Hear and Now:
Sound as Architectural Medium

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INTRODUCTION

Music and Architecture – at first thought no two disciplines could be more different: music, dynamically unfolding in the ephemeral medium of sound, and architecture, defining itself through its rooted materiality. Historically, however, these disciplines have in fact held much in common, each frequently providing the creative impetus or theoretical underpinning for the other.

From Antiquity to the early 18th century, the realms of music and architecture often intersected with synergistic results. While these interactions expressed themselves in many ways, they were most notably manifested through the intermediary discipline of mathematics and the Pythagorean idea of harmonic proportion, a concept validated in the works of Vitruvius, Alberti and Palladio. Despite the proven fruitfulness of this cross-fertilization from ancient Greece through the Baroque, the relationship fell out of favor in the late 17th and early 18th centuries largely through the rising influence of the French Academy. For the next two centuries the previously allied arts of music and architecture would have little incentive to experimentally interact.

With the dawn of the 20th century, however, architecture renewed its age-old association with music with particular vigor. Early on Frank Lloyd Wright invoked the spirits of Bach, Beethoven and Mozart in his writings, seeking to affiliate the act of architectural design with the art of musical composition. Later, desiring more substantive connections, Le Corbusier sought collaborations with progressive composers such as Edgard Varese, Iannis Xenakis and Olivier Messiaen in an attempt to aurally inform his work. The musical avant-garde, paralleling Modern architecture's rejection of the historical paradigm, likewise sought ways to bring about significant transformations in their field. From the Italian Futurists to the experimental works of John Cage, traditional forms of musical expression were brought into question and the definition of music was broadened to include environmental sounds and electronically generated, recorded and modified noises. Building upon these changes in the final two decades of the 20th century, architects such as Steven Holl, Frank Gehry and Daniel Libeskind often turned to music to find new sources of inter-disciplinary inspiration.

Most recently, however, it has been technological advancements that have inspired a new generation of designers to weave sonic elements into the architectural fabric. This paper examines three areas of digital technology first pioneered by composers, musicians and sound artists that have now been adopted by architects wishing to explore similar issues of time, indeterminacy, and transformation in their work. Briefly stated these three areas are:

Digital sampling: The use of computers to parse, replicate and/or electronically create a new work synthesized from portions of others.

Trans-generic interpretation: The use of digital technology to translate an event or thing into a different medium, for example, using sound as an analog for motion, or reinterpreting sonic expressions as physical or form.

Musical controllers and signal conversion: New developments in the areas of phonology, audio control and sound reproduction that have potential architectural applications.

II. DIGITAL SAMPLING

The development of magnetic recording tape in the 1930s and 40s provided musicians a new medium with which to create. The French composer Pierre Schaeffer was the first to develop a genre based on the idea of compositions assembled from sounds recorded on magnetic tape. Composers such as John Cage, Karlheinz Stockhausen and Pierre Boulez, among others,

soon followed. The advent of electronic recording technology in the late 1970s provided the ability to construct new works through digital sampling – the technique of electronically deconstructing and manipulating previously completed recordings. This technology further opened the door for new forms of creative expression in both popular and serious forms of music. Some twenty years later this technique ventured beyond the recording studio into the architectural studio. Architect Victoria Meyers offered an advanced studio course at Columbia University in 1997 entitled *Sampling: Architecture and Music*. Of the intent of this course she wrote,

> "Digital technology has led to the prominence of 'sampling' within music as well as formal quotation within architecture... [In this course] we attempted an understanding of the spatial strategy of sampling and its structural effect on the development of a contemporary language of architecture...sampling changes the numerical spatial analysis from one of proportion to one of fluid dynamics." (1)

Echoing Meyer's belief that digital sampling has architectural applications is the Spanish architectural critic Xavier Gonzalez. In his article *Cut and Paste: Memory and Quotation*, he speaks to the issue of architectural and musical authorship in the electronic age:

> "The question of quotation and copying in creation has been a constant theme since antiquity and touches all disciplines and arts: ... architecture, design, ... dance, music, ... etc. ... The phenomenon of recycling that began by contaminating art and music is now perceptible in architecture... In this we see the direct influence of techno culture with its technique of fabricating by manipulation of existing elements... As in music, the manipulation of forms, fragments and space implies an ability to think in terms of alloying, combination and following on, where architectural works run into one another and play, in turn, alternate roles of subject and object." (2)

This idea of the contemporary artist, be they architect or composer, as electronic *bricoleur*, adds another dimension to the concept of design as collage. Several designers have already executed projects that borrow from the paradigm as architect as DJ. The British architectural collective FAT (an acronym for Fashion Architecture Taste) in fact drew just such an inspiration, appropriately enough, from their commission to design The Brunel Room, a dance club in Swindon England in 1996. They state,

> "This project for a nightclub is conceived as a series of architectural samples analogous to those used by DJs playing at the club. [The project was created by] appropriating fragments of the everyday, and designed through sampling in PhotoShop..." (3)

We find the same technique quoted by OCEAN, an international internet-based network of architects. Practicing as an internationally dispersed collective the benefits of this type of electronic design are particularly valuable, allowing designers to instantaneously combine cross-cultural precedents. The members of the group describe their design approach thus:

> "...drawing from 'sampling', the practice in popular music of 'borrowing' fragments of songs, [our firm] has derived a kind of urban sampling to integrate spatial differences by cataloging the diverse or disjointed 'bits' of the city. Stringing these bits together – in the manner that a DJ 'loops' pieces of musical tracks into a melodic and rhythmic synthesis – [the architect] produces a cohesive urban unity." (4)

While sampling technology provides a new tool for the architect to compose space and form, it also raises serious issues relative to the question of authorship; a point raised by Postmodern and Post-structuralist critics alike. The fundamental distinctions between the abstract and ephemeral nature of music vis-à-vis the functional and requirements mandated by architecture here become particularly manifest, underscoring the primary challenge that must be addressed and successfully negotiated in any cross-disciplinary application of digital processes. Does the means of expression made possible by the technology subvert or overwhelm the art and science of the field?

III. TRANS-GENERIC INTERPRETATION

In the early twentieth century the idea of translating music into two and three-dimensional form found expression at the Bauhaus in the works of Wassily Kandinsky, Paul Klee and Henri Nouveau. Later, the development of electronic technology allowed for dynamic and instantaneous trans-generic interpretations. The composer John Cage was a pioneer in incorporating emerging technology to create music. An early work that illustrates this is Cage's multi-media piece for choreographer Merce Cunningham entitled *Variations V* (1965) in which he collaborated with musical synthesizer inventor Robert Moog, electrical engineer Billie Kluver and video artist Nam June Paik. Using short-wave receivers, oscillators and photoelectric cells, the dancers in the performance generated the sounds through their movements around a series of antennas located on the stage and by their movements through a series of light beams. In his role as "conductor", Cage sat at a bank of electronic controls and adjusted them as suggested by a predetermined "score", a set of transcriptions derived from an astronomical atlas. (5)

Hani Rashid and Lise Anne Couture, as principals in the firm Asymptote, have credited the work of John Cage for having a significant impact on their approach to architectural design. Their winning entry for the 1988 Los Angeles Olympic gateway

competition similarly plays off the idea of moving objects as music-generators. The "Steel Cloud" project proposed a series of galleries, libraries, theaters, cinemas parks and plazas to be suspended over the median strip of the Los Angeles freeway. Also to be included in the work was a digital sound machine that would compose and perform music according to the frequency of the cars traveling in and out of the city below – a seemingly appropriate hymn to the auto-centric culture of Southern California. The architects state: "Embodying Marcel Duchamp's axiom that modernity is 'the super-rapid position of rest', this architectural assemblage makes scale and meaning purposely disconcerting." (6) Duchamp, Cage's longtime friend and mentor, would no doubt be pleased to learn that his subversive notions had successfully infiltrated the field of architecture as well as art and music. This concept of an aleatory system as a legitimate means of creation would prove to garner much attention and success with the musical, as well as architectural, avant-garde in the years to follow.

Moving from the realm of un-built projects to a completed work illustrating a similar technique is Toyo Ito's "Tower of Winds". Built in Yokohama in 1986 and dismantled in 1995, a preexisting seventy-foot high concrete tower was covered in mirror-finish synthetic panels and encased in an oval-shaped envelope comprised of perforated aluminum sheets over steel framework. The tower utilized 1,280 lamps, 24 floodlights and 12 vertically arranged neon rings linked via sensors to a computer controller. Natural movements, such as wind, joined with the monitoring of ambient noises and the passage of time to change the patterns and intensity of the lighting effects. This trans-generic interpretation, one that has been described as "environmental music", using sound and other input to change the nature of the architecture, provided a real-time representation of one mode of energy transforming into another. Architect Toyo Ito writes of the project,

> "We cannot imagine the flow of electronic information, we see only the data feeding the computer and the results it produces. Yet one does imagine microchips in a certain manner...this is linked less to *form* than to a *space* through which invisible objects are flowing, spurred on by *electronically packaged information*." (7) [emphasis added]

Digital technology in this instance provides the designer with new tools to animate and inform structures in a manner and scale heretofore unimaginable. Projects utilizing inter-medial technology like Asymptote's and Ito's can be viewed as posing the question of interactivity at the scale of the city. What becomes critical in instances such as these, however, is the level of inquiry. Is interactivity treated merely as a novelty or superfluous high-tech decoration, or is it employed in a didactic and essential manner? How does it contribute in a meaningful way to the overall intention of the architectural expression?

IV. MUSICAL CONTROLLERS AND SIGNAL CONVERSION

Playing off Ito's comments about electronic technology and the way that it has entered into the disciplines of both contemporary architecture and music brings us to the third point in this presentation. Recent developments in the areas of musical controllers – the electronic means through which sound can be physically "composed" or modified, and signal conversion – how sound is delivered from a particular storage medium or generative source to the brain – have potential for use in architectural applications. Several sound-artists and composers have utilized this type of technology in creative works hoping to define or inform existing spaces. For example, artist Janet Cardiff, who frequently works in acoustic media, "restructured" the 16th century composition *Spem in Alium* by the English composer Thomas Tallis. Originally written for a forty-voice choir, Cardiff configured forty separate speakers around a space using them to play back the piece having re-recorded it using forty separate channels (rather than recording the choir's performance as a single collective unit). The effect of experiencing forty unique, individual voices as opposed to one single choir as one moves about the room is perceptually disconcerting. The acoustic effect achieved distorts and redefines the volumetric parameters of the room in which it is installed, blurring the boundaries between its spatial and acoustic dimensions. (8)

The means by which one now controls and reproduces sound has evolved dramatically over the last decade. The first of these, musical controllers, can be subdivided into two different genres – haptic controls (relying on touch or physical contact of some sort) and free-gesture controls (relying solely on movements in space that do not require physical contact of any sort). The Responsive Environments Group at MIT's Media Lab have developed much of this cutting-edge technology, frequently employing it in creating immersive musical environments. (9) As an example of haptic controls utilized in an architectural application we can turn to a recent project by the firm Antenna Design and their installation for the 2003 Design Triennial at the Cooper-Hewitt Museum in New York. Electronic devices embedded in the staircase between the ground level and second floor trigger a video displayed on a two-story rear-projection screen depicting of a shower of animated cherry blossoms. The speed and number of projected blossoms, as well as the dynamics of the accompanying audio track, are correlated to the number of individuals on the stairs and the speed at which they are moving, yielding a direct cause-and-effect relationship between the users and the audio-visual "ornamentation" of the space.

An example of the second type of controller, the free-gesture variety, can be found in a digitally augmented construct designed by Asymptote entitled Fluxspace 1.0, installed in San

Francisco in association with the California College of Arts and Crafts in 2000. The architects describe the work thus:

> "The 'architectural reality' of the installation was augmented by digitally manipulating the wireframe assemblies and their virtual surfaces. The transformations were then mapped precisely onto the physical objects in the gallery space through the use of video projectors. *These 'distortions' were then triggered by surface-embedded sensors, sensitive to movement and proximity.* Once the sensors were triggered animations of the distortion of the object were projected onto the physical piece, creating the effect of a structure in a constant state of mutation and distortion in real time and space. As one approached this built artifact or passed a hand over its surface, the object would immediately respond by means of its electronic counterpart. *An audio sound track derived from the same algorithmic structures deployed to manipulate the form accompanied each physical transformation, thus completing the multidimensional experience.*" (10) [emphasis added]

A completed building featuring a similar use of sound as an interactive means to inform physical space can be found in the work of the Dutch architectural firm NOX and the 1997 project for a water pavilion in the Netherlands. (11) The 65-meter long building is comprised of undulating, flowing forms, appropriate to its water theme. Moving through the space has been described by some as providing an experience similar to wandering through a computer game. This analogy is heightened through the use of sounds and lights that react to the movements of the participants, so that the building, exhibition and visitor become one in creating a unique interactive environmental experience. The environment brings to mind the prophetic musings of John Cage, who in his 1966 essay "Rhythm Etc." wrote that in the near future "there'll be centrally pulverized Muzak-plus performed by listeners who do nothing more than go through the room." (12)

Recent years have also seen dramatic advances in the field of signal conversion technology, how sounds are delivered from their source to the auditory system of the intended listener. Conventional voicecoil and cone speakers are well on their way to being supplanted by several high-tech alternatives. Audio transducers, systems that exploit the resonant qualities of common building materials – gypsum wallboard, plywood, tile, etc. – marketed as so-called "invisible speaker systems", have been commercially available for the past several years. In the near future transducers using a metalized polymer foil bonded to a piezoelectric diaphragm structure may allow the cladding of buildings to act as both microphones and loudspeakers. Such systems could be integrated in so-called "smart skins", building wraps in which a variety of environmental control and informational systems are embedded: the prototype recently developed by Dupont and exhibited at the Cooper-Hewitt Museum being an example of this kind of material.

Perhaps the two most interesting and promising advancements in signal conversion technology, however, are bone conductor transducers and HyperSonic Sound. While the idea of conveying sound through bone vibration has been used for quite a while in specific situations (most noticeably in hearing aids), this technology is only recently being investigated for use in mainstream public applications. A project experimenting with this technology in an architectural context was completed in 2000 in a seminar in advanced independent research led by Toshiko Mori at the Harvard Design School. (13) Two mass drivers were placed behind a bench at a height just above the midpoint of an average user's spine. A recording of automobile traffic was played using the wall as a transducer, making the primary mode of audition a type of bone conduction while the listener was seated and leaning back against the wall. The student designer, Ean White, states,

> "The use of traffic sounds was designed to acousmatically disrupt the perceived geography of the building. [...] With the use of bone conduction, whereby sound seems to inhabit one's body, my intent was to conflate sensations of personal and public acoustic spaces."

A similar transgression between inner and outer spaces is found in the potential for architectural applications of HyperSonic Sound (HSS). (14) Invented by one of the developers of the sonogram, Hypersonic sound utilizes a piezoelectric emitter to transmit a highly focused stream (3 degrees of spread over 500 feet) of ultra-high frequency sound waves. Much like the beam of light from a flashlight, the hypersonic waves do not spread in all directions like the sound from a conventional loudspeaker, but instead remain locked inside a slender cone of supersonic energy. In order to hear the sound, your ears must be in line with the column of ultrasound. For example, while your might be able to clearly hear the sounds directed toward you with the system, someone located just two feet away from you would not. Possible applications in audio/video conferencing, simultaneous translation, home and commercial theatres, paging systems and targeted advertising for retail sales are already under development, but the potential for more poetic architectural opportunities beyond these prosaic uses is enticing.

Software and hardware have come together in the examples cited here to produce perhaps the most direct means of establishing a true interactive relationship between people and the built environment. Haptic and gestural controls have direct architectural applications beyond their original development for use in musical composition. One can easily see how they might lend themselves to integration with various building systems – mechanical, electrical, telecommunications – just as these systems themselves further evolve from being mechanically to electronically based. The development of digital sound reproduction likewise has the potential to significantly broaden the definition of architectural acoustics from a primarily passive to an active one. The notion of establishing dialectic between an

architectural work and its users might very well take on a literal meaning as a structure's ability to communicate with its occupants moves closer to becoming a one to one conversation.

V. SUMMARY AND CONCLUSION

Some twenty-four centuries ago, in considering the realm of the senses, Plato chose to give equal importance to the ability to *hear* as well as to *see*. He did so for he believed it was through Pythagorean musical harmony that the irrefutable truth of mathematics, and thus the key to the order of the universe, could best be experienced. Despite Plato's teachings, sight historically has been privileged over the other senses with respect to architecture. Technological advancements in sound generation, control and reproduction over the past one hundred and twenty years, however, have done much to move us closer to a Platonic conception of architecture, one in which the sonic plays an increasingly important role. From Edison's first phonograph to the development of the microchip and the advent of digital technology, it is now possible for sound to be legitimately considered as an architectural medium. Many of the architectural applications discussed here are still in a nascent stage, and as such subject to the traditional pitfalls and false starts associated with emerging technology. Nevertheless, out of these early experiments undoubtedly will come fundamental technological advances that will change the role of sound in the built environment in the coming century. If it is true, as Walter Pater wrote in the 19th century, that all art aspires towards the condition of music, then these recent cross-disciplinary developments will play an important role in moving the art of architecture closer to that objective.

NOTES/REFERENCES

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