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Modulating eating behaviour with transcranial direct current stimulation (tDCS): A systematic literature review on the impact of eating behaviour traits

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1. Introduction

- The control of reward-driven eating behaviour (e.g. food craving, consumption) involve executive brain functions originating in the prefrontal cortex (PFC) [1].
- These functions drive goal-directed behaviours (e.g. weight maintenance) by inhibiting impulsive actions [1–3].
- Those with specific eating behaviour traits, such as binge eating, appear to have hypo-activation of the dorsolateral PFC (DLPFC) and impaired executive functioning, leading to overconsumption [4–6].
- Through tDCS, it may be possible to modulate the PFC with the aim of improving executive functioning leading to greater control of reward-driven behaviour.
- Large variation across studies (e.g. recruitment of those with heterogeneous trait characteristics) makes it difficult to identify consistent effects of tDCS on eating behaviour.

This review considers the effects of tDCS across eating-related measures, and explores whether an eating behaviour trait-dependent effect is evident.

2. Method

- A literature search of four databases (MEDLINE, PsycINFO, Scopus, Science Direct) was performed in July 2020.
- A total of 1,135 articles were identified and screened (Fig. 1).
- Studies using conventional sham-controlled tDCS to modulate eating behaviour measures in adult human participants included in the review.
- Study quality was assessed using the Cochrane Collaboration Risk of Bias (RoB2) tool.
- Random effects meta-analyses were performed, with subgroup analyses to identify differences between eating behaviour trait profiles.

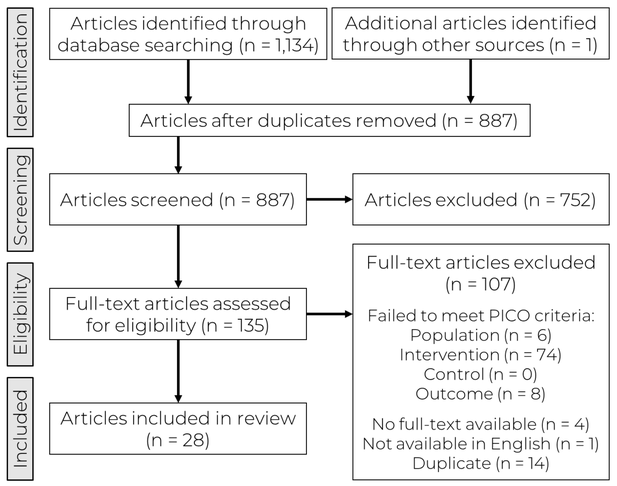

Fig. 1 PRISMA diagram illustrating selection process.

3. Results

Definitions:
"Healthy" individuals = no behavioural/medical conditions suggesting "problematic" eating behaviours
Trait groups = those with eating behaviour traits suggesting susceptibility to overconsumption
Note: this was irrespective of weight status

- Twenty-eight eligible studies were identified, including 12 between-participant and 16 within-participant designs.
- Only 7 showed overall low risk of bias, with bias arising from issues implementing or reporting blinding protocols in the remaining studies.
- Trivial overall effects (*g* = -0.12 to 0.09) of active versus sham tDCS were found across measures (Table 1).

Table 1 Summary of meta-analytic data, with subgroup data.

Measure	Overall Effect	"Healthy"	Trait Groups
Hunger	0.03 [-0.23, 0.29]	0.06 [-0.32, 0.44]	0.08 [-0.72, 0.88]
Desire to Eat	0.05 [-0.22, 0.31]	0.15 [-0.24, 0.54]	-0.08 [-0.69, 0.52]
Food Craving	-0.08 [-0.28. 0.12]	-0.06 [-0.29, 0.17]	-0.16 [-0.57, 0.26]
Explicit Wanting	-0.01 [-0.16, 0.14]	0.09 [-0.04, 0.22]	-0.12 [0.42, 0.19]
Implicit Wanting	-0.06 [-0.50, 0.37]	0.00 [-0.52, 0.53]	-0.19 [-1.66, 1.29]
Explicit Liking	0.08 [-0.05, 0.21]	0.05 [-0.53, 0.62]	0.10 [-0.34, 0.55]
Food Consumption	0.01 [-0.18. 0.20]	0.05 [-0.07, 0.17]	-0.12 [-0.76, 0.51]

Eating behaviour trait-dependent effects:

- Effect sizes observed for "healthy" individuals (*g* = -0.06 to 0.15) suggest these participants are unresponsive to stimulation.
- More consistent negative effect sizes (i.e. active tDCS reduces the eating-related measure) were found for trait groups, particularly for reward-driven measures.
- When considering individuals who display specific traits associated with the eating-related outcome measure (e.g. frequent food cravings, binge-type behaviour), larger effect sizes were identified (*g* = -1.03 to 0.60) (e.g. Fig. 2), suggesting these individuals are responsive to the effects of tDCS

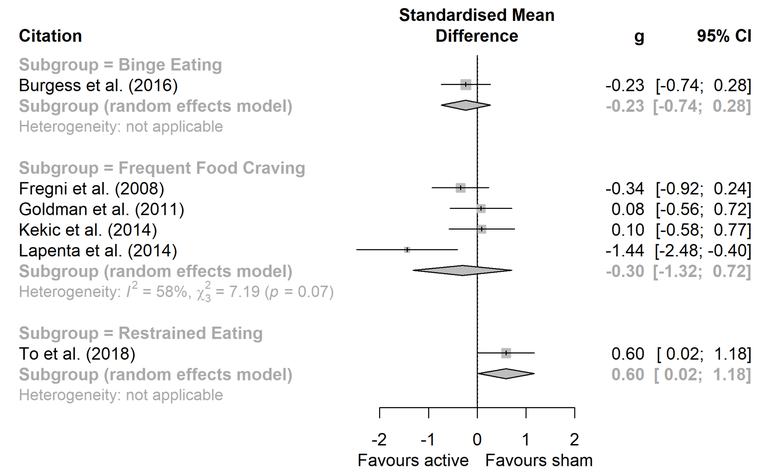

Fig. 2 Subgroup analyses comparing specific eating behaviour traits for food consumption measures.

4. Conclusion

This meta-data supports the eating behaviour trait-dependent effect of tDCS; those with traits suggesting susceptibility to overconsumption appear to benefit from the modulatory effect of tDCS, whereas "healthy" individuals appear unresponsive.

Future work should recruit those displaying eating behaviour trait susceptibility to overconsumption, with the aim of identifying more consistent effect of tDCS on eating-related measures.

(1) Joseph et al. (2011) Obes Rev 12: 800-812; (2) Pignatti et al. (2006) Eat Weight Disord 11: 126-132; (3) Miller & Cohen (2001) Annu Rev Neurosci 24: 167-202; (4) Karhunen et al. (2000) Psychiat Res-Neuroim 99: 29-42; (5) Boeka & Lokken (2011) Eat Weight Disord 16: e121-e126; (6) Lowe et al. (2019) Trends Cog Sci 23: 349-361