Effective transcranial direct current stimulation (tDCS) parameters for the modulation of eating behaviour: A systematic literature review

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1. Introduction

In recent years there has been increased interest in applying transcranial direct current stimulation (tDCS) for the modulation of eating behaviours associated with overconsumption and weight gain. While early studies found promising effects [1,2], more recent data shows equivocal findings [3-5]. This may be due to issues with experimental design (e.g. inadequate blinding) or the application of differing stimulation parameters (e.g. current intensity, electrode placement), with the modulatory effects of tDCS driven largely by the specific stimulation parameters and device set up [6]. This variation makes it very difficult to fully understand the ability of tDCS to modify eating behaviours. If indeed this technique is to be used as an additional or adjunctive treatment modality for weight management, it is important that these inconsistencies are addressed.

This review considers the effects of differing parameters on measures of eating behaviour, and how issues with experimental design and/or the application of differing stimulation parameters may be driving inconsistencies in findings.

2. Method

An electronic literature search of 4 databases (MEDLINE, PsycINFO, Scopus, Science Direct) was performed in July 2020, in line with PRISMA[c]. A total of 1,135 articles were identified, and screened (Figure 1) in line with the PICO[d] criteria (Table 1).

[c] Preferred Reporting Items for Systematic Reviews and Meta-Analyses [7].
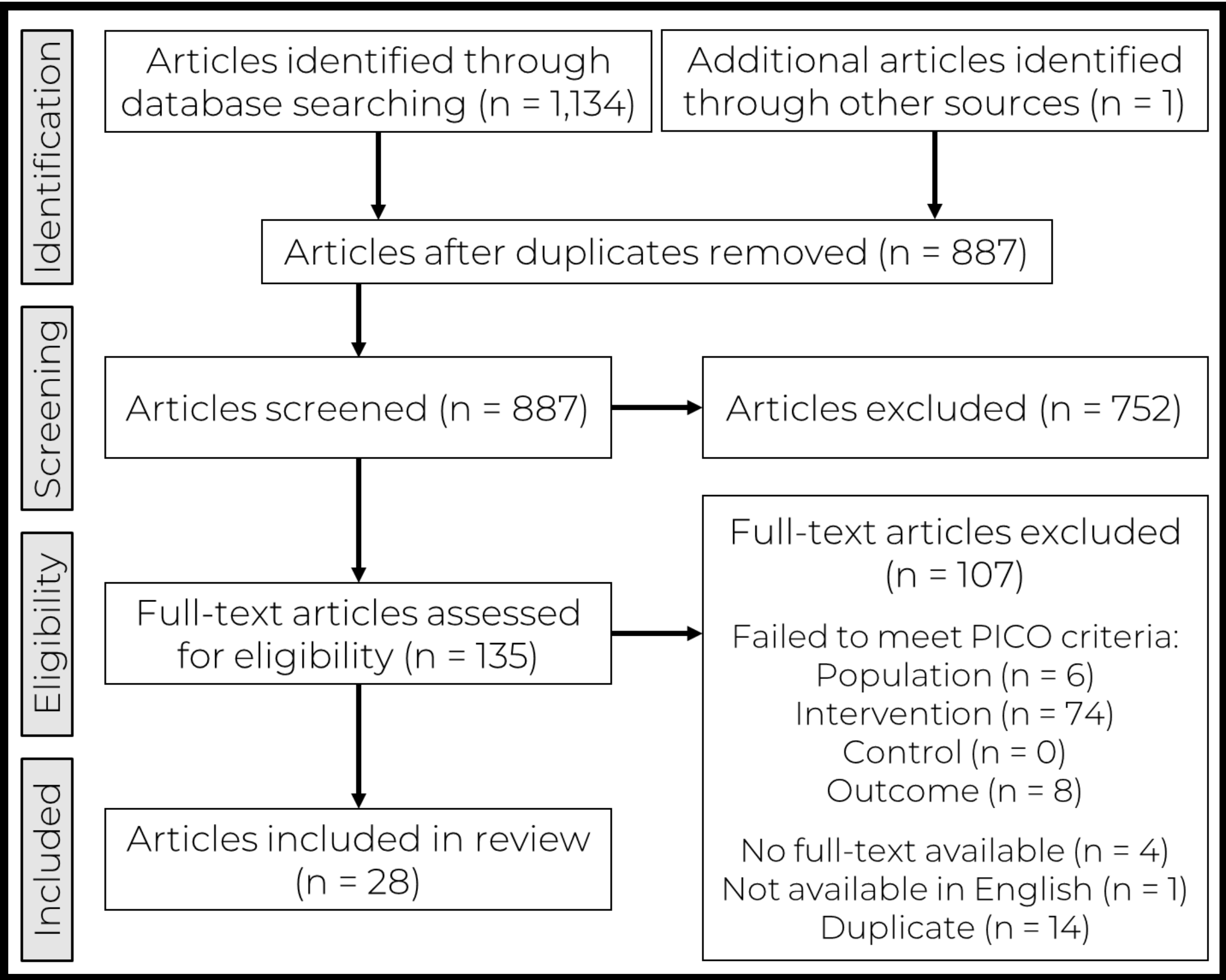[d] Population, Intervention, Control and Outcome.

Figure 1: PRISMA diagram showing the selection process.

Table 1: PICO criteria.

Population	Adult human participants
Intervention	Conventional tDCS (i.e. one anode, one cathode)
Control	Sham-controlled
Outcome	Eating-related measure (food craving, consumption, reward, subjective appetite

4. Conclusion

The absence of tDCS-mediated change in measures of eating behaviour appear to be driven by variation in applied parameters. Initial variation is important to experiment with the iterative application of parameters, blinding protocols and concurrent tasks. Once optimal parameters are established, more consistent application of those parameters which appear effective for modulating eating-related measures is important for identifying the impact of tDCS.

We outline specific parameters that appear effective of a behaviour level, and suggest researchers should apply these to improve the consistency of findings.

3. Results

Figure 2 captures the large variation in applied parameters across the 28 reviewed articles. This variation appeared to alter the effects of tDCS on eating-related measures, with some parameters resulting in null effects.
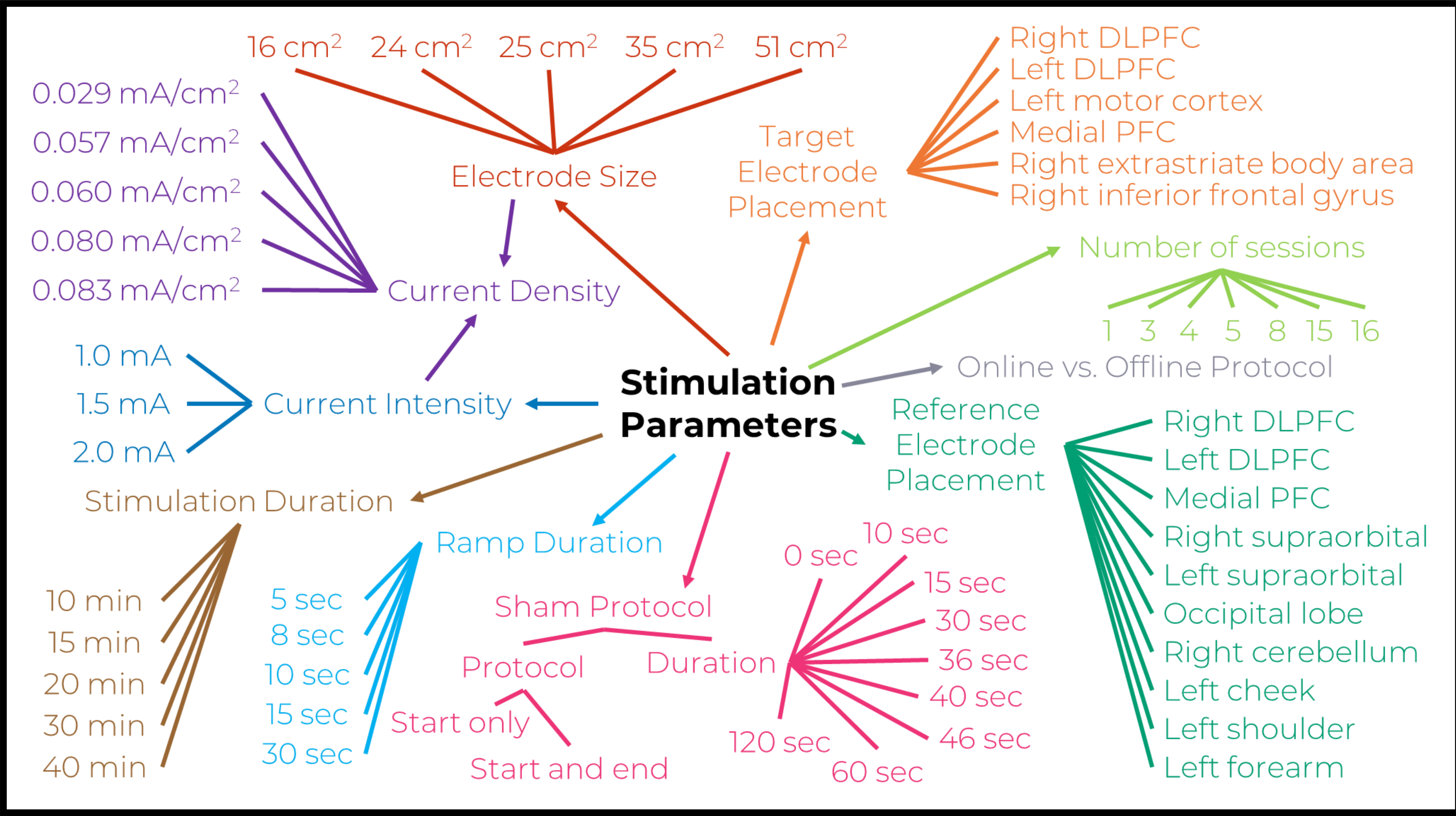

Figure 2: Overview of the variation in parameters across the reviewed studies.

From this variation, we identified those parameters that appear effective for modulating eating-related measures on a behavioural level (Table 2). In addition to these, researchers should follow a double-blind protocol with a within-participant (randomised and counterbalanced) design, particularly for single-session studies and where this fits the study aims. Articles should include sufficient detail on the study design and implemented parameters so the effects of parameter sets can be fully explored. Protocols using parameters known to affect the outcome, such as online tasks, should be carefully considered.

Table 2: Suggested parameters that future work should follow.

Montage	Target: Right DLPFC Reference: Cortical region away from DLPFC / Extracephalic region
Electrode Size	Target: ≤35 cm^2 Reference: Equal or greater than target electrode
Current Intensity	1.5 – 2.0 mA
Current Density	0.057 – 0.080 mA·cm^{-2}
Duration	20 minutes
Inter-session Interval	Single-session: >48 hours Multi-session: ≤24 hours
Offline / Online Protocol	Offline; Unrelated media as an online task may be appropriate for standardising participants' thoughts

[1] Fregni, F. et al. (2008) *Appetite* 51: 34-41; [2] Goldman, R.L. et al. (2011). *Appetite* 56: 741-746; [3] Sedgmond, J. et al. (2019). *Roy Soc Open Sci* 6: 181186; [4] Georgii, C. et al. (2017). *Physiol Behav* 177: 20-26; [5] Gluck, M.E. et al. (2015). *Obesity* 23: 2149-2156; [6] Antal, A. et al. (2017). *Clin Neurophysiol* 128: 1774-1809; [7] Moher, D. et al. (2009). *PLOS Med* 6: e1000097; [8] Filmer, H.L. et al. (2014). *Trends Neurosci* 37: 742-753; [9] Tremblay, S. et al. (2014). *Brain Stimul* 7: 773-783; [10] Thair, H. et al. (2017). *Front Neurosci* 11: 641.