Cybrid Principles: Guidelines for Merging Physical and Cyber Spaces

Peter Anders

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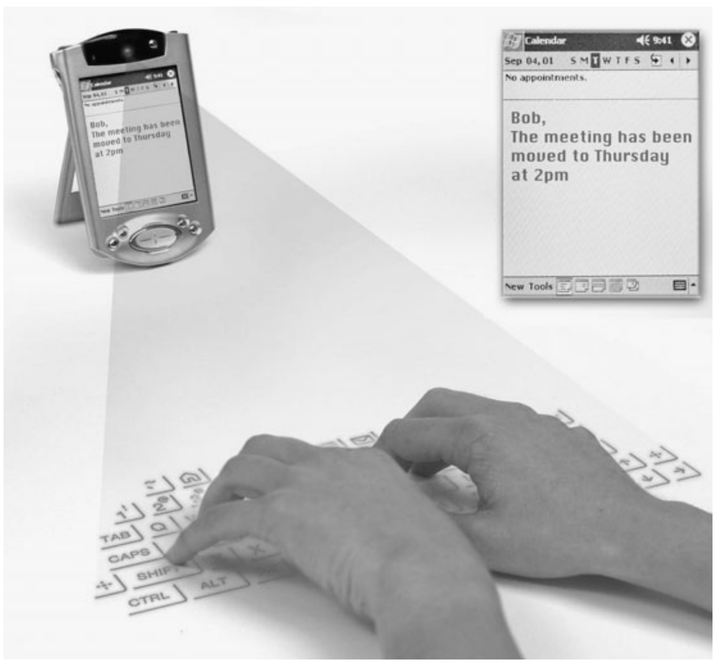
This article introduces seven principles for the design of mixed reality compositions. Contrasting the novelty of mixed reality technology, we have derived these principles from basic needs served by traditional architecture as well as those that have arisen since the introduction of information technologies. These principles draw also from research in cognitive science, human-computer interface design and the recognition of the multivalent, psychosomatic nature of space.

1. Background

Architectural computing encompasses a range of techniques that includes CAD, modeling, virtual reality (VR), networked collaboration and digital fabrication. Common to all these is the use of a digital database and a means for its manifestation. Such manifestation varies by technique. With VR the manifestation is symbolic, an interactive display of spatial objects, while with digital fabrication it is physical artifacts produced by digital lathing or stereolithography. The database shared by such manifestations is an abstract constituents of a project – one that effects its materialization. The interdependence of digital and material elements places such projects within the domain of mixed reality, a field of research that combines digital entities with physical settings or artifacts. The causative nature of the architectural database, however, calls for the identification of a special class of objects that hybridize the material and virtual aspects of their being within one composition. We refer to these entities as *cybrids*. [1]

Many conventional technologies already merge physical and virtual spaces. For instance the virtual space of a television show would not exist without the physicality of the television screen or projector. However the cybrid interdependence of physical and cyberspaces is most clear in interactive technologies where actions in the virtual space affect the physical space and vice versa. A good example of a cybrid appliance is the Canesta keyboard. Designed to integrate with portable computers and PDA's the keyboard itself is a laser projection onto a surface (Fig. 1). One can imagine a PDA propped on a desktop with a screen projected onto the desk's



► Figure 1. This image shows the Canesta keyboard in use. (Copyright 2002 from Canesta Inc.)

surface. Sensors detect where and when fingers touch the virtual keyboard image and the PDA registers the keystrokes as it would for a conventional keyboard. The integration of virtual and physical is clear: manipulation of the physical PDA determines where the keyboard is located, manipulation of the virtual keyboard affects the PDA's operations and display.

Expanding this idea to a larger scale, we can foresee environments that are integrated compositions of physical and virtual architecture. The technologies that would bring this about already exist: distributed computing, mixed reality, and a range of display technologies. Cybernetic controls of buildings and their security systems already approach the interactivity necessary for cybrid operation. However, cybrids are not so much dependent upon individual technologies, so much as their combined effect on the user. Cybrids are based on an empirical understanding of space, one that correlates physical and virtual experience within a compositional strategy. [1]

The present article situates cybrids within architectural discourse by proposing a set of principles derived from architecture's theory and practice. The effort is somewhat hampered by materialist values prevalent in architecture. Although a CAD database may produce a building, it may find other uses as a mixed reality – or perhaps remain entirely in cyberspace. This ambiguity countervails orthodox practice in spite of the architectural nature of the project's database and products. Although differences between virtual and physical spaces would seem to be clear, their similarities could blur distinctions in some projects. This is especially so when we consider the psychological nature of space versus the built space of conventional practice. In order to avoid a materialist/idealist impasse we assume here an empirical approach that considers space to be a psychosomatic phenomenon. This accords with both philosophical developments in the past century and research in the cognitive sciences. We find that an empirical understanding of space is useful in that both physical and virtual objects have equal weight in our consideration.

The cybrid principles that emerge from this investigation serve fundamental human needs through the agency of architecture and its technologies. Architecture traditionally provides us with a communal social reality, a physical context, and a framework for cultural coherence. Contemporary society has similar needs, but these needs have extended beyond the physical domain of conventional architectural practice to include the demands caused by long-range communication, the conflicting and confusing modes of operation of information technologies, and disengagement due to overwhelming flows of information. Cybrids can help by providing coherence for mediated interaction, and a framework for various direct and transmitted modes of communication.

2. The Need for a Shared Social Reality

There is, argues sociologist Daniel Bell, a need for a shared social reality, one that transcends materiality in support of the modern experience. He writes, "In the last 150 years reality has been technics, tools, and things made by men, yet with an independent existence, outside men, in a reified world. Now reality is becoming only the social world, excluding nature and things, and experienced primarily through the reciprocal consciousness of others, rather than some external reality. Society increasingly becomes a web of consciousness, a form of imagination to be realized as a social construction." [2] This observation offers us a new model for understanding and accommodating modern culture, one conducive to the development of cybrids. To address these needs it is useful to relate the characteristics of cyberspace to the traditional modes of architecture.

Indeed many such needs would, in earlier times, have fallen within the scope of architecture. Environments for social interaction – whether for work, play or worship – have to this day been realized in a spectrum of building types. Architecture's role in their creation is borne out not only in its history, but in studies conducted on territoriality and architecture's service to human need. Architect Byron Mikellides cites the work of ethologists R. Ardrey and F. F. Darling and psychologist W. C. Schultz in outlining needs met by human territory. Among these needs he includes security, stimulation, identity, inclusion, control, and affection. [3] He notes the parallels of this list with similar lists of sociologists A. Maslow and Kurt Goldstein and Michael Argyle, a social psychologist at Oxford. Differences between these lists vary between internally driven psychological needs – such as sex and self-actualization – to physiological external demands of safety, sustenance, and even aesthetic need.

Architecture, a cultivated form of territorial control, meets many of our externally-driven needs. This would accord with the work of Danish psychologist Ingrid Gehl who asserts architecture's unique capacity to meet human needs. In her book, *Bo-Miljo*, she presents the human environment as comprising four attributes: dimension, arrangement, location, and sensory stimuli. [4] She shows these attributes – matters fundamental to architecture – to be useful in resolving physiological, safety and psychological needs. Gehl tacitly assumes that architecture and its built products are one – since architecture otherwise would neither shelter nor comfort us. However this holistic view is balanced by an assessment of psychological needs met by architecture. Gehl contends that architecture structures our experience. That is it orients us, provides context, and lets us meaningfully place objects in our surroundings. Architecture, she claims, reinforces individual experience, sustains social contact, continuity and communal identity. These needs are not solely concerns of the modern day, but appear to be intrinsic to being human.

Despite its past success architecture's focus on materiality, both in theory and practice, has rendered it increasingly inadequate for the challenges presented by telematics and global culture. The premises of modern technological culture – its accelerated pace and distributed, asynchronous nature – strain architectural notions of materiality, permanence, and even of presence itself. [5] Traditional architecture, in contrast, serves a stable and localized clientele, its methods conduce to the production of physical structures. Many members of the discipline, among them technology's most avid proponents, maintain that the computer simply speeds up conventional processes – that the material ends remain the same. However, as we have noted, contemporary information and telecommunications technologies render these assumptions problematic at best.

3. Toward Principles for the Design of Cybrids

We have argued for a need to create a shared social reality in the face of increasing technological change. This overarching need could be met by attending 1] the need for a coherent communality, 2] the need for a context against which to assess change, and 3] a need for a corroborative, cognitive framework for the increasing flow of information. To expand architecture's role we must compare the traditional means by which architecture met these needs with their redefinition in light of contemporary technologies. We shall discuss them in the following order: 1] coherence and systemic behaviors; 2] context and space; and 3] corroboration and the extended sensorium.

3.1. Coherence and Systemic Behaviors

Buildings support our physical and mental well-being and, arguably, the cognitive and social processes of our daily affairs. Architecture's materiality is important not only in serving these individual needs but also in creating a *social reality* – one that may be observed directly by all that encounter it. A shared experience of such environments provides the coherent, communal foundation for society. The intransigence of buildings grounds a culture, distinguishing it with landmarks and places of gathering. Traditionally, at least, the coherence of a society was commensurate with the duration and consistency of its material environment. Such consistency was disclosed by various means, many of which remain techniques taught in schools of architecture and urban planning. They include materials of construction, spatial composition, service to occupant needs, physical setting, and relationships between constituent elements. Such consistencies are largely spatial and depend to a great degree on the material attributes of architecture. They are marked by architecture's stability relative to its changing contents and occupants. Built architecture's resistance to change, we argue, marks its behavior over time. Its immutability serves its coherence as much as any of its material elements.

Insofar as cyberspace may emulate physical stasis, many of the techniques of traditional architecture apply to cybrids' compositional coherence. [6] User expectations may be fulfilled by simple mimicry of physical effects. This has been the hallmark of virtual reality simulations and, by extension, the cyberspace components of cybrid architectures. [7] However, the contents of neither cyberspace nor virtual reality are inert by nature. They may change dynamically, altering shape and composition slowly or instantaneously depending on their system's design. An observer, unaware of the system's behavioral rules, would be confused as to cause and effect in such an environment. The experience would be incoherent if the program behind it did not take the user's expectations into consideration. Coherence in such an environment is a matter of behavior *over time* more than the static relationship between elements we find in physical buildings.

The behavior of computational simulations and their fulfillment of user expectations expand the subject of human-computer interface [HCI] design to an environmental scale. HCI is an established field of inquiry that brings together researchers in cognitive science, computer technology, psychology and industrial design. A belief commonly held within HCI community is that users' expectations directly affect their experience with the computer. [8] From the standpoint of HCI the capricious program above would exemplify a *bad interface* in that users couldn't anticipate the effect of their actions. The user infers coherent behavior from his experience with the system. It is through this coherence that the user takes meaning that will help him in his further dealings.

A theme underlying HCI is the search for what is called the *transparent interface*, a human-computer interface that so anticipates users' expectations that it quickly recedes from the users' attention as they go about the work at hand. [9] [10] It is said that such interfaces employ a *natural* language based on observations and assumptions about the user. [11] [12] Underlying such assumptions are social, psychological, and physical observations of human behavior ranging from the orientation of the body to innate cultural values. [13] These are among the many dispositions that inform user expectations. Systems that deny these expectations call attention to themselves and, so, lose their transparency. Whether this is desirable depends on the purpose of the system; what may be good for art or entertainment may not be so for a production tool. Appropriate, coherent behavior is highly valued in spaces as well as their occupants. An observer entering a building expects the behavior of the structure to be static. Although the same observer entering cyberspace or VR may not expect a static environment, she will likely assume that body orientation, up, down, right and left still matter. Turning her head to the left should reveal virtual objects to her left side. She would expect as much in a physical environment except that in a simulated environment *nothing can be taken for granted*. The system could just as likely show what's on her right side depending on the program. For this reason in even apparently stable simulations the coherent behavior of a system – its response to human action and expectation – is vital to its success. [14]

In systems that hybridize physical and cyberspaces, as would our cybrids, users are best served by attending the coherence of systematic static and dynamic behaviors. [15] We might expect static behaviors to follow the principles of conventional architecture: proportion, scale, and compositional relationships. Some qualities – form, orientation, and lighting for example – may transcend physicality entirely. Conversely, dynamic or time-dependent behaviors would follow a carefully crafted HCI interactive program. In contrast to the stasis valued in orthodox architectural practices, cybrid architecture entails a close coupling between static/dynamic behaviors in the light of user expectations. By creating such coherence the architect serves not only the individual user but others who communally share the system as well.

3.2. Context and Space

Social behavior is often subject to the architecture that houses it. Behavior at a pub is not suitable for a church, for instance. Nor would be gymnastics at the local library. Architecture in such cases serves the activities both by attending their functional needs, as well as by providing a meaningful – even symbolic – setting for their conduct. This implicates our earlier observations about coherence in architecture, but the coherence provided by context operates on many levels. Of particular interest is the way architectural space informs its contents, providing a format for a spectrum of information and sensation. An art museum provides us with a useful example.

The interior of a museum is designed for meaningful display. Exhibit halls, information desks, meeting areas all conduce to a satisfying experience for the visitor. This aesthetic and cultural context tempers the viewer's expectations and informs all objects that he encounters. The museum's contents provide an inter-modal spectrum of experience: three-dimensional sculpture, paintings, labels, brochures, posters, books, film, video and, now, computers. Each artifact is inflected by its surroundings. They and the museum itself comprise the context of the visitor's *museum experience*. The power of the setting to charge its contents is amusingly demonstrated by the cartoon that shows museum-goers pondering the mop and bucket of the gallery's custodian.

The matter of context extends beyond building typologies to questions of place and space itself. If, following Webster's Dictionary, we take *context* to mean the inter-related conditions or environment in which something exists, we tacitly accept the observer's role in relating those conditions – spatial or otherwise. The cognitive act of relating things discloses our use of space to help us think. [1] Here we enter the domain of cognitive science which we cannot elaborate here except to observe the informational role

[1] Curiously, we do so in the very act of generating the percepts and phenomena of space itself.

that space plays in human consciousness. The various modes by which we attain the museum experience include moving about the spaces, seeing sculpture, reading text, interpreting paintings, talking with the staff. All these modes – whether or not innately spatial – are implicit within spatial experience. We may thus regard space as the coherent, internally generated display of sensory information conditioned by body, mind and memory.

This psychosomatic definition of space owes much to twentieth century philosophy and science, particularly the phenomenology of contemporary philosophy, and science's implication of the observer in his or her observations. Curiously, this understanding contrasts with concurrent architectural practice that, in stressing the built environment, often neglects the cognitive, empirical nature of space. The materialist view of space – a subject which architects claim to master – is at odds with a long history of philosophical and scientific inquiry. Challenging the priority of materialism, then, asserts a more idealist view of space, one conducive to the creation of cybrids, and one that mediates between older cultural values and the realities of contemporary technology.

The designer's task, then, is to provide meaningful settings within which information – or data – may be turned to knowledge. This setting needs not necessarily be material, nor even spatial. However, since we are disposed to locating and identifying stimuli, we can expect spatial presentation to be useful for apprehending a range of audio, visual, tactile, symbolic and textual information. Space would form a context for their appreciation. Whereas orthodox architecture might limit its scope to the space of construction, this reconceptualization proposes a greater space of consciousness, a *comprehensive space* that mediates between physicality and the evanescence of data structure and flow. This comprehensive space is a context for modern culture and its technologies. It is grounded in the phenomenology of space and forms the foundation of cybrid development.

3.3. Corroboration and the Extended Sensorium

A building is part of our normal empirical world. The hand confirms a wall to be where the eye sees it. The tap of our footsteps comes from the floor we feel below us. Any discrepancy between sensations either seems strange, is ignored, or – in the case of the eyes and ears – yields a higher dimension that accounts for the error. In short, the building seems natural so long as our senses corroborate its effects. Sensory corroboration seems fundamental to our conception of the world and, using it as a point of departure, we can quickly see its relevance to modern information technologies. [16] Indeed, as Marshall McLuhan argues, these technologies have extended our senses beyond our bodies and have disclosed to us a world otherwise unseen. [17] The corroboration of technological effects with those of our direct, unaided observation is crucial to cybrids. For cybrids depend on the meaningful conflation of mediated and directly observed realities.

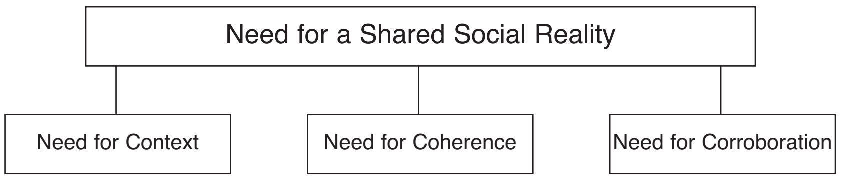
The media instruments that comprise our extended sensorium fall roughly into two classes: sensory and *symbolic media*. Whereas symbolic media conveys representational or allusive information, *sensory media*'s products resemble those of direct observation. The image seen though a telescope, for instance, is analogous to the image we perceive directly. Body orientation, and the direction of our gaze are the same regardless of whether we use the instrument. We can easily corroborate what we would see without the telescope. This holds true also in the case of mechanical and electrical hearing aids. The artificial acoustic image resembles that sensed by the unaided ear– the relationship is obvious. However, the relationship between *symbolic media* and direct observation is not so clear. The digital read-out of a Geiger counter may have no resemblance to the rock we see before us. Yet they are phenomenally related, each tells us something different about the rock. Reconciling the symbolic and visual information is not as easy as relating stereoscopic images; it requires processing in different parts of the brain and a degree of abstract thought.

Symbolic media differ from the effects of direct observation in other ways. While photography *extends* our sight, it is temporally and spatially distinct from direct viewing. A photograph may show a scene that happened years ago. It requires altogether different viewing angles and body positions than actually seeing the source of the image. Similarly, a stereo recording of a symphony is disjoint from the time and place of the performance – and thereby attenuated in ways different from an electronic hearing aid. Despite these abstractions synthesizing experience from symbolic media and direct observation is an everyday act. Viewing exhibits in our art museum, for example, is greatly enhanced by the labels and texts that annotate the displays. We experience the show in distinct modalities, mediated and unmediated – yet we are able to unify them within the same experience. This is no accident, for a museum exhibit is *designed to be coherent*. The label/explanations must hang next to the displays otherwise the viewer may miss the point of the exhibit entirely. A pile of labels disjoint from their paintings is useless. The more we attenuate symbolic media from their source [in time, space, or resemblance] the harder it is for the viewer to synthesize their relationship. Conversely, the more that symbolic media relate to their source, the easier it is for observers to corroborate them and derive meaning from their experience. This is particularly important in the creation of cybrids in which physical and cyberspaces are meaningfully integrated.

4. Defining Cybrid Principles

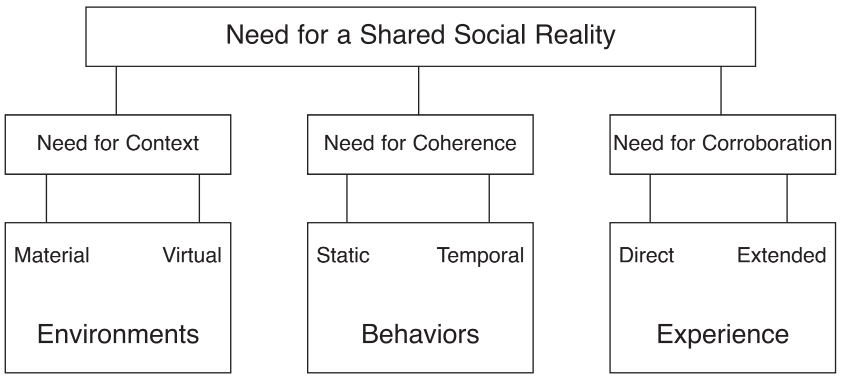
Below is a diagram of the social and psychological needs laid out previously. Shown is a relationship between the overarching need and tributary needs by whose solution the larger need may be met.

▶ Figure 2. Relationship of Needs



Each of the tributary needs might be accommodated by the extended architecture of cybrids. Such accommodations would typically range between mundane attributes of buildings to those of digital, electronic environments. For example, the need for context may be resolved by environments, either material (buildings) or virtual (cyberspace). The need for coherence can be met with a range of behaviors whether static (relationships between solids) or temporal (dynamic, time-based). Finally the need for corroboration may be addressed in environments that we experience or sense directly (buildings, cities), as well as those we detect through the extended senses of media technology (digital worlds, VR). Below we have expanded the diagram to show possible architectural resolutions (Fig. 3).

▶ Figure 3. Needs addressed through architecture



This diagram embraces opposing qualities of architectural resolutions under the terms of architectural Environments, Behaviors and user *Experience*. It reconciles extremes, for cybrids by definition would 1) integrate material and simulated environments 2) exhibit both static *and* time-sensitive behaviors 3) and be experienced both directly *and* through the extensions of media. We propose below seven principles for the creation of cybrids, defining their service and setting the stage for the designers, occupants and society that create them. Readers will note that the principles are pragmatic in two senses, one practical the other philosophical. They are practical in that they stress the user's experience rather than specific technologies. This avoids over-refinement and obsolescence that would encumber what should be general principles. A philosophical pragmatism is evidenced by provisional definitions that assist in developing cybrids. An example would be *comprehensive space*, the gestalt for designing cybrids. Despite its overtones this term is specific to cybrids' design, and makes no claims to philosophical or scientific truths. Its pragmatism lies in providing the mental framework for cybrid architecture's designers and users.

1. Comprehensive Space: Cybrids exist in a comprehensive space that comprises the material, symbolic and cognitive attributes of spatial experience.

While *comprehensive space* implicates the cybrid user's experience, it is particularly useful to designers of cybrids. It encourages development of projects free of bias toward either material or simulated solutions, offering instead the broad spectrum that lies between. As a mental frame for cybrid development it has useful entailments. For instance cybrids evolve from a space recognized as a product of consciousness. This space pre-exists any of the project's manifestations, surviving until the last memory of the project is lost. This suggests that the *life* of the project extends from the earliest inclinations of its creators to well beyond its construction. The cybrid is thus understood to be an evolving entity rather than a final product, it embodies the information of its design, production, its use, transformation and eventual dissolution.

2. Composition: Cybrids are mixed-reality compositions that comprise material and simulated elements.

This principle stresses the integration of physical and cyberspaces in the mind of the designer and, in turn, that of the observer. Our earlier example of the Canesta keyboard demonstrated such a compositional strategy: the PDA screen would have to be spatially related to the projected keyboard in order for the interaction to work. An architectural cybrid's composition could likewise be observed in a variety of modes, through direct observation or via technology. – be it projections, screens, or over the internet. The design of the cybrid would determine the nature of constituent elements, as well as the type and number of techniques that would support it.

3. Corroboration: Cybrids offer a range of empirical modes that corroborate one another to a determined degree.

The corroboration of experiential modes leads to a holistic understanding of a cybrid.. A movie theater provides a simple example of such corroboration. Within the theater we are, arguably, in a cybrid that links the physical theater with the virtual space of the movie. The effectiveness of the illusion is enhanced by the corroboration of stereophonic sound with the action on the screen. When an actress moves from one side of the screen to the other, the sound follows her. In an architectural cybrid, the virtual actor (or avatar) may be contrained to act within the physical space so that the sound, image and space of the virtual are coherently situated within the actual space. Such corroboration is important to the understanding of cybrids as compositions rather than mere aggregations of effects, a subject addressed in Principle 2. The degree to which the modes corroborate one another is determined initially by the designer, and later may be modified by the cybrid's occupants.

4. Reciprocity: There is reciprocity between a cybrid's physical and cyberspaces such that actions in one domain may affect the other.

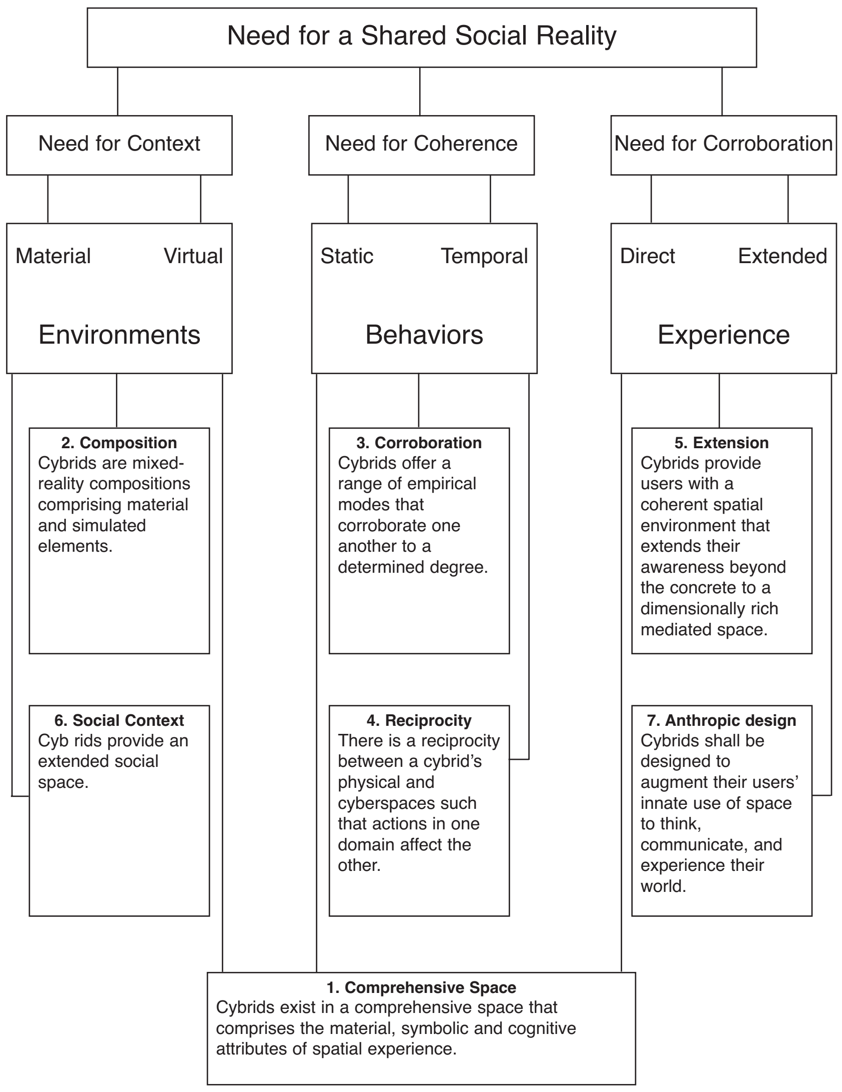
This principle describes a reciprocity or coupling of states determined at the outset of a project and modified thereafter. This reciprocity addresses the coherent behavior of the cybrid composition, or the integrity of the cybrid, rather than the technology whereby it is manifested. Strong or weak reciprocity of these states depends on the needs of the user. Weak reciprocity includes the coincidence between a spatial data base and a building, as in the CAD files used to build a structure. In such cases coupling only serves the instrumentality of the CAD file to the builder's actions. This is a weak coupling because it is barely reciprocal – if at all. Strong reciprocity entails a tighter coupling between material and cyberspaces such that changes in one state affect the other. This would suggest a cybernetic, self-regulating system at work in cybrid operation. Current examples would include monitoring/control systems, surveillance and building operation networks.

5. Extension: Cybrids provide users with a coherent spatial environment that extends their awareness beyond the concrete world to a dimensionally rich, mediated space.

This principle stresses the spatial qualities of the cybrid and the ability of users to generate spatial experience from a variety of informational sources. As cybrids would make possible the observation of abstract and simulated artifacts, we may consider them to be part of the extended sensorium described earlier. Also, because of the reciprocity of states in cybrids, occupants in a cybrid's physical domain may be observed from cyberspace, and vice versa. In this way the presence of the observer is extended into the reciprocating domain. As is the case with other principles listed here, the degree to which observers are extended is determined by the designer and later adjusted by the occupant.

6. Social Context: Cybrids provide an extended social space.

In light of the foregoing principles and the degree to which both physical and cyberspaces conduce to social activity, cybrids may form a structured social space. Beyond sustaining the activities of its occupants, cybrids may



◀ Figure 4. Service of cybrid principles to needs.

host telepresent users and offer a meaningful social context for their interaction with those physically present. Such interaction could be based on historical/anthropological models for interaction with spirits, deities or other non-physical entities. Examples of such ritual interaction are suggested by myth, legend, structured metaphors, and occult practices.

7. Anthropic Design: Cybrids shall be designed to augment their users' innate use of space to think, communicate, and experience their world.

Anthropic cyberspace has been defined as "an electronic environment designed to augment our innate use of space to think, communicate, and navigate our world." [18] Our seventh principle expands upon this definition to include both the material and cyberspatial aspects of cybrids. The cybrid environment is structured for ease of use much as one might expect from architecture. While this would seem obvious in a building, it is not so in cyberspaces where spatial artifacts and their presentation may seem arbitrary. The design of cybrid space considers the awareness and presence of the observer. It is here assumed, as it was in the first principle, that the observer/occupants of the cybrid mentally complete the cybrid's composition from the evidence of their direct and extended senses as well as their cognition and memory.

Shown below (Fig. 4) is an extension of our earlier diagrams. It shows how the seven principles described above apply, primarily, to architecture's accommodation of contemporary needs. In practice, however, one would find the principles would overlap or otherwise reinforce one another.

5. Conclusions

The seven principles offered in this paper address the increasingly mixed reality in which we live. Beyond architecture they present guidelines for the production of various kinds of artifacts, tools and artworks. We may already see similar principles at work in the design of human-computer interfaces, digital games, and like efforts in responsive environment design. An important aspect of the principles however is their independence from specific technologies and the principles' grounding in human experience – the empirical approach described at the beginning of the paper. These seven principles are intended to guide the design of cybrids and provide a foundation for a polyvalent practice of architecture. Beyond architecture, we hope that the principles find their use in the design of new work that merges the physical and cyberspaces of our world.

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