Empirical Research on the Ethics of Brain-Computer Interface Technology: A Scoping Review

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Introduction and Background

- Recent advances in BCI research has prompted increased scholarly interest into ethical and societal issues surrounding BCI[1]

- There has been an increase in qualitative and quantitative empirical research on active or potential BCI users
  - Some studies report concerning findings, such as "radical psychological distress" experienced by some BCI users[2]

- BCI users are the ones who have the most salient and immediate considerations regarding the ethics of BCI

- Simultaneously, there is increasing concern about media hype of BCI[3] while BCI professionals are reporting an increase in ethical concerns[4]

- We conducted a first-of-its-kind principled literature review focused on academic papers about empirical studies into BCI ethics

[1] Coin, A., Mulder, M., & Dubljević, V. (2020). Ethical aspects of BCI technology: what is the state of the art?. *Philosophies*, 5(4), 31.
[2] Gilbert, F., Cook, M., O'Brien, T., & Illes, J. (2019). Embodiment and estrangement: results from a first-in-human "intelligent BCI" trial. *Science and engineering ethics*, 25(1), 83-96.
[3] Gilbert, F., Pham, C., Viaña, J., & Gillam, W. (2019). Increasing brain-computer interface media depictions: pressing ethical concerns. *Brain-Computer Interfaces*, 6(3), 49-70.
[4] Kögel, J., Schmid, J. R., Jox, R. J., & Friedrich, O. (2020). Using brain-computer interfaces: a scoping review of studies employing social research methods. *BMC medical ethics*, 20(1), 1-17.

Materials and Methods

- We draw inspiration from the foundational literature review on BCI ethics by Burwell et al.[5] and follow from our previous work that updates this amidst a rapidly growing body of knowledge[1]

- Literature search conducted in January of 2021 on PubMed and Web of Science[6] using adapted coding scheme from prior work

Figure 1: Screening

Total Sources	413
Title Screening	289
Abstract Screening	135
Coding Sources	49
Final Sources	18
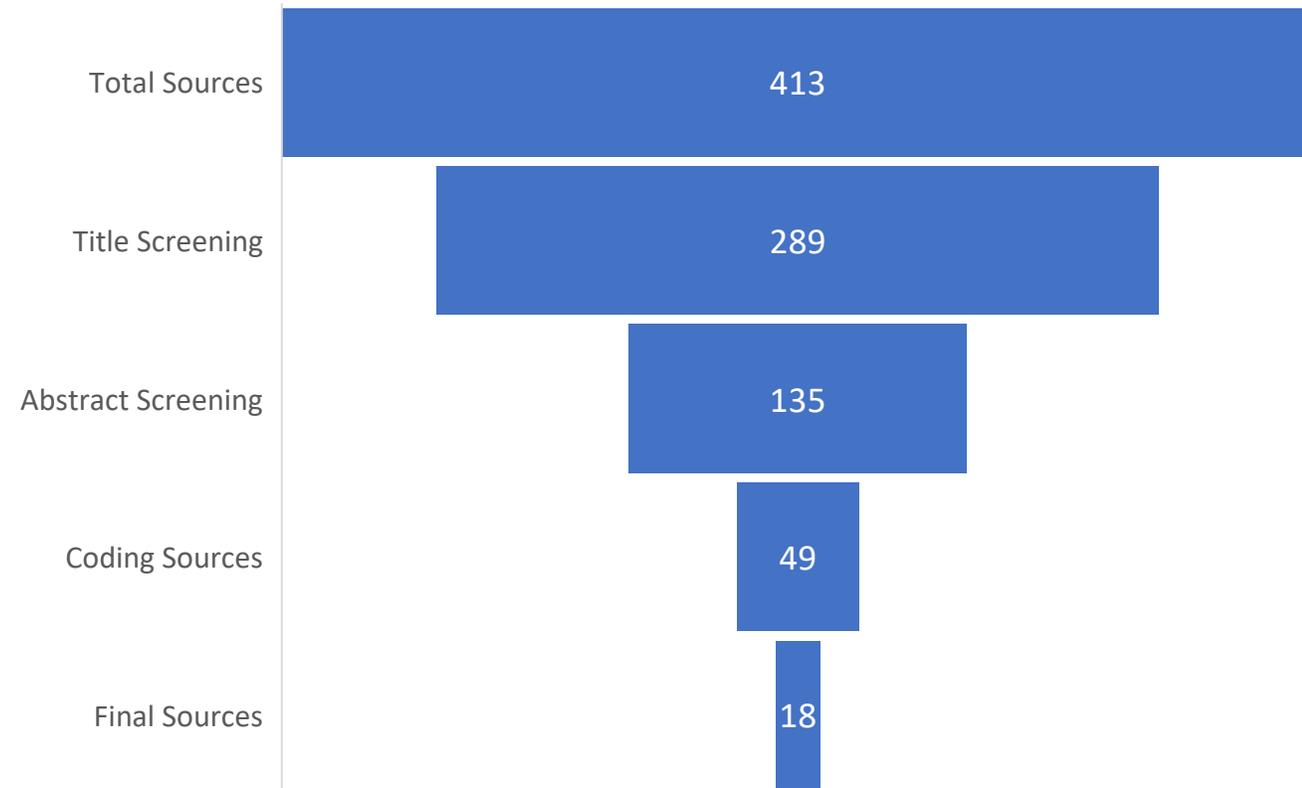
[5] Burwell, S., Sample, M., & Racine, E. (2017). Ethical aspects of brain computer interfaces: a scoping review. *BMC medical ethics*, 18(1), 1-11.
[6] **PubMed:** (("brain computer interface" OR "BCI" OR "brain machine interface" OR "Brain-computer Interfaces"[Mesh]) AND (("personhood" OR "Personhood"[Mesh]) OR "cyborg" OR "identity" OR ("autonomy" OR "Personal autonomy"[Mesh]) OR ("liability" OR "Liability, Legal"[Mesh]) OR "responsibility" OR ("stigma" OR "Social stigma"[Mesh]) OR ("consent" OR "Informed Consent"[Mesh]) OR ("privacy" OR "Privacy"[Mesh]) OR ("justice" OR "Social Justice"[Mesh])))
Web of Science: TS=("brain computer interface" OR "BCI" OR "brain machine interface") AND TS=("personhood" OR "cyborg" OR "identity" OR "autonomy" OR "Personal autonomy" OR "liability" OR "legal" OR "responsibility" OR "stigma" OR "social stigma" OR "consent" OR "informed consent" OR "privacy" OR "justice" OR "social justice")

Category	Distribution out of 18 Studies		Selected Representative Quotes
Psychological Factors	14/18	77.8 %	"Psychological issues of anxiety, participant attitude and managing distractions" [7] "An increased sense of control, leading to a sense of substantial augmented confidence" [2]
Societal Implications	13/18	72.2 %	"It also made me feel like I was different to everyone else [...] I didn't want to show anyone that I have it" [2]
Usability and Feasibility	13/18	72.2 %	"Users may become frustrated, bored, or exhausted when confronted with a BCI that does not work properly" [8]
User Safety	12/18	66.7 %	"Patients were very concerned about medical and infectious risks related to invasive methods." [9]
Research Ethics & Informed Consent	12/18	66.7 %	"Overoptimistic promises or manipulation must be avoided during decision making and consent processes''[9]
Humanity and Personhood	12/18	66.7 %	"Psychosocial difficulties after implantation – feelings of self-estrangement, an altered self-image, a lack of motivation, and alienation from others" [10]
Autonomy	11/18	61.1 %	"[BCIs may] increase independence and [provide] opportunities for creativity and self-expression" [4] "Feelings associated with having no control would seem to indicate a perceived loss of autonomy" [11]
Responsibility and Regulation	11/18	61.1 %	"Ascription of accountability for unsuccessful BCI use oscillates between personal and technological issues leading to some uncertainty when it comes to attributing agency or accountability" [12]
Privacy and Security	10/18	55.6 %	"One patient expressed concern about data security [...] and the risks of misuse." [9]
Dependence	7/18	38.9 %	"Some implanted patients may be at risk of over-reliance on advisory devices." [11]
Enhancement	6/18	33.3 %	"A [...] discrepancy between an expert debate driven by theory and an everyday-life perspective of patients can be observed with the issue of enhancement." [9]
Justice	3/18	16.7 %	"All patients stressed the need to ensure fair access to such health care technologies." [9]
Military Applications	3/18	16.7 %	(Only mentioned as an example in discussion sections.)

[7] Blain-Moraes, S., Schaff, R., Gruis, K. L., Huggins, J. E., & Wren, P. A. (2012). Barriers to and mediators of brain–computer interface user acceptance: focus group findings. *Ergonomics*, *55*(5), 516-525.

[8] Grübler, G., Al-Khodairy, A., Leeb, R., Pisotta, I., Riccio, A., Rohm, M., & Hildt, E. (2014). Psychosocial and ethical aspects in non-invasive EEG-based BCI research—a survey among BCI users and BCI professionals. *Neuroethics*, 7(1), 29-41.

[9] Schicktanz, S., Amelung, T., & Rieger, J. W. (2015). Qualitative assessment of patients' attitudes and expectations toward BCIs and implications for future technology development. *Frontiers in systems neuroscience*, 9, 64.

[10] Brown, T., Thompson, M. C., Herron, J., Ko, A., Chizeck, H., & Goering, S. (2016). Controlling our brains–a case study on the implications of brain-computer interface-triggered deep brain stimulation for essential tremor. *Brain-Computer Interfaces*, 3(4), 165-170.

[11] Gilbert, F., O'brien, T., & Cook, M. (2018). The effects of closed-loop brain implants on autonomy and deliberation: what are the risks of being kept in the loop?. *Cambridge Quarterly of Healthcare Ethics*, 27(2), 316-325.

[12] Kögel, J., Jox, R. J., & Friedrich, O. (2020). What is it like to use a BCI?–insights from an interview study with brain-computer interface users. BMC medical ethics, 21(1), 1-14.

Results

- The empirical literature suggests a multitude of ethical and social concerns previously noted and emerging that may prevent the integration of BCI technology into everyday use

- Apart from the already familiar topics of user safety, research ethics, etc., we note an increase in discussion on Psychological Factors (77.8%, n=14) and the emerging topic of Dependence (38.9%, n=7)

- Psychological Factors include potential psychological disruptions that may emerge from BCI use, such as fatigue, frustration, anxiety[7], or depression[2]
  - Potential risks are not yet fully understood

- Dependence is an emerging theme in recent years. Two predominant forms of dependence discussed in the literature:
  - Dependence on the technology: ethical concerns stemming from users who might become dependent on their BCI devices for normal functioning
  - Physical dependence on caretakers: how relationship dynamics with caregivers might change as a result of BCI technology

Discussion and Conclusion

- Discourse on the ethics of BCI has been largely theoretical and conceptual, but it is important to look at the empirical research into BCI ethics as it pertains to BCI users

- Active and potential BCI users have the most salient and immediate epistemic position regarding the potential ethical and social implications of BCI

- The empirical research into BCI ethics suggests a multitude of potential concerns with BCI use that should inform commercialization of BCI technology

- Of particular concern is the potential for BCI users to experience "radical psychological distress" and changes to self-perceptions of identity and personhood[2]

- More research is needed to fully understand the impact of BCI devices on user dependence, both on the device itself and on caregivers

- Further empirical research into BCI ethics is needed to continue to guide policy grounded in reality for this rapidly advancing technology