

# Augmenting Consciousness through Invasive Technologies: How Do Cochlear Implant Patients Engage Activity in the World?

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**Background:** Our ability to understand the mind has focused primarily on the explanation of behavior, leaving the question of conscious experience untouched and quite enigmatic [1]. The psychology of consciousness pertains to functional notions of the inner state of being and intrinsic internal governing structures such as self-inwardness, self-awareness, attention, voluntary control, knowledge, etc [2]. Vygotsky stated that the: “social dimension of consciousness is primarily in time and in fact,” where “individual consciousness is derivative and secondary” [3]. He held to the philosophical grounding of the theory of activity [4], arguing that to adequately understand the individual, one must recognize the societal implications related to individual lives and their conscious engagement with the social world. Based on his “cultural-historical activity theory” (CHAT), he posited that cognitive operations are specifically sociocultural structures and processes [5] that incorporate cultural artifacts into activity or the cultural mediation of action. As such, CHAT can be used to observe the socially embodied self [6, 7], where consciousness is augmented by fusing minds and tools or technologies, what Dourish stated as embodied experiences of what we “see and understand” [8]. Within this sociocultural model, consciousness can be mediated through invasive technologies. For example, human-machine augmentation (HMA) exists in corrective medical procedures that implant technologies that restore, enhance, or correct the human function of hearing, vision, or cognition. In each case, these enhancements have the potential to make our lives better, while also being augmented and increasingly artificial.

**Problem:** Surgically inserted into the inner ear, cochlear implants provide access to sound to the deaf by stimulating nerve fibers through auditory information received from the external world [9]. Studies have shown that after six months of implantation, children have a significant enhancement in mental shifting aptitude, picture vocabulary capability, working memory, and psychomotor speed [10]. While children with cochlear implants appreciate the opportunities afforded them through the implants, they still seem to suffer from social difficulties involving friendship and “fitting in” especially during adolescence. In some instances, studies have shown that adolescents with cochlear implants began to feel alienated and depressed because they perceive themselves as different from their peers [11]. Adult patients also experienced feelings of estrangement after implantation. One phenomenological study of a 50-year-old deaf woman (after a cochlear implantation) suggested that her embodied world experience of consciousness became distorted, while manifesting signs of paranoia, fear, anxiety, and danger [12]. Due to increasing use of augmenting technologies (such as cochlear implants), we argue that consciousness is being transformed by means of extending bodies and minds [13, 14]. We also hold that the blurring of the boundaries between natural consciousness and artificial systems is an evolutionary transition from mere human-computer interaction to HMA. As such, we ask, if, and to what degree are invasive technologies changing self-awareness and the inner life of consciousness in the context of human activity? Are augmenting technologies positively impacting the evolution of consciousness and enhancing the sociocultural experience of implant recipients?

**Methods:** Participants will include 30 adults between the ages of 18 and 50: 15 with cochlear implants and 15 without. The study will involve three methods of data collection: (1) A controlled in-lab study will include virtual 3D animated scenes in a CAVE, ranging from a calm natural environment with progressive degrees of complex change in the images and sounds, (2) A one-week observation using the Experience Sampling Method (7x per day cognitive/emotional logging), and (3) Post-test face-to-face interviews and questionnaire. We will also compare participants using physiological bio-sensory tracking during all three methods, including: heart rate (cardiac trends), galvanic skin response (moisture/electrical conductivity, skin temperature (body temp patterns), and heat flux (heat dissipation). Data analysis will help to determine patterns and correlations between cognitive activity, consciousness of surrounding (persons, things, and context) and physiological bio-readings.

**Broader Impact:** The last two decades have seen the exponential emergence of mediational change in human consciousness due to the ubiquitous use of information technology. The intertwining nature of technology is profoundly influencing our relationship to the world. We argue that the synthesis of mind with technology (as psychological tool) is facilitating a different construction of consciousness: a product of an artificially assimilated system that convergences natural and artificial bodies and minds. This study hopes to identify significant differences in the affects of invasive technology on consciousness between users and non-users of cochlear implants.

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