Special Issue: Subliminal/Unaware Cues and Perception of Presence in Virtual, Telepresence, and Automotive Environments

Guest Editors’ Introduction

Theory and Technological Implications of Subliminal Perception Research

The term “subliminal perception” has been around for many years and is generally understood as perception that can occur without conscious awareness. The idea that subliminal perception provokes a significant impact on thoughts or behaviors strikes many people as counterintuitive. Recent findings support the notion of perception without conscious awareness, and oppose the intuitive notion that consciousness is necessary for perception (Ramsoy & Overgaard, 2004). The discussion whether subliminal perception actually changes thoughts/behavior traces back to the question whether a stimulus is perceived even when there is no awareness of it. Rapid advance of new technologies, such as EEG and fMRI, provides a way to measure directly effects of subliminal stimuli, which leads to a revival of studies on the link between subliminal stimuli and behavior, thought, and emotional changes.

The central objective of this special issue is to provoke an active debate on the impact, role and adequacy of using information below threshold in virtual environments, teleoperation, or augmented reality. The papers in this issue deal with the concept of subliminal perception, its basic characteristics, and appropriate research methodologies using neural, physiological, cognitive, or behavioral responses to subliminal cues in virtual/augmented reality, teleoperation, and automotive contexts. It features a collection of current, state-of-the-art research results discussing the effects of subliminal stimuli and behavior.

1 Importance of Subliminal Perception in the Context of Presence

“Presence is filled with stimulating material applicable to the study of human–machine interfaces and sensorimotor/cognitive behavior” (MIT Press Presence website, 2014). With this focus, it was only a matter of time until one of the most controversial topics in psychology found its way into the journal: the role and function of subliminal perception—a very special category of sensory cues—in real or virtual environments. Since mediated environments such as virtual environments (VE) allow full control of the sensory stimuli, VE-based studies of the relationship between subliminal stimuli and human responses might have a major contribution to the methodology and understanding of design of presence states in virtual worlds, while at the same time contributing to the methodology of research of subliminal perception.

One particular motivation for dedicating a special issue of Presence to subliminal perception research stems from the fact that humans are exposed to approximately 10 million bits of information per second—out of which, more than 99% without active awareness, and only a very small fraction of 10 to 50 bits per second is processed consciously (Norrstrand, 1998). Most research on presence is centered around the latter, and fewer studies look at the first. This special issue addresses the role of the 99% processed without active awareness, in presence perception.

Human–machine interaction (HMI) has in the past primarily focused on technological aspects, such as new interface technologies and automated systems for context/activity recognition, or other forms of automated processing. The most recent challenge of ICT research is to allow communication that follows everyday perceptual patterns in a non-mediated environment, i.e., transform the experience in a virtual world into an identical experience in the non-virtual, including stimuli that are perceived unawarely, but have an effect on thought and behavior. Through the availability of suitable and mobile hardware components (e.g., see-through eyeglasses,
vibrotactile belts or small transducers integrated into the clothing, small and wireless operating earphones, scent dispersers, etc.), the approach of information transmission in an unconscious, subliminal communication has been made possible.

If these technologies are used appropriately, it is expected to offer timely and cost-efficient opportunities to make a significant contribution towards a more natural presence experience. Furthermore, extensive sensory stimuli in a VE might result in cognitive and physical overload, leading to operating errors and discontent. We anticipate that subliminal stimuli can incrementally provide meaningful information about the environment without supplementary workload.

To sum up, the compatibility with other demands and conditions, interactions with further explicit information channels, and impact on a users’ workload while interacting with the VE system were of interest in this special issue for a broader deployment of subliminal cues in the near future.

2 Brief Introduction to the Field of Subliminal Perception

The notion that stimuli presented below conscious awareness influence cognition and behavior is not new. Since Peirce and Jastrow first reported in 1885 that people could perceive small differences in pressure to the skin without conscious awareness of difference in intensity, considerable research has shown that presenting subliminal cues is correlated with changes in cognitive and motor responses in various contexts. A number of similar studies of perception without awareness were conducted, culminating in 1957 in Vicary’s fallacious subliminal experiment, “eat popcorn, drink Coke,” which claimed that subliminal stimuli can not only influence behavior, but also have a long-term effect on consumer choices (O’Barr 2005). After that, the field of subliminal persuasion/perception lapsed into disarray until the 1990s, when more advanced sensor technologies improved research methodologies. Two key reports on robust subliminal priming methods showed that genuinely invisible primes could influence processing at a semantic level (Greenwald, Draine, & Abrams, 1996) and subliminal stimuli can elicit not only a behavior, but also a detectable neural activity in the motor cortex (Dehaene et al., 1998). These recent findings suggest a new, well-established scientific methodology for research on the effects of subliminal research.

3 Submissions and Review Process

The articles submitted to this special issue have undergone a rigorous peer-review process where the manuscripts were reviewed by at least two independent reviewers each. In total, 13 articles were submitted to the special issue and 60 review reports were written for the review process (2–3 rounds of review). Guest editors performed meta-reviews on the papers in each round of review, and finally—according to an objective score sheet—the 6 best articles (acceptance rate 46%) were selected for publication. Each of the accepted papers has received at least one review with highest ranking, and the second with at least second-highest ranking.

3.1 Summary of Contributions

Several papers in this special issue look at subliminal perception in virtual environments. Cetnarski, Betella, Prins, Kouider, and Verschure challenge the classic perceptual paradigm in their paper, “Subliminal Response Priming in Mixed Reality: The Ecological Validity of a Classic Paradigm of Perception,” by looking at the effects of subliminal stimuli in realistic and ecologically valid contexts. They investigated the impact of subliminal cues in an immersive navigation task in a mixed reality-virtual world termed the “eXperience Induction Machine.” Participants performed a navigation task through a maze at high speed. At random points in time, one group of participants was exposed to subliminal aversive stimuli that had the potential to bias their decision in the context of the task. Their results indicate the existence of a subliminal “channel of interaction” between the participants and the environment.

Peña and Yoo take a social view using a generic avatar in “Under Pressure: Avatar Appearance and Cognitive Load Effects on Attitudes, Trustworthiness, Bidding, and Interpersonal Distance in a Virtual Store,” and present a study about the effects of avatar salespersons’ appearance (dressed either in black or white) on interactions in the virtual environment. Their research shows
that even though users are not consciously aware of avatars’ appearance, this subtle difference can significantly influence virtual interactions unconsciously. They also provide thought-provoking discussions about the relationship of users’ cognitive load and stereotypical perception, which can be further investigated.

A third paper in the context of virtual environments looks at the effects of subliminal cues on decision making. In “Subliminal Cueing of Selection Behavior in a Virtual Environment,” Aranyi and colleagues present a study on using subliminal (visual) cueing for a forced-choice selection task within virtual environments. The authors demonstrate a statistically significant cueing results, and proceed with a meticulous analysis of available data, presenting numerous metrics pertaining to subliminal cueing, including several approaches to determining stimulus visibility and assessing effect sizes. The result has a practical impact on diverse fields of applications, ranging from advertisement, assistance in daily routines, to supporting in-car tasks, etc., as a more robust effect would increase the practical utility for cueing in realistic environments.

The effect of subliminal cues on driving performance and road safety was the subject of two papers. “The Potential of Subliminal Information Displays to Change Driver Behavior,” written by Riener, Chalfoun, and Frasson, focuses on the potential use of subliminal information in the context of driving. Their paper also nicely outlines terminologies and taxonomy of subliminal perception, which contributes to making the field mature. They widely review research on subliminal approaches using various modalities (visual, auditory, olfactory, and tactile) and provide case studies about the applications of subliminal cues to the automotive domain; and thus, readers can get some sense of actual research of this domain.

An emotional aspect of awareness in driving performance is described by Jeon, Walker, and Gable in their paper “Anger Effects on Driver Situation Awareness and Driving Performance.” They examined participants’ behaviors in a driving simulator after anger or neutral affect induction. Their results showed that an induced angry state can degrade driver situation awareness and performance compared to a neutral state, without influencing participants’ subjective judgment. Perceived workload was not affected by anger either. The authors suggested that the effects of anger occurred below their level of conscious awareness.

An interesting effect of subliminal cues on collaboration is presented by Tan, Luyten, van den Bergh, Schöning, and Coninx in their paper, “The Role of Physiological Cues During Remote Collaboration.” They studied the effect of empathic communication for enhanced social and emotional understanding in remote collaboration. The idea behind their work is that by empowering users to get a better understanding of their remote collaborators, collaboration can become more efficient and more satisfying. Their studies confirmed that using visualization of physiological cues can significantly improve the empathy levels during remote collaboration—higher than voice-only interactions and comparable to the usage of videoconferencing systems. This approach has high application potential, in particular in information-sensitive conversations, to avoid additional mental burden on remote partners by ensuring sufficient empathy.

3.2 Things We have Learned and Things We Need to Explore More

A number of manuscripts studied emotions in the context of subliminal perception, suggesting an effect of subliminal perception and changes in emotional states. The findings suggest a clear link between subliminal cues and changes in emotional states. What the underlying mechanism is that translates a sensory signal into activation of emotional brain areas is not clear. There are a number of theories and mechanisms to account for emotional effects (affect-as-information, affect infusion model, somatic markers, cognitive appraisal mechanisms, etc.). However, there is no single theory to explain every phenomenon. As affective science has rapidly grown as an independent discipline, more and more affect mechanisms in relation to (or independent of) cognitive processes will be identified. An interesting point is that most studies involve negative emotions (e.g., aversiveness, anger, etc.). Open questions include “Does this result hold true for positive emotions and affect?”, “Is the underlying mechanism that links subliminal cues with changes towards positive emotions similar to the change for negative emotions?”, etc.

Overall, it seems that most papers support the link between subliminal perception, decision making and be-
behavioral effects. Papers in this special issue show a wide range of effects of subliminal perception, including a cognitive task (decision making), individual behaviors (navigating or driving), and even collective behaviors (collaboration). This seems very promising in terms of the application of subliminal cues or techniques in design of novel interfaces, such as in vehicles or at home. Many more situations or contexts that we have not studied, or even imagined, could benefit from the use of subliminal cues. Ethical considerations are crucial here, since subliminal cues, being perceived on an unnoticeable level, might be used unethically for manipulation or to control individuals.

With respect to methodologies, most studies used performance-based indirect measurements. We are aware that researchers are becoming interested in various physiological or neurological techniques. Thus, we hope to see more manuscripts that utilize diverse methods in the next special issue. As Riener and colleagues introduce in their paper, any type of modality seems to have the potential to deal with subliminal perception. Future empirical research is expected to disentangle which modality/ies are optimal for specific application domains.

Given the abundant lessons from this special issue, we still have a long way to go before we fully understand this domain. We need to further discuss philosophical and ethical aspects of subliminal perception or cues. The majority of the papers describe research conducted in the virtual environment or laboratory, and thus, the feasibility of the subliminal perception in real settings still remains an open question. Even though we demonstrate diverse angles of subliminal perception research in this special issue, more basic research is of interest to identify fundamental characteristics of subliminal cues (e.g., reachable bandwidth, natural bounds, complexity of information, speed of perception, strength, duration, and frequency of subliminal interactions, etc.).

4 Future Research: Emerging Models, Emerging Applications

Can we indeed sense the depressive mode of a person and interfere subliminally to improve her/his state of well being? Can we help a visitor in a foreign city find the train station using subliminal cues? Can we indeed improve learning pace and memory using subliminal cues? These are the questions that need further research. The nature of such research will probably be multidisciplinary, involving expertise in engineering and technological design, experts on human behavior, and experts on the human brain. Social scientists looking at the social aspects are crucial—how is social interaction affected by subliminal cues, and how are such cues used to improve the experience of presence in remote places, with people, and objects, across a wide range of sensory experience of subliminal touch (e.g. Hilsenrat & Reiner, 2011), olfactory effects of weak scents of childhood, unheard yet perceived music of the Beatles, and unnoticeable visual flowing patterns? How would a crowd respond to subliminal cues? Is the common perception larger than the variance across individuals? What is the psychophysics of subliminal cues? What are the thresholds at which a cue turns subliminal/supraliminal? And what is the distribution of threshold levels across populations? An additional exciting domain lies in the potential enhancement of cognitive processes through priming and subliminal cues—will a subliminal hint help an ageing person perform a task or enhance problem solving?

Improved measurement devices are expected to have an impact on integration of subliminal cues into communication technologies for a fuller range of supra- and subliminal sensory experience. Subliminal perception is a double-edged sword: providing opportunities for fine and friendly support of individual behavior/learning/action, for their well being; while at the same time such cues could be used for goals that are inappropriate to the well being of the individual, such as sales and commercial effects, which should be banned. Research on such ethical and legal issues is necessary, will be of interest, and will help understand the range of applications of perception below awareness.

5 Conclusion

In conclusion, we greatly appreciate all the authors and reviewers for their contribution to shaping this special issue. We cordially invite you to a fascinating journey
through a collection of high-quality research papers assembled for the first time in a journal.

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References


