Baseline Differences in Anxiety Affects Attention and tDCS-mediated Category Learning

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INTRODUCTION

- Anxiety serves to bias attention towards bottom-up, stimulus-driven processing at the expense of top-down, explicitly purpose-driven processing[1].
- The extent of this bias can be measured by the orienting scale of the Attention Networks Task (ANT)[2].
- It is unclear how the interaction between anxiety and attention transfers to freeview of naturalistic scenes.

Study Aims:

Explore the interaction between baseline differences in self-report state affect and subsequent tDCS-mediated category learning.

METHOD

Design: In double-blind design, subjects randomized to receive 30 min of anodal, cathodal, (both 2.0 mA) or sham stimulation (0.1 mA) on rVLPFC with the return electrode on the contralateral triceps.

- Profile of Mood States, ANT, Remote Associates Test administered prior to tDCS application.

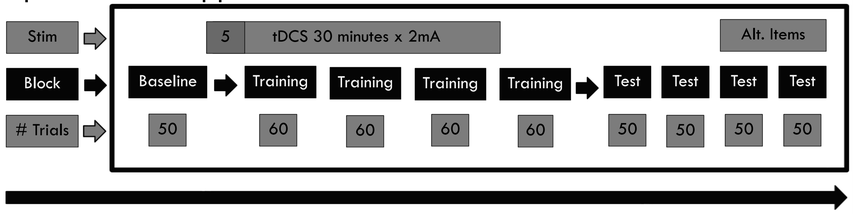

Figure 1: Study design

Task:

- Within a novel discovery learning paradigm, subjects learned to categorize pictures of European streets into two categories via accuracy feedback. Pictures were static street views from Google Maps.
- Pictures differentiated with 2 arbitrary rules, side of street picture was taken on (Rule 1, top-down rule) and hidden objects inserted into pictures (Rule 2, bottom-up rule). Rule 1 was present in all stimuli, while rule 2 was present in half of stimuli.
- The 2 rules were consistent throughout the protocol until test blocks 3 & 4. Subjects were classified as Rule 1 or 2 learners based on performance in blocks 3 & 4.

Figure 2: Category "1" example stimuli, rule 1 & 2 present

ANALYSIS

- Subjects were classified as Rule 1 or Rule 2 learners based on performance in test blocks 3 & 4 (Figure 3).
- Multinominal logistic regression was used to model the relationship between baseline measures and Rule learning.

RULE GROUP COMPARISON

	Total	Anodal	Cathodal	Sham		Age		Male	Female
Rule	*N*	*N*	*N*	*N*	*Mean*	*SD*	*Range*	*N*	*N*
Rule 1	19	8	8	3	21.9	5.3	21	12	7
Rule 2	14	8	4	2	20.2	3.4	13	5	9
No Rule	21	2	6	13	26.3	11.5	38	6	15
Total	54	18	18	18	23.2	8.3	38	23	31

Table 1: Subject demographics by group

	Orienting		RAT # Correct		Tension	
Rule	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Rule 1	29.09	22.65	7.11	3.23	1.16	1.50
Rule 2	44.19	39.19	7.64	2.95	5.14	3.92
No Rule	55.35	37.83	7.05	2.59	2.52	2.21

Table 2: Means and standard deviations for continuous variables by rule learning group.

MULTINOMINAL LOGISTIC REGRESSION

- Three criteria significantly predicted subject classification as Rule 1vs No Rule learners. Receiving anodal stimulation made it more likely subjects would learn Rule 1, while higher tension and orienting scores predicted No Rule learning.
- Two criteria significantly predicted subject classification as Rule 2 rather than Rule 1 learners. Greater orienting and tension scores made it more likely subjects would learn Rule 2 rather than Rule 1.
- The overall model had a classification accuracy of 74.1%, ranging from 64.3% accuracy for Rule 2 learners, 78.9% for Rule 1 learners, and 76.2% for No Rule learners.

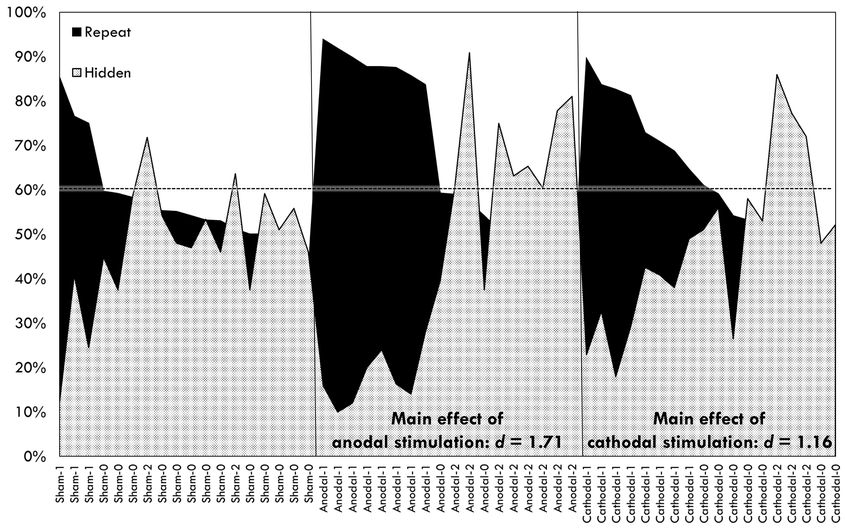

Figure 3: Categorization accuracy by rule group and stimulation condition in blocks 3 & 4.

MULTINOMINAL LOGISTIC REGRESSION

	No Rule versus Rule 1 (reference)		Rule 2 versus Rule 1 (reference)	
Variable	B (SE)	OR (95% CI)	B (SE)	OR (95% CI)
Orienting	0.05 (0.02)*	1.05 (1.01, 1.09)	0.04 (0.02)*	1.04 (1.01, 1.08)
RAT # Correct	0.25 (0.16)	1.29 (0.94, 1.77)	0.29 (0.02)	1.34 (0.94, 1.92)
Tension	0.77 (0.33)*	2.17 (1.14, 4.09)	1.07 (0.34)*	2.93 (1.51, 5.71)
Cathodal Stim	-1.78 (1.02)	0.17 (0.02, 1.26)	-0.39 (1.39)	0.67 (0.04, 10.24)
Anodal Stim	-3.69 (1.31)*	0.03 (0.01, 0.33)	-0.17 (1.45)	0.84 (0.05, 14.29)

Table 3: Predictors of rule learning in multinomial logistic regression. * $p < 0.05$.

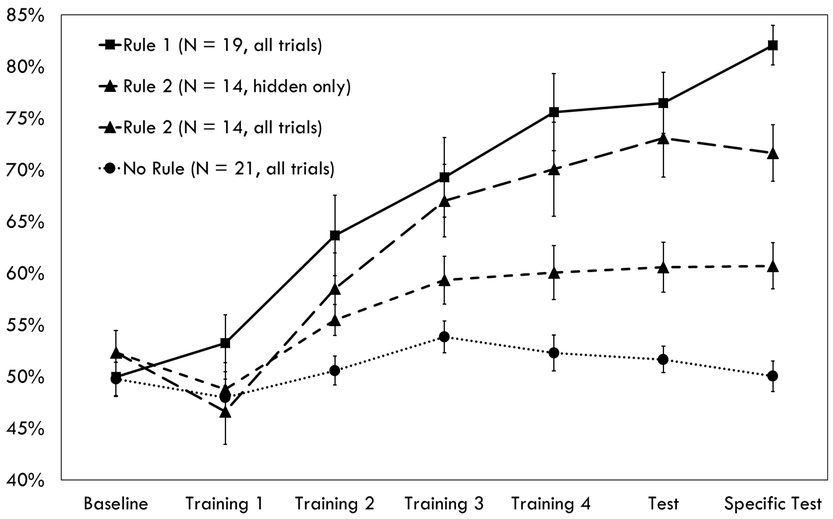

Figure 4: Categorization accuracy by rule group across training with Rule 2 learners represented both on Rule 2 accuracy only and on overall accuracy. Error bars +/- 1 SE.

DISCUSSION

- Quality of attention subjects had as they began the task influenced tDCS-mediated rule learning, with initial differences in attention correlated with self-reported tension.
- Results concur with predictions of Attentional Control Theory, which states that anxiety alters the balance of attention towards implicit, bottom-up processing[3].
- In discovery learning context, Rule 2 learners likely influenced more by stimuli within the pictures rather than top-down goals, possibly hindering systematic hypothesis testing and insight[4].
- Results are relevant to real world tasks that occur under situations of anxiety or fatigue[5].

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