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Environmental Design for the Physical–Virtual Continuum

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The COVID-19 pandemic has shifted daily patterns for individuals around the globe, with scholars confirming changes in the use of physical and digital spaces and technologies (Aguilar-Farias et al., 2021; Barankevich & Loebach, 2022; Bin et al., 2021). The rapid transmission of COVID demanded new ways of disconnecting from physical spaces and building virtual relationships. The shifting dynamics between virtual, physical, and hybrid interactions are not ideas that are new or unique to the pandemic (cf., Negroponte, 1995; Park & Evans, 2018; Sommer, 2002; Stokols & Montero, 2002). Yet, the COVID Era prompted heightened awareness of the interplay between physical and digital environments in connecting us to each other and facilitating our daily activities (Ottoni et al., 2022). Many behavioral patterns established over the course of the pandemic have been maintained, especially the use of digital technologies in everyday activities. These patterns will likely continue to alter our interactions with and within our physical and digital spaces.

In 2022, hesitation persists about returning to pre-COVID habits and routines of interaction with our everyday surroundings. This is especially evident in workplaces, as some employers demand a return to physical offices whereas others advocate for a future without them (Hsu, 2022). COVID has contributed toward an increase in virtual meetings, remote work, and cloud-based collaboration "spaces," all relying on digital technologies to create interpersonal connections, find support, and afford online teamwork. The convenience of virtual work has also impacted design firms, expanding the range of collaborative opportunities between designers and end users. More controversially, the ability to work from home during any time of day or week has blurred the distinction between work and home, and altered expectations regarding work hours and supervision. As the boundaries between work, play, and home become less pronounced, it will be increasingly important to understand which virtual–physical spheres are conflicting and which are complementary (Stokols, 2018). Understanding the systems, processes, and activities of these overlapping and embedded worlds can help guide their creation and use.

The growing intermingling of digital and physical spheres calls for theoretical and empirical consideration.[1] Prior research in environmental psychology has examined the importance of physical design features in influencing human behavior and well-being (Gifford, 2014; Zadeh et al., 2014), with scholars addressing the impacts of digital worlds on outcomes including mental and physical health (Fodor et al., 2018; Frost & Rickwood, 2017). However, it is crucial to understand the changing patterns of human–environment transaction in the context of our hybridized physical–virtual surroundings. Currently, there is a dearth of research that encompasses the joint influence of the virtual and physical on outcomes (Stokols, 2019). The growing interdependence between virtual and physical environments, including our greater immersion in digital domains and disengagement from physical ones, calls for a fundamental restructuring of our understanding of health-promotive and pro-social environments. The need for further design research on the dynamics of hybridized physical–virtual environments is urgent and immediate due to the evolutionary speed and pervasiveness of new technologies, along with the digital worlds within which they are situated (e.g., self-driving cars, virtual and augmented realities, the metaverse). The embeddedness of such technologies within our lives has enabled unprecedented opportunities for connection and collaboration but has also led to fragmentation of attention and disorientation as we oscillate between the virtual and physical. These oscillations, which are likely to become more frequent and disorienting as digital spaces become more immersive, may exacerbate emotional stress and/or confusion. Some of the consequences of our hybridized surroundings are already visible—yet our understanding of the interplay between these spheres and how to create physical spaces for them remains underdeveloped.

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Individuals' Orientations to Their Physical and Virtual Worlds

The emergence of digital technologies has affected the level of interaction and immersion that individuals have with both their virtual and physical surroundings, leading to fundamental shifts in people–environment relationships (Stokols, 2018). These levels of immersion vary by patterns of activity, spatial affordances, and occupants' needs within particular settings. Misra and Stokols (2012) outlined four major orientations between people, physical places, and their virtual worlds: *placeless, cyber-based, place-based*, and *place-cyber-based*.

Globalization and the digital age have necessitated new design strategies which, in some cases, have resulted in virtual settings that are not culturally or geographically rooted (cf., Blanchard, 2004; Blanchard & Horan, 1998; Eldemery, 2009). Relatedly, some individuals exhibit *placeless* environmental orientation—a personal style or disposition in which individuals are psychologically disengaged from both physical and virtual settings. This disengagement is associated with a lack of commitment and psychological attachment (Misra & Stokols, 2012). However, even individuals with placeless orientations still function within physical, and often digital, spaces that impinge on their behavioral routines and social interactions. Considering individuals' environmental orientations from the vantage point of design requires an examination of their interaction with a physical space regardless of their level of attachment.

The *placeless* orientation along with the three others—*cyber-based, place-based*, and *place-cyber-based*—are situated along a virtual–physical space continuum. These environmental orientations reflect an individual's identity and attachment to physical and digital spaces according to their socio-emotional needs (Misra & Stokols, 2012). Those with cyber-based orientations largely engage with others and define their identity through participation in digital environments (e.g., immersion in blogging, online gaming), whereas those with place-based orientations do so primarily in physical spaces. Place-cyber orientations entail a more balanced engagement with both physical and cyber spaces. While earlier discussions of environmental orientations included a range and dispersion of individuals along the continuum, the pandemic has led to an acceleration of lifestyle changes emphasizing digital worlds. It seems plausible that individuals with an entirely place-based orientation have now shifted more toward the middle of the continuum. Although the level of interaction and immersion within each type of space changes based on one's position along the continuum, physical and digital worlds jointly influence their everyday behavior, emotions, and well-being to some extent. As such, various points on the continuum require different digital and physical environmental considerations.

On one end of the continuum, some individuals' high level of participation in physical spaces reflects their immersive involvement with fixed and semi-fixed features of the environment (Hall, 1966) and the people situated within those place-based settings. Here, technologies are usually unobtrusive and exist primarily to help occupants' coordinate their face-to-face (F2F) interactions. While such environments consist mainly of physical spheres, with fewer openings into digital worlds, the ubiquity of modern technology means that digital spheres increasingly will permeate the vast majority of people's everyday physical surroundings. Nonetheless, people with predominantly place-based orientations define their personal identity and sense of community primarily through in-person interactions and activities. Spaces of meaningful interaction with others can encompass a variety of third, second, and first places (Oldenburg, 1999) that are imbued with meaning and, often, collective memories.

On the other hand, individuals with predominantly cyber-based orientations are less likely to absorb and interact with their immediate physical surroundings as compared to people with place-based, or place-cyber orientations, due to their immersion within the digital. Yet, even among individuals who typically minimize their engagement with the immediate physical world in favor of the digital environment, salient features of their place-based surroundings also affect their patterns of interactions with virtual settings (cf., Gergen, 2002).

For many, interactions with physical and digital environments occupy a different portion of the continuum, reflecting more balanced levels of personal engagement in their physical and cyber worlds. These different worlds jointly influence each other within a geographically bounded area from which individuals access a variety of virtual settings (Stokols, 2018).

Leveraging the Physical–Virtual Continuum for Design

Differing orientations to the physical and/or virtual, the rise of virtual design consulting services (e.g., Havenly), the popularization of remote work, and enhancements in design technologies have changed the way that interior designers create new spaces. These changes foreshadow broader trends in design and the role of the designer. As the tools and capabilities of designers allow for faster, more precise calculations and immersive simulations of imagined solutions, designers may have more time for formulating alternative creative ideas and assessing their impacts. As more activities and interactions shift into

hybrid spheres, the physical and digital design sectors will need to collaborate in the creation of digital and physical spaces to ensure the compatibility and success of both. Design of the physical, then, will not only consider but also engage in the creation of the digital.

Physical copresence among other designers and the project site is often required at critical junctures of the design process. However, these F2F moments may become increasingly rare with the proliferation of and improvements in virtual and augmented reality (VR, AR). The merits of using the latest software technologies are appealing, as they enable collaboration, creation, and evaluations among designers across the globe. The current sharing and simultaneous editing of digital models will become more realistic with enhanced technological capabilities, allowing for concurrent walkthroughs of spaces. These opportunities will likely translate to more client buy-in as environmental simulations achieve higher fidelity, enabling greater understanding and more rapid assessments of alternative design solutions.

Design has already shifted toward the creation of spaces that can support various digital and place-based orientations. However, interior designers cannot disregard physical environments for the sake of purely digital ones. For instance, even clients with predominantly cyber orientations are dependent on the physical affordances of place-based surroundings. Whereas high fidelity VR provides immersive visual and audio simulations of water elements and other environmental features such as the presence of trees or other people, current VR technologies do not effectively capture the tactile and olfactory qualities of the physical, such as the *wetness* of water, the *smell* of a forest, the *taste* of food and drinks at a café, or the *touch* of another person. As virtual design consultation has increased in popularity, it becomes critical to ensure that the implications of our work are considered in a coherent context that accounts for elements not easily conveyed through digital simulations of environments nor visible within a video call window. Assessments of alternative design plans should be thorough and account for the multifaceted complexities of our virtual and physical worlds.

Looking toward the future, we will likely witness large-scale shifts not only in the spaces within and methods through which designers create, but also the kinds of settings that prospective users deem valuable and appealing. The proliferation of digital technologies within all spheres of life has meant that few types of environments have remained undisturbed by modifications in how human settings are conceptualized and used. The home has become a prominent source of "polyfunctional" interactions, encompassing a blend of online and place-based activities (Stokols et al., 2009). The COVID-19 pandemic prompted a change in the use of third places, the consequences of which are not fully understood (Stokols, 2020). Yet, there will be a continuing strong need for home workspaces, public places, green spaces, and other physical settings as individuals oscillate between immersion within digital spheres eventuating in reduced awareness of their material surroundings, and at other times, their desire for direct physical contact with nature and other people.

Behavioral and Design Implications of the Physical–Virtual Continuum

Given the complexity of digital-age environments, how can we leverage the virtual–physical continuum in ways that enhance our complicated, hybrid lifestyles? To do so, we must assess the implications of the environments that we live in, work in, play in, and create. The majority of research examining the design of the physical and digital typically focuses on one type of environment or the other. For example, recent work has investigated a range of topics in relation to the built environment, including the importance of biophilic workspaces (Dravigne et al., 2008; Dreyer et al., 2018), features of mental and behavioral health facilities (Shepley et al., 2022), and the relationship between green spaces and crime (Bogar & Beyer, 2015; Sadatsafavi et al., 2022; Shepley et al., 2019). When examining digital spheres, those that have been assessed most often in terms of VR technologies include people's experiences within digital worlds (e.g., Kalantari et al., 2022) and the evaluation of alternative physical design decisions (e.g., Dunston et al., 2011). However, the intermingling of virtual and physical environments noted above also necessitates research into the behavioral implications of our hybrid worlds.

We must broaden our understanding of individuals' diverse environmental orientations—especially how the design of physical and digital realms either constrain or support their cyber-place orientations. How can we enhance the virtual–physical continuum to improve behavioral and health outcomes among users who have different cyber-place orientations? Designing supportive environments entails not only maximizing compatibility among people's physical and virtual worlds, but also understanding how to create hybrid environments that promote more positive outcomes for their occupants. For example, physical environments have been assessed for their ability to encourage or hinder social outcomes (e.g., Osmond, 1957; Sommer, 1967), including their capacity to facilitate positive social interactions (Sailer & McCulloh, 2012), community engagement (Zhu, 2015), and the development of social capital (Button et al., 2013). The design of physical spaces provides varying degrees of fit for the interactions occurring within them, depending on their spatial qualities and affordances (Gibson, 1977). In similar ways, digital spaces can also support users' behavioral and health outcomes. However, lack of fit between

a person's activities and the virtual–physical continuum might result in a range of adverse outcomes, depending on the user's needs and salient features of immediate surroundings. In some, interactions occurring in digital settings might hinder the creation of weak ties in physical spaces. Alternatively, strong ties among individuals occupying physical environments could get eroded through frequent participation in digital spaces. It might be necessary to bolster the weak and strong ties found in digital spheres through participation together in physical space (e.g., the *Meet-Up* app that enables strangers to schedule future activities together such as hiking or tennis in an agreed-upon place). Despite (or because of) current trends toward people's greater participation in digital worlds, it is critically important for designers to create physical settings that maximize individuals' opportunities to establish both strong and weak social ties, supplementing online interactions and connections with participation in socially engaging places where individuals can enjoy being physically copresent with others. Design scenarios that support these goals have not been clearly delineated, and the most supportive environmental features along the virtual–physical continuum for bolstering social support and social capital have yet to be codified (e.g., perhaps in the form of a "pattern language" for hybridized environments; cf., Alexander et al., 1977).

The findings from future studies, ideally, will enable us to leverage intentional design decisions to maximize behavioral and health outcomes for various points along the virtual–physical continuum, and among users with different cyber or place-based orientations. It is vital to understand and uncover the kinds of environmental features and settings that are most conducive for various interactions, as a basis for design decisions and guidelines that target and maximize specific positive outcomes for individuals and their communities. The evolution of technologies, along with the digital spheres that they inhabit and create, will likely reveal various ways that design does or does not adequately support the mixed modalities of people's digital-era interactions. However, we suggest that researchers, designers, and community members discourage people's disinvestment from physical spaces and in-person connections, even as greater attention and resources are directed toward technology-based interactions. Individuals' increased immersion in virtual spheres is by no means equivalent to a reduction in their need for in-person physical connection, and we do not yet understand the behavioral and emotional ramifications of people's prolonged participation in predominantly virtual worlds (such as *Second Life* and online gaming), or their embrace of primarily cyber lifestyles.

It is crucial for researchers and designers to gain a broader understanding of people's transactions with their virtual and physical world—especially as converging and sometimes conflicting virtual and physical environments, propelled by increasingly immersive technologies, shape our behaviors and outcomes. We call for this research because an inadequate understanding can result in incongruities between individuals and their surroundings, leading to the lack of person–environment fit and diminished physical and mental health. We do not advocate designers' neglect of digital environments while they focus exclusively on developing evidence-based guidelines for creating physical ones, nor vice versa. Rather, we encourage the conceptualization and development of places and people's interactions within them through the lens of a virtual–physical continuum, and in relation to individuals' varying cyber-place orientations, especially as more individuals move toward cyber-place lifestyles. As contemporary modes of virtual life sometimes blur the importance of, and sometimes replace, the most significant physical settings in our lives, how can we create engaging, high-quality spaces along the physical–virtual continuum in ways that accommodate and support occupants' diverse environmental needs? How can we foster fulfilling relationships occurring in mixed modalities while minimizing overload, stress, and disorientation? What are the consequences of our polyfunctional lives, and how might designers address these through the creation of more integrated, supportive, and socially orienting environments?

Declaration of Conflicting Interests

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Note

1. The shifts from physical toward virtual and blended environments have necessitated an extension of the lexicon of environment–behavior (EB). With the pervasiveness of the cybersphere, many concepts require reevaluation and redefinition for the inclusion of digital technologies or virtual spheres in order to remain salient in the digital age. In some cases, new concepts will have to be created

in order to address the emerging phenomena. For example, research on wayfinding now includes studies of digital aids and mapping devices. Privacy research has shifted from focusing mainly on auditory and visual considerations to include studies of online identity theft and spyware. Within Bronfenbrenner's (1979) model, there is no examination of virtual settings and their embeddedness within and across different environmental scales. Contemporary research in ecological psychology now encompasses studies of virtual behavior settings and virtual communities (cf., Blanchard, 2004; Stokols, 2018). For more discussion of the changing conceptual landscape of EB and environmental design research, see Sommer (2002) and Stokols (2018, 2019).

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