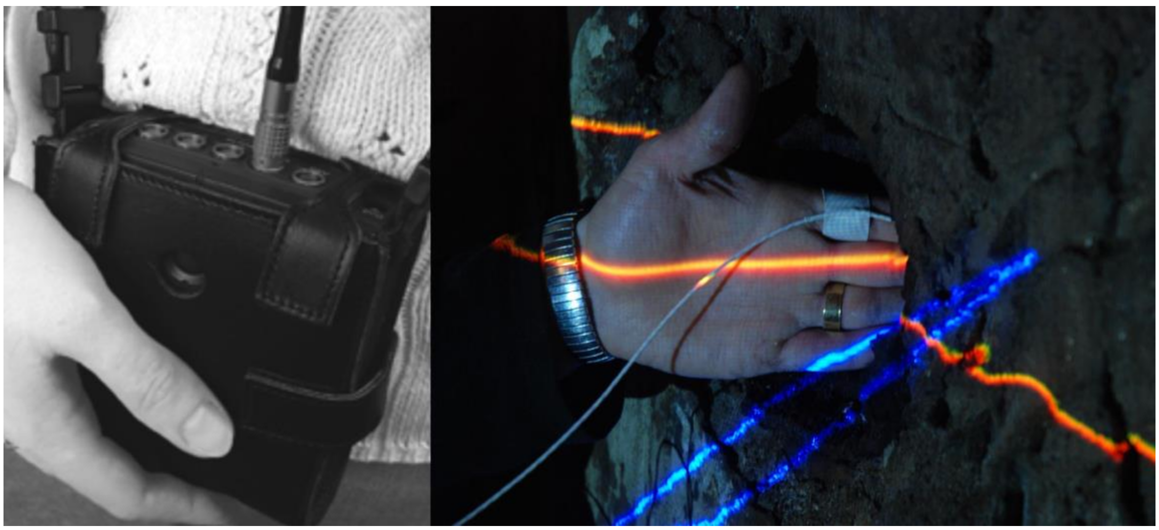
Operating as an intelligent extension to our multimodal bodies, these devices are designed for collecting and receiving data, as well as transmitting perceptually sensitive information as audio-visual information in a live and reflexive manner using real-time processing. Multimodal perception recognizes the integration of the different sense modalities that combine to reveal meaningful perceptual experiences. Here, the technology is used to chart and record the systems of human-environment communication that conveys both a message signal and amplitude reading that measures the force of signal. Thus the spatial apparatus combines data from multiple readings, triangulating the input to inform a more critical methodology. The primary objective here is to design a system of sensors that respond to a variety of stimuli felt by the occupants' experience of the environment at any isolated point in space.

For example the eye tracking system is able to record eye movement of a subject negotiating the changing physical and ambient states of their location. The technology is used to analyse user behaviour by recording visual fixations. The head-mounted kit (Figure 1) is video-based and records the order and number of visual fixations, which are documented by the image processing software. The subject wears a helmet, on which two cameras are mounted; one records the pupil movement, whilst the other records the subject's field of view. Both cameras are calibrated, making it possible to manually plot the subject's eye movements in relation to the viewed scene. This system uses mobile technology (iViewX™ HED by SMI) that allows free movement in space whilst tracking the movements of the pupil relative to the head and field of vision. Simultaneously the software presents a documentary video comprising a scene made up of fixations and saccades, creating a scan path to show loci, duration and salience of visual stimulus. The system tracks iris-pupil contrast, and, rather than calculating statistical representations for the aggregate analysis of the subjects spatial experience, I used the live eye-tracking data to parametrically drive an audio-visual installation (Vection Builder 2010) at the Roman Baths, Bath as part of an artist in Residency.



<CAP>Figure 1: Eye tracking, Roman Baths, Bath.

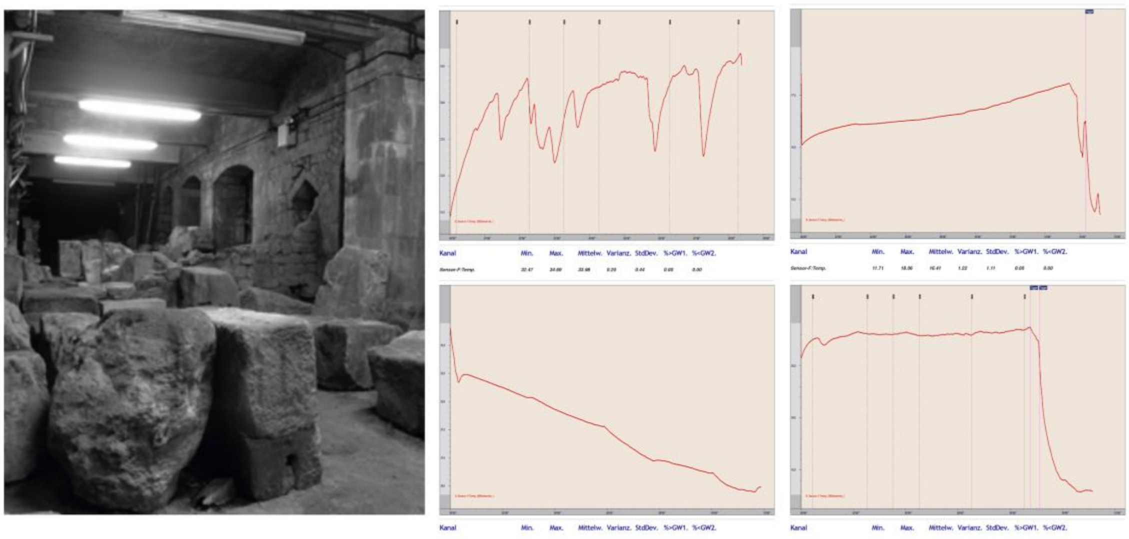
<NP>Another sensor technology used is the biofeedback apparatus that measures physiological and biometrical data. This device enables the measurement of temperature and conductance of the skin, respiratory frequency and volume, heart frequency and rhythm and muscle tension. These tools can be used to measure the complex physiological impact of microclimates at particular points in a space over time at a specific length of time. A participant has the sensors attached to their body and carries a mobile device to record the physiological and biometrical impact of the space. That data is recorded by means of a graph line showing the relation between variables over time. When using many participants from the combination of long-term observations, a general pattern of biofeedback responses can be determined, whereabouts a predetermined ‘mark’ in time creates a series of anchor points, enabling comparison of data.



<CAP>Figure 2: Biofeedback sensor.

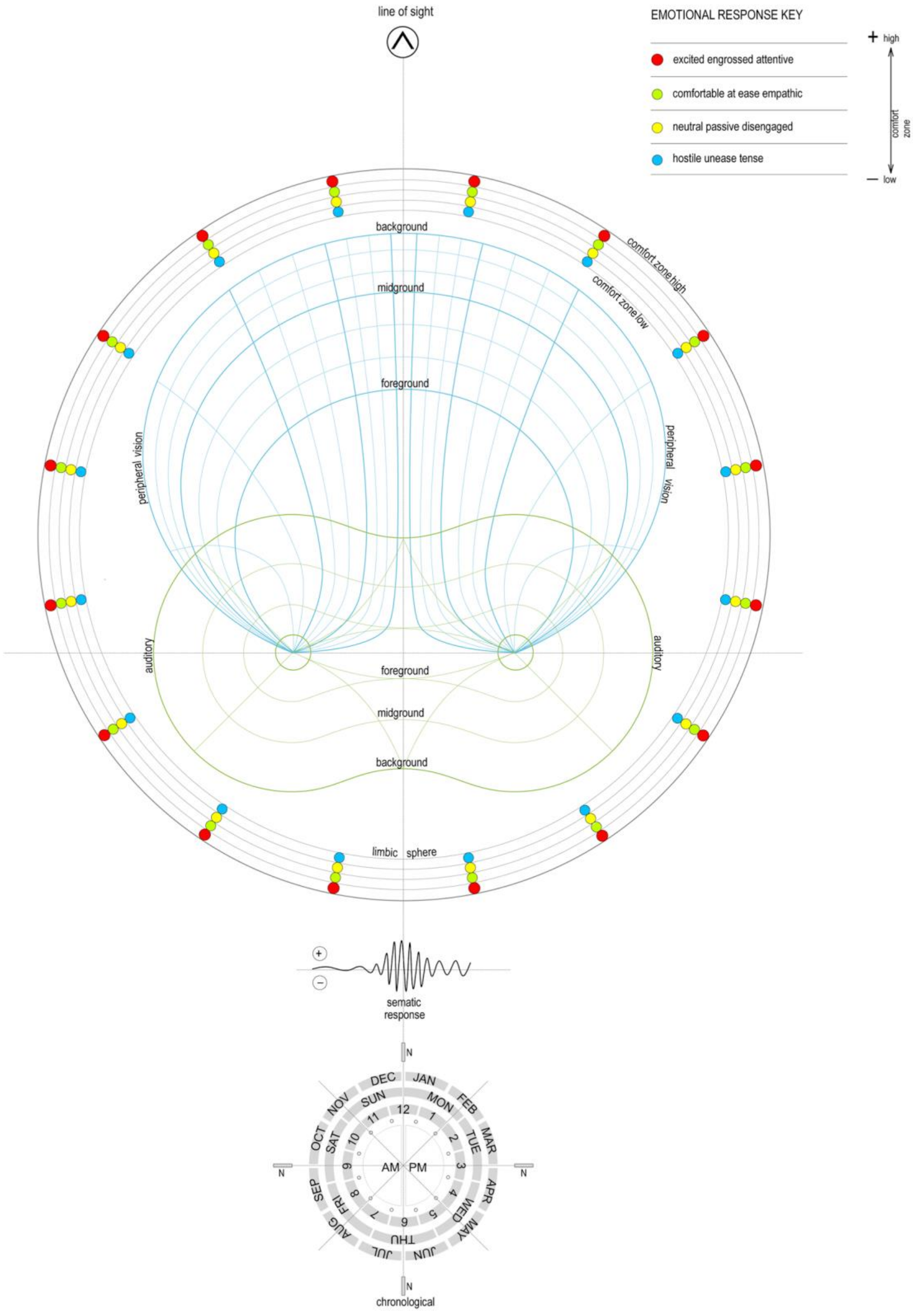
<NP>Each biofeedback response creates a line or gradient tracing the excitation (and inhibition) fluctuations of the participant’s central nervous system in direct response to the experiential qualities of any given space. This builds up a profile for understanding the ‘strength of stimuli’ in correlation to the external environment. These tracings are marked with time units to create graphical images with deformation values that comprise amplitudes per time unit. These readings can reveal reflexive behaviours in space perception, for example when interpreting temperature changes in biofeedback analysis, a temperature rise indicates relaxation, while a temperature drop relates to the activation of tension or stress. The body’s temperature drops as a result of the blood being directed away from the subjects’ extremities – straight to the vital organs – to facilitate a raised level of arousal. This is known as the ‘fight or flight’ response,

whereby blood flow is increased to the brain and muscle groups to facilitate engaged action. To reach a better understanding of these results, the subjects can be asked to complete a self-reporting feedback task to collect a more interpretivist validity of the findings.



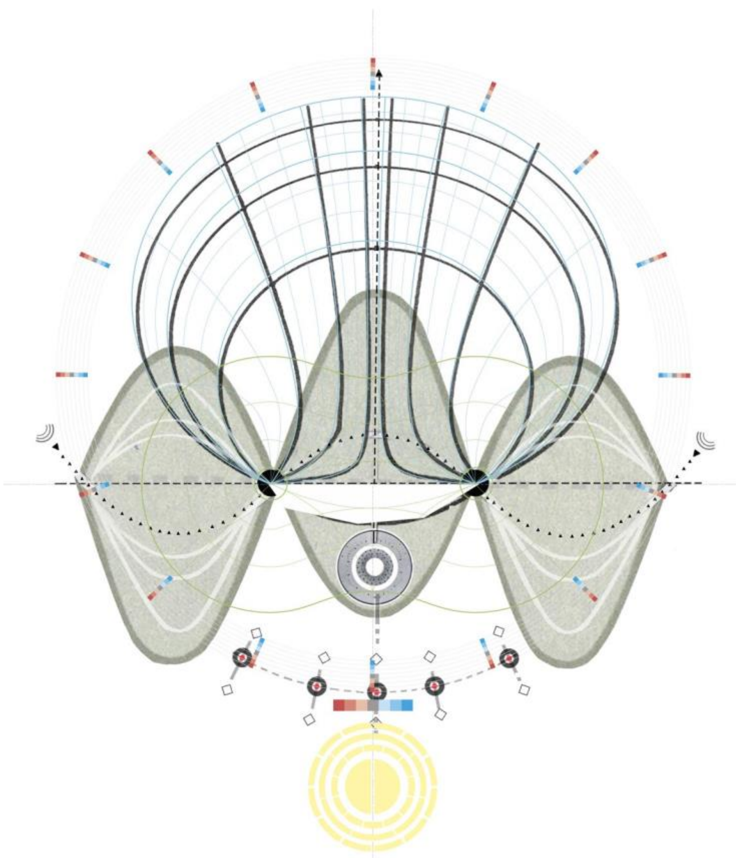
<CAP>Figure 3: Biofeedback graphs.

<NP>As well as digital sensors, more traditional, self-reporting maps and questionnaires are used to explore a more reflective examination of a site study. These are called Cognitive-tope maps, which are tasked to sequester perceptual-specific data together with qualitative information. Also designed from the perspective of multimodal perception, these graph(ic) representations record the nature and location of situated cognition affects. It was also imperative to ensure that these maps were designed to be as usable as possible. Moreover, within cartography, there is a general rule to not have more than seven different variables to decipher, as it is acknowledged through cartographic research and practice that more than this creates recall problems for the user – and thus increased difficulty completing the graphic.



<CAP>Figure 4: Cognitive-tope map.

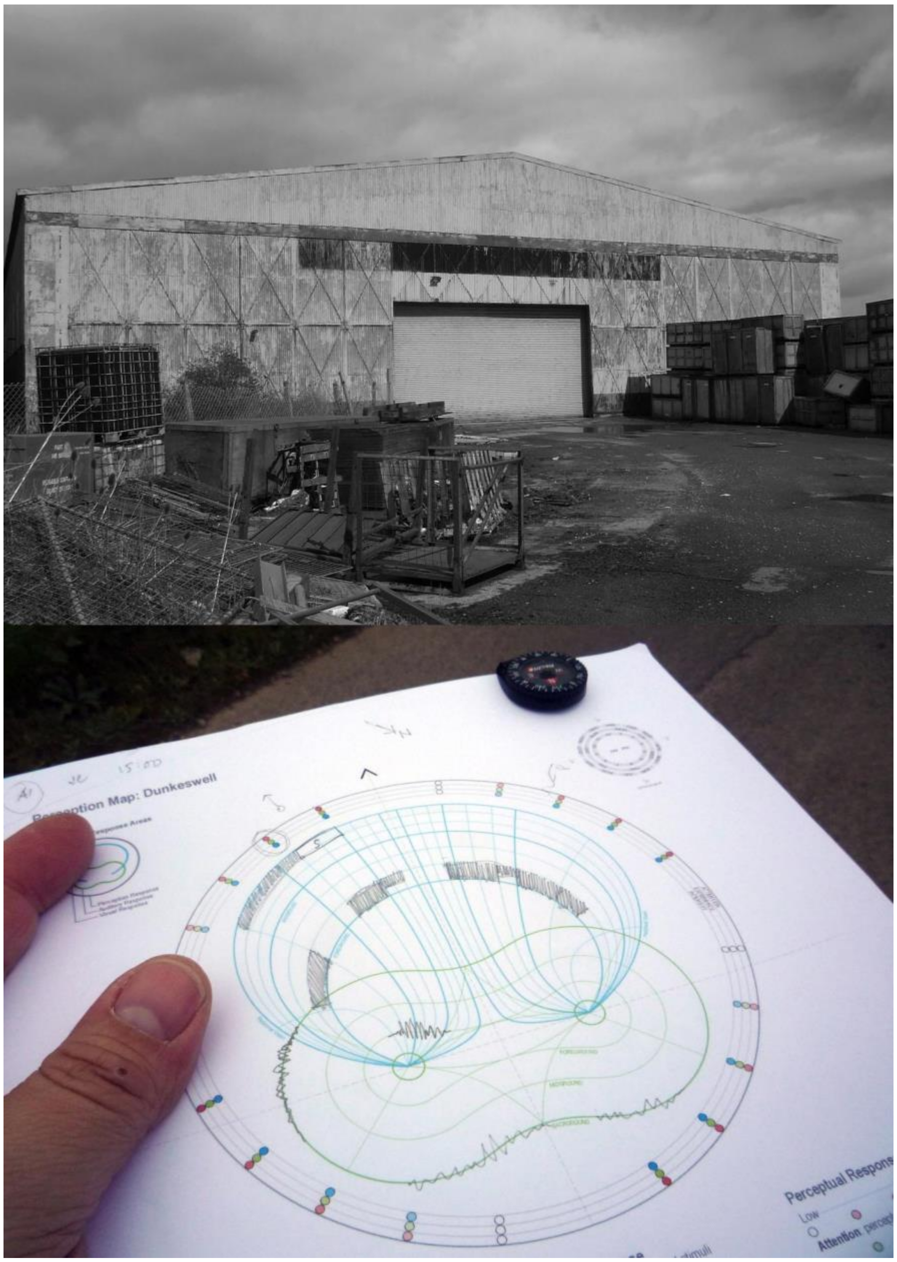
<NP>There are numerous individual tools and techniques for recording our response to single physical or psychological stimuli in the environment, but what options are available and effective for recording numerous responses at once? There did not seem to be anything that was practical or simple to implement. As such, the Cognitive-tope map was conceived to provide a recording of both physical and psychological responses within the built environment. The basic concept of the tool is that of a graph with the participant or recorder placed at its centre. In order to be reflective of our 3D world, the graph needed to have a way of recording stimuli in all planes. As such it represents a 360° view with graphic codes employed to represent attributes such as location, elevation and signal. A form of graph was devised as it had a basis in familiarity for a potential user, and also enabled quick-and-easy recording of mark-making.



<CAP>Figure 5: Cognitive-tope prototype.

<NP>The design of elements in the graphs refers to human form. Vision occupies an appropriate *field* of coverage at the top of the graph (heads-up and forward looking). Sound has

360° coverage, as does smell and touch, although in ever diminishing extents to reflect the distance at which they are normally detected. The manner of representing a user's response is again chosen to reflect some of the norms in the respective fields. For example, a wave-form is used to signify sound recordings, with a greater magnitude for louder sounds. Throughout the design processes, a balance is sought between recording numerous (sometimes simultaneous) stimuli in a clear graphic form that is also relatively simple for the user to undertake.



<CAP>Figure 6: Cognitive-tope pilot.

<NP>Recordings were conducted in a serial fashion such that at regular intervals new recordings were made. This would then help construct a response image of a larger site at a particular moment in time; in essence, re-examination of the completed graphs should help re-construct the site.

<TEXT>By placing the researcher at the centre of the inquiry, the method forms an ‘integrative observation’ (Schwalbach 2009: 17). As identified by sociologist of biomedical science and technologies Adele E. Clarke (2005: 85) in *Situational Analysis*, the researcher carrying out the task is considered the ‘research instrument’. Clarke puts forward three helpful modes of situational analysis. First, doing situational mapping does not inform a ‘final analytic product’ (Clarke 2005: 85), rather it establishes a rigorous strategy for interrogating the data. Second, situational analysis uses visual codes and abstracted diagrams to convey meaning and aid comparison and communication. Third, the process of situational analysis positions the researcher directly within the investigation whereby the experience becomes tacit. Clarke (2005: 84) argues that ‘Situational maps and analysis can be used as analytic exercises simply to get the researcher moving into and then around in the data’.

The Cognitive-tope map integrates Clarke’s transactional approach to situational analysis by considering mapping as an ‘auxiliary apparatus’[1] (Freud 1963: 208). It provides the spatial practitioner with a specific fieldwork tool to directly investigate the ‘spatial qualities and atmospheric impressions’ (Schwalbach 2009: 34). The design of the map exploits a series of visual abstraction processes to circumnavigate problematical linguistic representations of perceptual space, and by constructing a series of radial vertices projected into a plan arrangement, the cognitive-tope mapping system generates a set of overlapping metrical layers that deconstructs perception into concentric fields that are graphically distributed on the page to represent the phenomenal self mimetically.

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[1] First published in 1925, Sigmund Freud’s essay *The Mystic Writing Pad* offers writing as a tool to bring together modes of sensations, both conscious and subconscious within a recording framework to make the data available for later recollection.

The metrical layers or field domains consist of a visual field, auditory field, somatic field, limbic field and chronological dial. Each domain has a field view of 360° that converges on two nodal points equidistant from the concentric rings of radial geometry. Each nodal point corresponds to the percipients' left eye/ear and right eye/ear, thereby establishing the bipolar loci of vision and hearing. The cognitive-tope mapping system operates as a form of 'Homuncular or systemic decomposition' (Robbins and Aydede 2009: 107).

<H1>Visual, auditory, somatic and limbic fields and chronological dial

<NP>The visual field has a bipolar coordinate for locating the left and right eye, with a centreline that runs through the entire spherical field to help establish the direction of the percipient's visual direction. The visual domain is designed to record the user's spatial orientation and visual point of view or POV[2] identified by three hyperbolic curves denoting foreground, mid-ground and background. The visual domain also identifies the user's fovea and peripheral vision. The organizational framework for the visual field evolves from the interpretation of Veith-Müller's *diagram of visual geometry* in *The Geometry of Visual Space* (Wagner 2006: 33). This model, however, was further developed by the addition of Blain Brown's (2002: 42, 9) 'rule of thirds' that divides the field reference frames into thirds, enabling the domain to be broken down into clearer 'building blocks of scenes'. This framing device establishes a strategy for decomposing the visual scene into tonal blocks that articulate the 'visual forces' (Brown 2002: 37) of the visual field. This enables the user to simplify the range of visual perception and concentrate on evaluating the local tones. This allows for assessing the relationship between form and space, whereby the qualities of the visual scene are abstracted and extended through the interplay of contrast, proportion, intensity, distribution and direction. Three-dimensionality arises from the viewer's use of the fore/mid/background zones, with depth being noted through the overlapping of compositional elements and relative size. By reducing the visual scene into basic tonal elements, the process puts greater emphasis onto the forces of visual composition, rather than scenic detail.

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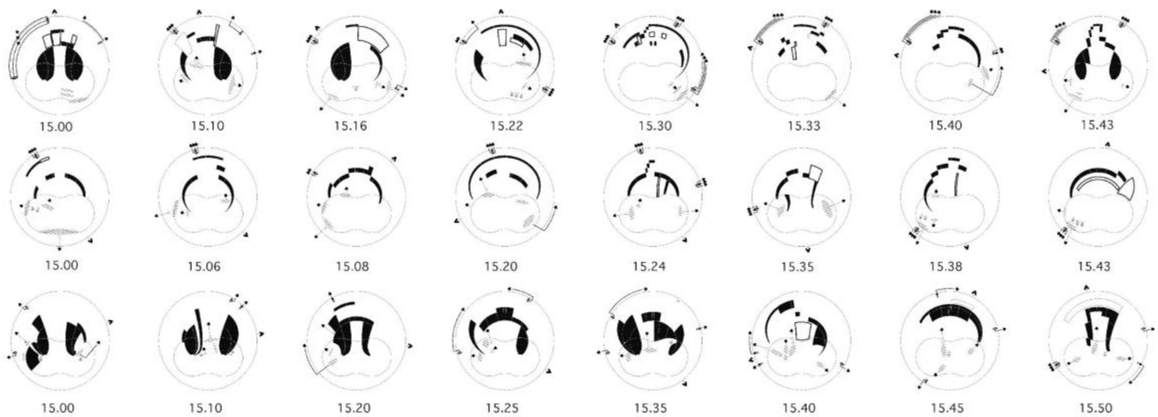
[2] In filmmaking the visual point of view is abbreviated to 'POV' and can assume objective and subjective associations according to the location of the camera in relation to the performer's perspective.

<TEXT>The auditory field is acoustically sectioned into three zones of 360° concentric graphs, centred on the bipolar loci of the left and right ear. The percipient uses the auditory map to graphically visualize the spatial appearance of the explicit sound event. The auditory field interprets Canadian music composer and environmentalist R. Murray Schafer’s (1977: 129) sound envelope topology to visualize the sonic ‘attack, body, transient and decay’. By adding a locational component, the user can chart the directional content of the sound, enriching the aesthetic quality of the sonic study with a three-dimensional locator that charts the movement and durational content of the auditory environment.

The somatic field relates directly to body position and movement within the percipients kinesphere (Laban). This domain was specifically designed to map the inter-related fields of kinaesthesia and equilibrioception (what is the source of this term – please provide citation), reducing the complexity of accelerometer data into a single section of body awareness, namely the sense of motion, acceleration and balance. The user can chart their somatic awareness on a graph denoting the intensity of body position, marked by the level of joint and muscle tension, together with the ability to maintain a postural equilibrium or balance. The somatic field enables the user to calibrate the body’s position adjacent to the environment in a three-dimensional manner.

Limbic derives from neurological science and relates to the brain structures associated with emotion, behaviour and memory (Levitan and Kaczmarek 2002). The term stems from the Latin word ‘limbus’ that refers to ‘border’, neatly corresponding to a boundary condition. The limbic field uses a Likert scale to chart the participant’s psychological response to capture a value of intensity on a visual analogue scale consisting of radial lines. The limbic field uses a bipolar scaling method to record a hyper-vigilant response to psychological stimuli in conjunction to a positive or negative relationship towards the enveloping environment. The scale operates as a psychometric scale with the addition of a locational component, thus making it possible to site the incidence of cognitive dissonance relative to the participant’s origin. The limbic field has a four-point scale with interval levels, which are colour coded to aid legibility. The scale enables the user to reflect on and chart the performativity of the emotive response establishing a form of mapping that charts the psychological inter-relationship of the spatially explicit environment.

Lastly, the chronological dial enables the user to note the time, date and orientation relative to the north point, allowing a temporal and directional framework to be established for sequential mapping and accurate retrieval of data. The cognitive-tope map serves to amplify the perception of space by magnifying the affective stimuli together with charting the locational trigger as a perceived point in space. These maps help build the dynamic values and behaviour of how we perceive, through the use of a visual interface that is designed to visualize the perception of space with greater granularity of situational depth and temporal awareness. These maps, whilst revealing the forces and sets of attention, can also evoke patterns of signature agent-environment reflexive behaviours leading to a greater understanding of the impact of architectural space on human occupation.



<CAP>Figure 7: Perception notation matrix.

<H1>Microcontrollers, sound generation and software

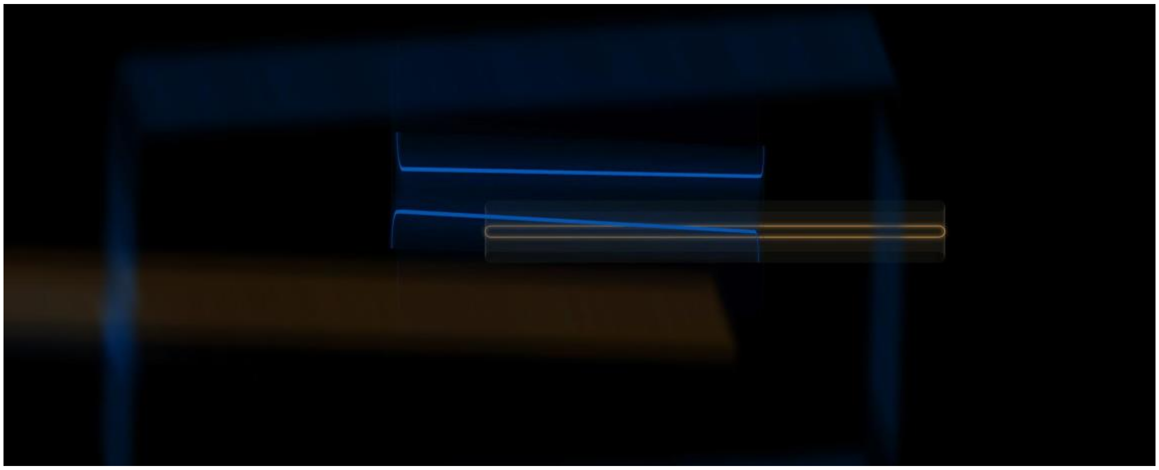
<NP>The software used for this research includes Pure Data with custom-made programmes and Arduino components that enable real-time processing capabilities. Because the research involves the study of perception through the movement and interaction of space the software is conceived as a processing vehicle allowing participants to engage and trigger audio-visual responses through the use of sensor technologies and depth/movement sensors. The software enables system-system communication, creating a live, interactive and immersive experience that concomitantly triggers and responds to participatory interaction. Essentially the software creates a live processing engine that drives the research, giving rise to a heightened sense of interaction condition, called ‘coaction field’ (Tiffin and Terashima 2001). When coupled with sound, the software helps generate data-specific numerical forms that can be translated into sound outputs in a live and reflexive manner.

<CAP>Figure 8: Pure Data patch, *Open State*, Japan.

<NP>The audio within my work is designed to telescope the immersive qualities of the spatial setting. Tending to use site- or data-specific sounds, I use Pure Data – a visual programming language similar to MaxMSP, created by Miller Puckette – to generate sounds from live data streaming generated from the various sensors and/or for generating sounds and interactive multimedia works by synthesizing audio effects from earlier profiling experiments. Simply listening to an environment can trigger a greater consciousness for a space; the sound portrays its three-dimensional volume, materiality, layout and function. These features can be transcribed into a form of notation that when reverse engineered and charged with sonic output, creating a sound world that performs the makes audible of a transient space characteristic of situated cognition. These audio investigations respond to the phenomenological experiences of occupying an environment without the sense of light.

<CAP>Figure 9: *The Birth of Memory*, sound-dance collaboration.

<NP>The tool set for this research includes affective cueing. The audio-visual instruments include the design and projection of visual ‘triggers’. These use a simple abstracted language designed for biasing attentional pickup through the use of visual cues that have a high visual impact value, designed to modify behaviour. The trigger events consist of tilting verticals known as the Coriolis illusion in flying. They create conflict between vision and balance, the simultaneous expansion and contraction of overlapping frames create a ‘trombone’ (Morris 2007: 61) moment and pitching with acceleration. This emphasizes the sense of gravitational pull to the observer. These visual illusions attract the participant’s eye to a series of attentional cues and aim to trigger a shift in perception and bodily recognition of spatial occupancy.


<CAP>Figure 10: Trigger frame sequence.

<NP>As well as to positively prime an observer's attention, they can also be used to elicit modes of body-space conflict. These trigger events are designed to function as an 'anti-environment' (McLuhan 1970: 30) device. These visual projections play with the notion that when the environment fails to meet our expectations, these aspects are suddenly in the forefront of our perceptual experience. It is proposed that visual cues can be designed to lead participants to have certain expectations. This can thereby influence their perceptual experience – as used in cinematography to instruct a particular emotive response. Known as 'phi phenomenon' (Corrigan and White 2009: 524) visual cues give rise to the psychophysical illusion of movement through, and within, architectural space.

<H1>Conclusion

<NP>This research advances the understanding of hyper-vigilant spatial analysis. It enhances knowledge into and the application of audio-visual instruments for site analysis and experimental architectural practice. This work argues for a greater awareness of spatial perception together with environmental cogency through the design and calibration of these instruments. It promotes an increased awareness of the causal and synergistic relationship of site-responsive stimuli leading to somatosensory amplification of affective site readings, latent traces and affordance triggers. The audio-visual devices explored here are attuned to record, reveal and amplify these design contingencies, and by synthesizing an operant tool set the participants' spatial consciousness is elevated to a higher level of spatial acuity, pulling the percipient into a more immersive mode of hyper-vigilant attention. These instruments engage

the body with the site in a more fundamental manner. The body comes to know itself more as a relational mode of interchange whereby the audio-visual instruments actively promote an interactionist methodology, repositioning architectural practice to that of an ‘effector system’ (Robbins and Ayded 2009: 7). By advocating perception as an effective structure for design consideration, these audio-visual instruments penetrate the inner essence of perceptual space to provide a greater in-depth understanding of the reception of and effect on architectural space.

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