A Bird’s-Eye View of the Field of Neuromodulation Technology:
A bibliographic network analysis on transcranial direct current stimulation (tDCS) research studies

Anita Jwa
Department of Psychology
Stanford University
Aims of the Study

• This study applies bibliographic network analysis methods to:
  (1) assess the level of maturity of the field of a neuromodulation technology and
  (2) investigate the prevalence and diffusion of ethical concerns, such as uncertainty around
      the efficacy of neuromodulation technology, within the field.

• Transcranial direct current stimulation (tDCS) as a case study
Data

• Web of Science search with the term “transcranial direct current stimulation” (4,225 articles)
  o for comparison, also collected “transcranial magnetic stimulation (22,000 articles) and “deep brain stimulation” (20,000 articles)

• Citation network analysis with R (bibliometrix & igraph package)
Part I: Modularity as an index of maturity in the field

• Shwed and Bearman (2010)
  Modularity is an index of internal division of a citation network that reflects the level of contestation in the field.
    o Modularity compares the odds of within-community ties with these odds after a random rewiring of the network (Newman, 2006)
    o Partitioning a network into communities by maximizing modularity
Critical review papers on the inconsistent findings among tDCS studies were published (Horvath et al, 2015a; Horvath et al, 2015b)
Part II: Emergence and diffusion of ethical concerns in the field

• Identified papers with abstracts that include
  o terms indicate results that are not statistically significant
    : not significant, not statistically significant, insignificant, no effects ...
Part II: Preliminary results

- tDCS
- TMS
- DBS
Discussion

• The temporal changes of modularity in the citation network
  o decreasing trend until 2016 followed by a sharp increase
  o indicates that consensus has not yet formed
  o the future trajectory might follow cyclical pattern (“a case where consensus forms, is destroyed, and is rebuilt” without reaching the unification stage (Shwed & Bearman, 2010).

• Increase of papers reported results that are not statistically significant

• The contestation around the efficacy of tDCS are still ongoing within the field
  o tDCS is not mature enough to reach the stage of normal science (Kuhn, 1962)
  o impetuous application of this technology, especially outside the clinical context, could lead to harmful consequences.