Hoth Intelligence:
Modeling Neuroethics in the Start-Up and Clinical Settings

Sunidhi Ramesh, MD[1, 2, 3] and Tyler Alexander, BA[1, 3]

1) Thomas Jefferson University in Philadelphia, PA; 2) Wills Eye Hospital in Philadelphia, PA; 3) Hoth Intelligence

WHAT IS THE GOAL OF HOTH?

Founded in 2021 by two students, Hoth Intelligence is an up-and-coming start up in the tech industry aiming to introduce artificial intelligence and augmented reality to the healthcare space. Its core technology uses the Microsoft Hololens to add accuracy to otherwise "blind" procedures; prime examples are ventriculoperitoneal cerebral shunts in neurosurgery, long-term treatment options for hydrocephalus that typically have a high failure rate (30-40% within the first year, according to some sources) due to inaccurate placement.

To address this issue, Hoth's technology overlays images of a patient's MRI or CT scans onto the patient's anatomy through the Hololens; this effectively gives providers a precise and accurate path to insertion specific to the patient. The implications of the technology are tremendous, as further development can expand the applications to other procedures in other surgical specialties—a potential state-of-the-art addition to the modern world of personalized medicine.

Notably, the technology has already met FDA standards for shunt placement with an error rate that falls below a shocking 10%. Currently, the company is working towards FDA approval.

Hoth Intelligence

WHERE IS THE NEED FOR NEUROETHICS?

As the company grows, a number of questions arise. What are the dangers of introducing augmented reality and artificial intelligence to this space? Are there consequences that we have not considered? How do we develop our technology *responsibly* in a world of haste technology development?

Unsurprisingly, the answers may lie in neuroethics, as one of the primary applications of the field is in the development of neurotechnology. What should we consider before we create it? How can we be responsible with its development? What types of issues can we foresee regarding its implementation and use? What are the risks? It should be noted that these questions are particularly complicated due to the inherent variety of "neurotechnology"; the term is nebulous and encompasses a large range of devices and tools. Some are invasive; others are wearable. Some replace existing human abilities; others augment them. Some involve reversible interventions; others are permanent. A few are all of these things. Thus, the need is apparent as is the niche to fill it.

FRAMEWORK TO APPLYING NEUROETHICS IN THE START-UP AND CLINICAL SETTINGS

Acknowledge a need for the ethical evaluation of a new technology or of novel clinical interventions

Identify individuals able and willing to aid in these ethical evaluations

Establish an outline of concepts to be deliberated with each new intervention (see right panel for concepts specific to Hoth)

Find a modality to *share* ethical discourse with other team members

Create a culture of awareness and responsible reporting, where *all* members of the team feel responsible for the ethical products

REFERENCES

1. Johnson, L. Syd M., and Karen S. Rommelfanger, eds. The Routledge handbook of neuroethics. Routledge, 2018.
2. Illes, Judy, and Barbara J. Sahakian, eds. Oxford handbook of neuroethics. OUP Oxford, 2011.
3. Reddy, G. Kesava, Papireddy Bollam, and Gloria Caldito. "Long-term outcomes of ventriculoperitoneal shunt surgery in patients with hydrocephalus." World neurosurgery 81.2 (2014): 404-410.

SAMPLE OUTLINE OF CONCEPTS

Justice and access: Will patients who have access to hospitals that can afford our technology be able to receive this degree of care?

Modulation and enhancement: Does the use of the technology change the patient beyond simple decreases in intracranial pressure? Are there side effects we have not identified or have not considered?

Stigma, social notions, and identity: The technology has apparent and obvious medical uses. But what do patients think of it? Are they amenable to its use? What are their concerns?

Marketing: Who is being marketed to? Patients or providers? How can we be careful to market our technology without overselling its capabilities?

Privacy: Does the technology "remember" the brain scans we upload? How can privacy pre-emptively be maintained?

Responsibility and long-term implications: If a scan shows an incidental tumor that may affect the patient's long-term earning potential, how do we keep his/her employer from finding out? In other words, how do we use the technology only for procedures and nothing else? And, if the technology makes a "mistake" — whose fault is it?

CONCLUSIONS

The challenges ahead are not simple or easily surmountable. What I have learned through my work with Hoth is that there is a dire *need* for careful consideration, strenuous research, and the responsible marketing of neurotechnology moving forward. What I have also learned (and learned quite quickly) is that we are in the beginning of a golden era of neurotechnology — Hoth and its contemporaries are real-life evidence of this. Neurotechnology can be molded to be what we want it to be; it can solve problems we have pondered for generations. The questions we have to answer are exciting ones, at the precipice of innovation, creativity, and change.