Leeds Trinity University

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Modulating eating behaviour with transcranial direct current stimulation (tDCS)

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OBESITY Reviews

WORLD OBESITY

BEHAVIOUR/MANAGEMENT

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

Jordan D. Beaumont, Natalie C. Smith, David Starr, Danielle Davis, Michelle Dalton, Alexander Nowicky, Mark Russell, Martin J. Barwood ... See fewer authors

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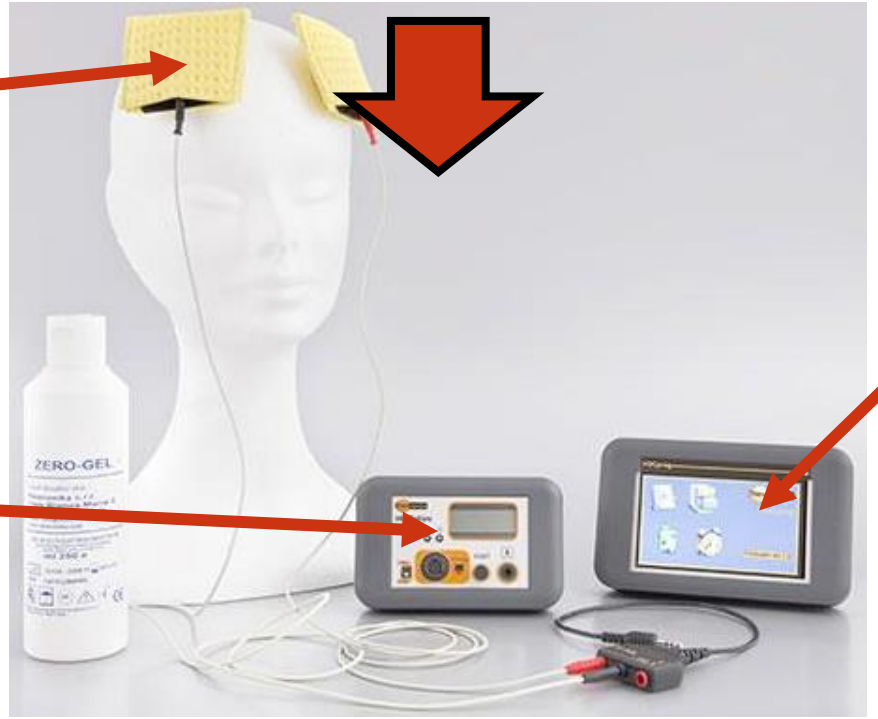
What is tDCS?

A non-invasive method of brain stimulation where a weak electrical current is passed between electrodes placed on the scalp

Electrodes
(housed in saline-soaked sponges)



Programming device
(sets customised parameters)

Battery-powered stimulation device
(2x 1.5V AA batteries)

Filmer et al. (2014)

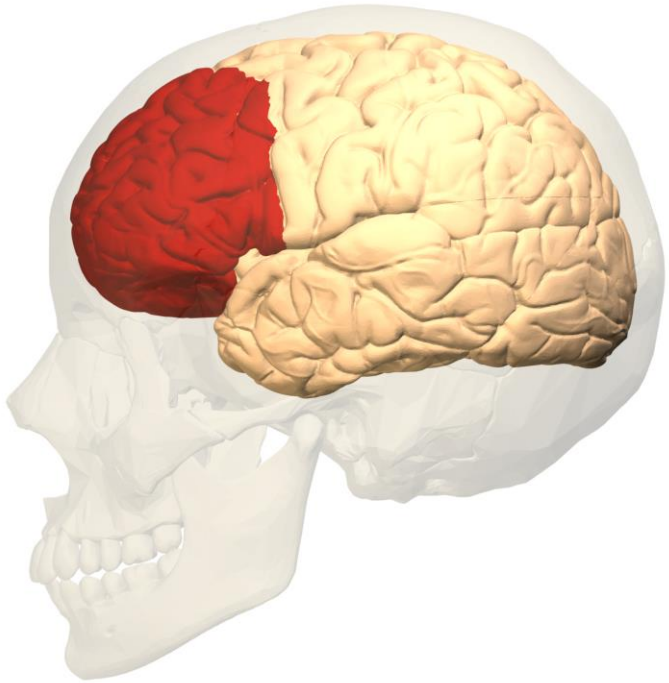
What is tDCS?

A non-invasive method of brain stimulation where a weak electrical current is passed between electrodes placed on the scalp

Causes acute and reversible changes in activity of a specific region of the brain, which temporarily modifies behaviour, learning and task performance

Filmer et al. (2014)

Cognitive Control of Eating Behaviour

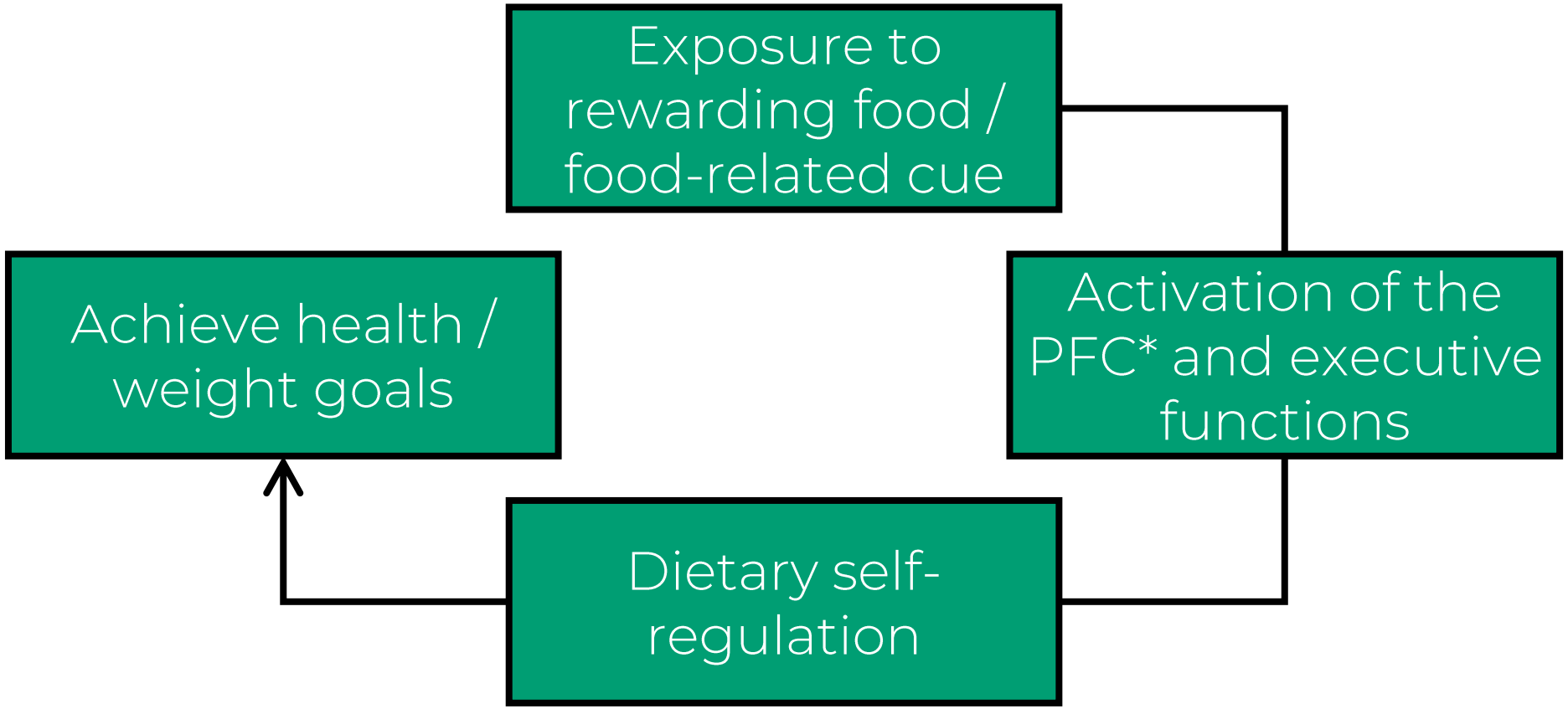


Prefrontal cortex (PFC) and executive functions

- The control of eating behaviour involves executive brain functions, which originate in the PFC
- These functions allow goal-directed behaviours through the inhibition of impulsive actions

Miller and Cohen, 2001; Pignatta et al., 2006; Joseph et al., 2011

Cognitive Control of Eating Behaviour



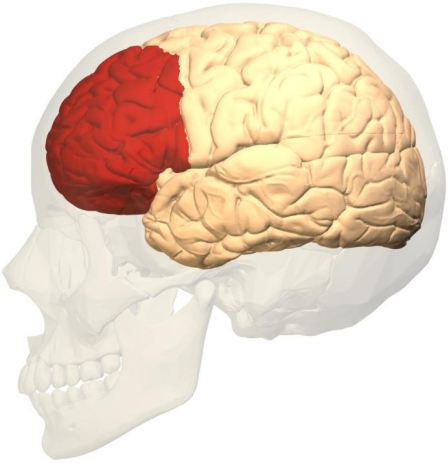


Figure adapted from Lowe et al. (2019); *prefrontal cortex

Cognitive Control of Eating Behaviour

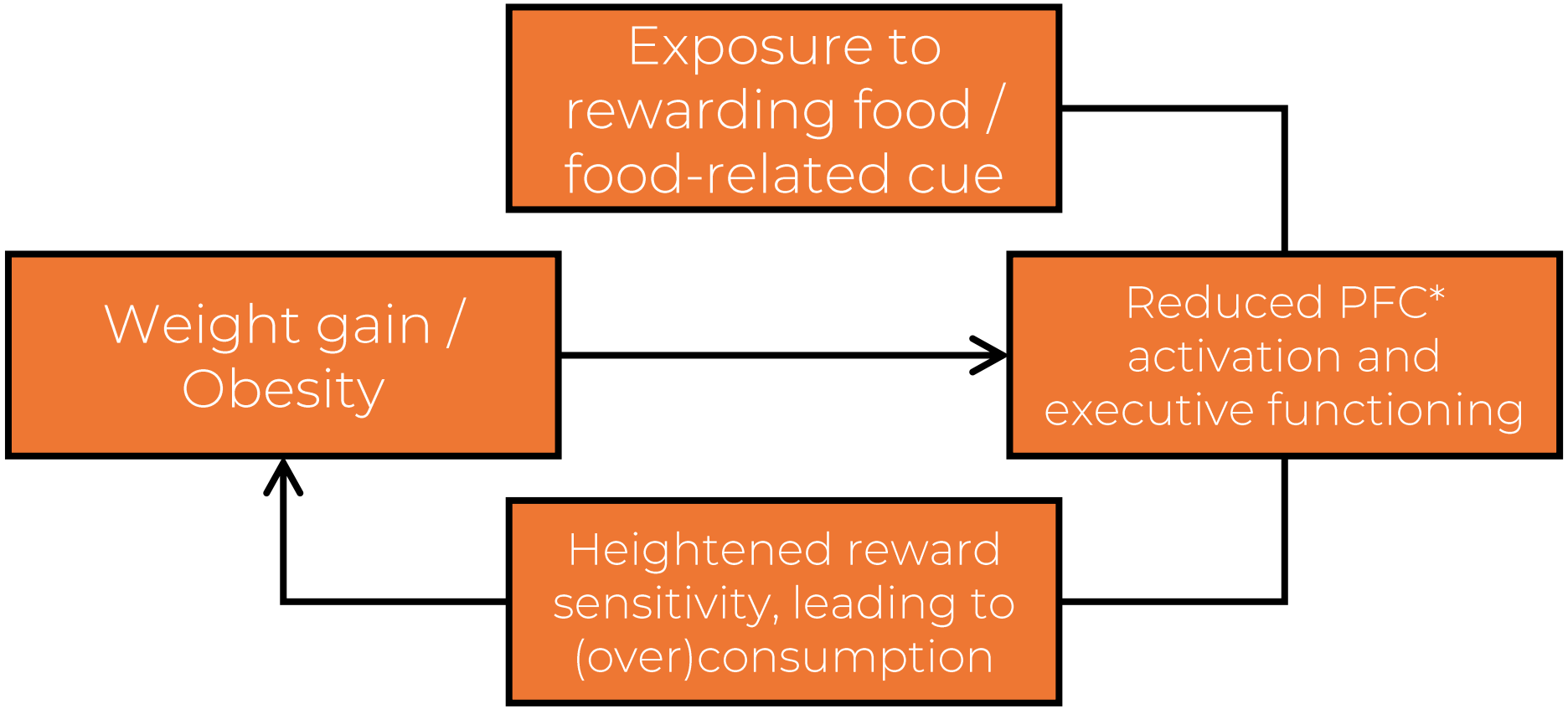
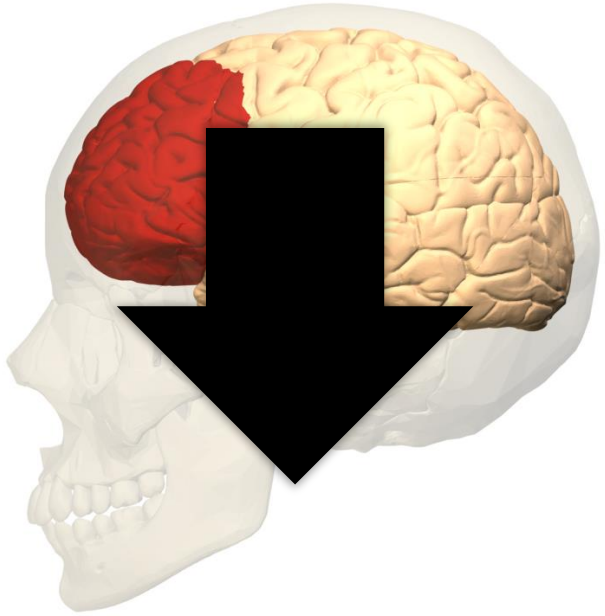


Figure adapted from Lowe et al. (2019); *prefrontal cortex

tDCS and the Control of Eating Behaviour



+

=?

Reduced PFC activity

tDCS (to increase activity)

tDCS is popular…

TDCS IN OBESITY: CURRENT RESEARCH

"The translation of tDCS into the field of obesity is still at a very early stage, with many challenges and open questions ahead. There is a need for foundational studies that generate adequate knowledge base and principles to guide the development of this emerging field."
(Alonso-Alonso, 2013, p. 2)

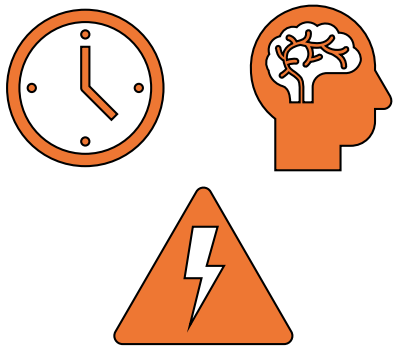
- 7 studies using overweight/obese
  (Montenegro et al., 2012; Bravo et al., 2015; Gluck et al., 2015; Burgess et al., 2016; Grundeis et al., 2017; Heinitz et al., 2017; Ray et al., 2017)
- 3 studies using mixed healthy weight and overweight/obese
  (Kekic et al., 2014; Ljubisavljevic et al., 2016; Georgii et al., 2017)

10 studies (Oct 2018)

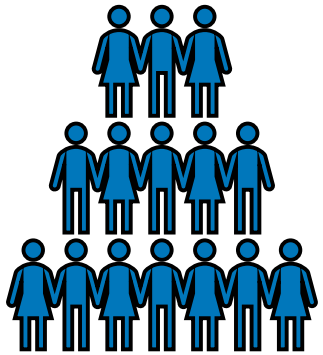
More than doubled since then – 28 included in our reviews!

...but...

Study design



Stimulation parameters



Participant characteristics

These vary greatly between studies, providing equivocal effects...

...it's very difficult to identify a consistent effect of tDCS!

Aim

Consider the effects of tDCS across eating-related measures (food craving, food consumption, food reward, subjective appetite)

Determine the impact of eating behaviour traits on these measures

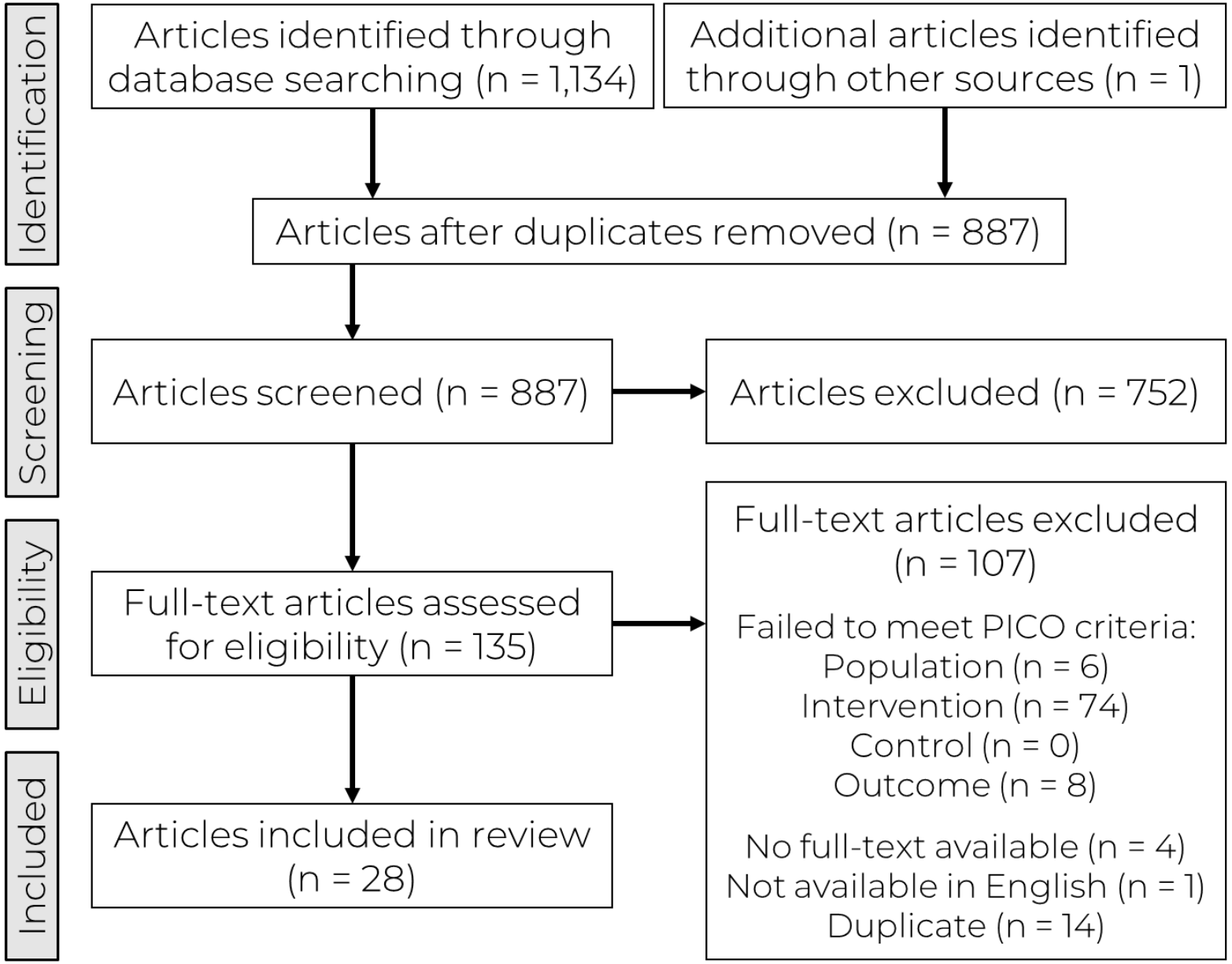
Method

Literature search performed using MEDLINE, PsycINFO, Scopus and Science Direct databases in March 2019 and repeated in July 2020

Inclusion 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)

Literature Search



Meta-Analysis

Mean, standard deviation and sample size were extracted from studies to calculate estimate of effect (effect size) and perform a random effects analysis

- Effect size (Hedges' *g*), interpreted as trivial (*g* < 0.20), small (*g* = 0.20), moderate (*g* = 0.50), large (*g* > 0.80) (Deeks et al., 2021)

- Focussed on single-session tDCS

- Subgroup analysis: "healthy" versus trait groups

“Healthy” vs Trait Groups

“Healthy” individuals

The consensus definition of “healthy” related to a lack of medical or behavioural conditions and was irrespective of weight status

Trait groups

Those with specific behaviour traits associated with overconsumption (e.g. Prader Willi syndrome, frequent food cravings, restrained eating, binge eating disorder)

Results

Measure	Overall Effect (*g* [95% CI])	Subgroup Analyses (*g* [95% CI])	
		"Healthy" Group	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)

Results

Food Consumption

Overall	"Healthy"	Trait (overall)	Binge eating
0.01 (-0.18, 0.20)	0.05 (-0.18, 0.16)	-0.12 (-0.76, 0.51)	-0.23 (-0.74, 0.28)

Explicit Wanting

Overall	"Healthy"	Trait (overall)	Frequent Craving
-0.01 (-0.16, 0.14)	0.09 (-0.04, 0.22)	-0.12 (-0.42, 0.19)	-0.45 (-1.03, 0.11)

Hunger

Overall	"Healthy"	Trait (overall)	Prader Willi syndrome
0.03 (-0.23, 0.29)	0.06 (-0.32, 0.44)	-0.08 (-0.72, 0.88)	-1.03 (-2.50, 0.43)

g (95% CI)

Summary

“Healthy” individuals

=

Unresponsive to tDCS

Trait groups

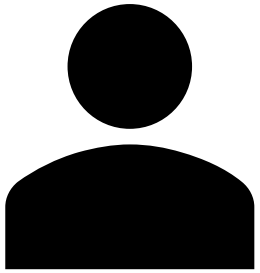
=

Responsive to tDCS

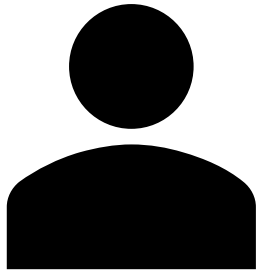
Recommendations

1. Recruit participants who display eating behaviour traits suggesting susceptibility to overconsumption
2. Focus on traits specific to the outcome measure of interest
3. Establish participants' baseline executive functioning capabilities and monitor any changes post-stimulation
4. Limit the information provided to participants, as this can drive any effects on eating behaviour outcomes
5. Incorporate a comprehensive group of validated measures, including food reward
6. Control fasting duration and measure baseline subjective appetite, even where this is not a measure of interest

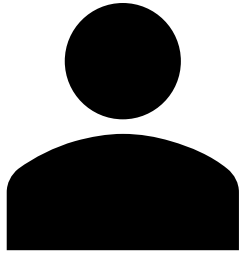
Acknowledgements



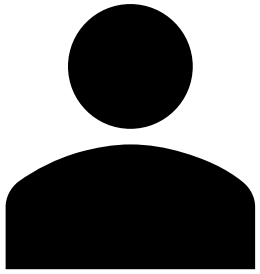
Prof. Martin Barwood



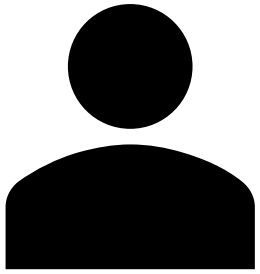
Dr. Danielle Davis



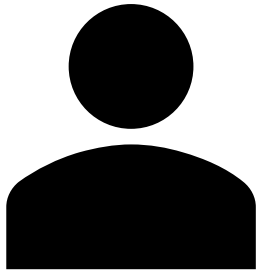
Dr. Michelle Dalton



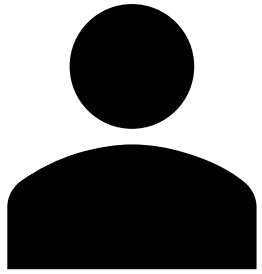
Prof. Mark Russell



Natalie Smith



David Starr



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