tDCS over prefrontal cortex prevents task-relevant inhibition in an uncommon ending sentence completion task

Emilio R. Tamez[1], David S. Rosen[2], Sharon L. Thompson-Schill[1]
[1]Center for Cognitive Neuroscience, University of Pennsylvania; [2]Applied Brain and Cognitive Sciences, Drexel University

Motivation

Cognitive control is known to play a large role in creativity[a]. Transcrianial direct current stimulation (tDCS) over the PFC has been used previously to modulate cognitive control, as well as creative tool use[b] and verbal creativity[c].

Our questions:

1) What is the role of cognitive control in a verbal creativity task?
2) Is decreased cognitive control beneficial in this type of creative task?
3) What are some aspects of generated responses that contribute to creativity?

Methods

Tasks

1) Reading span test (RS)
2) FAS phonemic fluency test (FAS)
3) Sentence Completion[d] Task: "Finish sentence with a word that is uncommon, but also appropriate. Respond as fast as possible."

Data

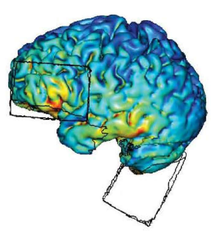
- RT & responses.
- Response-Cloze and Response-Sentence (context) LSA.
- Creativity (CREAT), novelty and appropriateness (combined, called NOV).

Model

- VAR~Stimulation+FAS+RS+ 1|Subject + 1|Stimulus

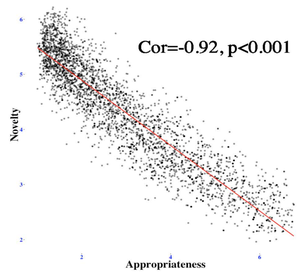
Stimulation

- Cathodal, anodal, and sham (n=15).
- F7, contra. Mastoid.
- 1.5 mA for 17min.
- Stim began 3 min prior to 1st trial.

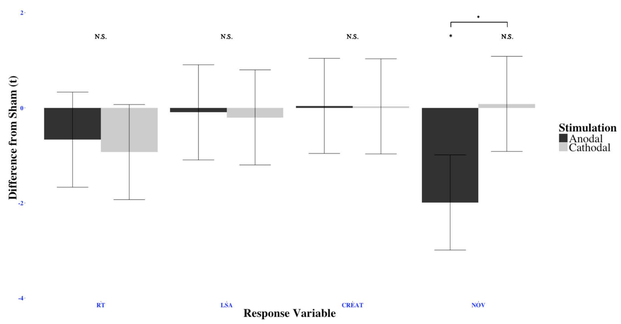


Current Flow Model[b]

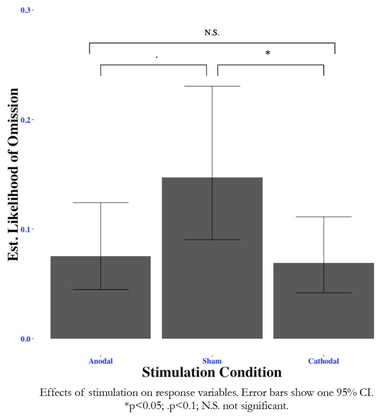
Effects of Stimulation



Novelty Appropriatness Composite:
NOV=Novel * (8-Approp)



Effects of stimulation on response variables. Error bars show one s.d. from mean t statistic (=1). *p<0.05; N.S. not significant.

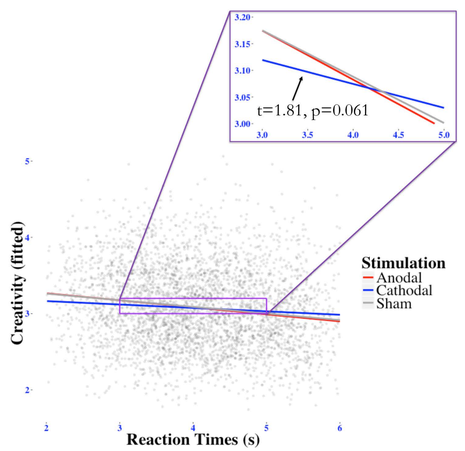


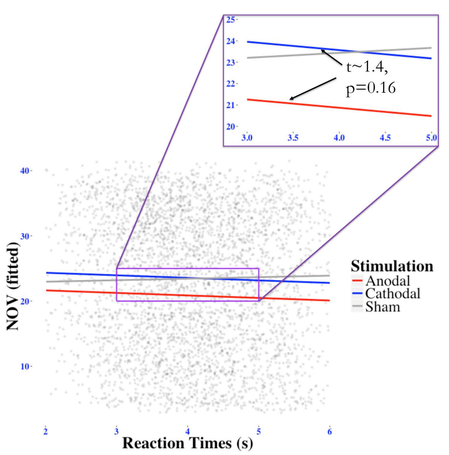
Effects of stimulation on response variables. Error bars show one 95% CI. *p<0.05; .p<0.1; N.S. not significant.

Response "errors" by condition

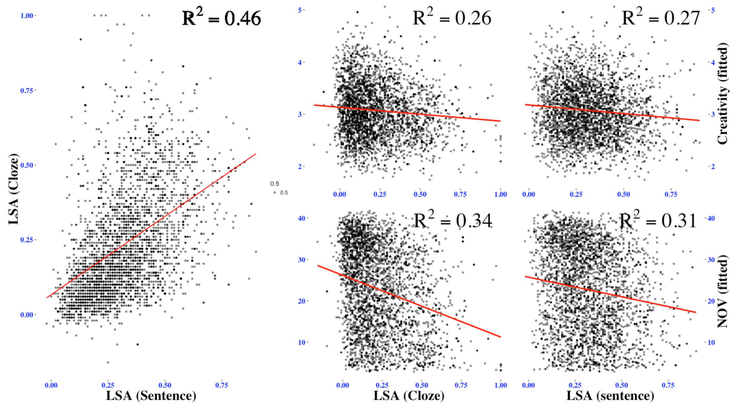
	Antonym	Synonym	Non-sense	Total
Anodal	1.85%	2.24%	0.26%	4.35%
Sham	1.69%	1.26%	0.46%	3.41%
Cathodal	2.93%	1.67%	0.54%	5.14%
Total	6.47%	5.17%	1.26%	

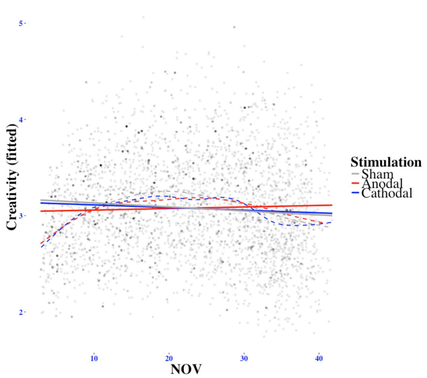
- 14% of trials omitted.
- Response omissions were marginally modulated by stimulation, relative to sham.
- Antonym production was increased in cathodal, synonyms were increased in anodal, no effect on non-sensical errors.





Components of Creativity





- (above) Semantic similarity to context explains more variance in creativity and less in NOV than the response.
- (left) Tradeoff not linearly related to creativity, but relationship altered by stimulation.

Summary

1) Increased cognitive control may heighten attention to context, increasing appropriateness and decreasing novelty of response.
2) Decreased cognitive control may alter strategy employed in response selection (thereby moderating the relationship between RT and creativity of response).
3) A highly creative response is neither very appropriate nor very novel, but rather balances the two.
4) Semantic distance from a normal response and from the context relates to creativity, but not perfectly.

References

[a]Chrisikou, Weber, & Thompson-Schill (2014). A matched filter hypothesis for cognitive control. Neuropsychologia, 62, 341-355.
[b]Chrisikou, et al. (2013). Noninvasive transcranial direct current stimulation over the left prefrontal cortex facilitates cognitive flexibility in tool use. Cog. Neuroscience, 4(2), 81-89.
[c]Mayseless & Shamay-Tsoory (2015). Enhancing verbal creativity: modulating creativity by altering the balance between the right and left inferior frontal gyrus with tDCS. Neuroscience, 167-176.
[d]Block & Baldwin (2010). Cloze probability and completion norms for 498 sentences: behavioral and neural validation using event-related potentials. Beh res Methods, 42(3), 665-670.

Contact
Emilio Tamez (temilio@sas.upenn.edu)
Dave Rosen (dsr38@drexel.edu)
Follow QR code to lab website for reprint.