THE INFLUENCE OF NUTRITION KNOWLEDGE ON THE SELF-REGULATION OF EATING

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ABSTRACT

Self-regulation of eating behaviour refers to the ability to make healthy dietary choices, resist temptation and maintain a healthier diet over the longer term through monitoring, controlling and modifying thoughts, feeling and behaviour in response to food and related cues. Greater nutrition knowledge appears to be correlated with improved self-regulatory capacity, but evidence is lacking. The present study explored self-regulation capacity of individuals with knowledge of nutrition versus a lay audience. A total of 71 participants completed an online survey measuring nutritional knowledge, general self-regulatory capacity, the self-regulation of eating, trait eating behaviours and body image perception. General self-regulation capacity was negatively correlated with nutrition knowledge scores ($r = -.320$, $p = .017$), where greater self-regulation was associated with poorer nutrition-related knowledge. There was no correlation between self-regulation specific to eating behaviour and nutrition knowledge ($r = -.064$, $p = .634$). These findings suggest a poor link between self-regulatory capacity and nutrition knowledge. However, findings show a link between self-regulation, perceived struggle to maintain a healthy weight and disordered eating behaviours (e.g., uncontrolled and emotional eating), suggesting dietary self-regulation may be important for preventing problematic eating behaviours.

Keywords: Eating behaviour; Food choice; Cognitive function

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INTRODUCTION

Eating is a distinct behaviour in that we must consume food to survive (Meule & Vögele, 2013). What we eat, when we eat, and how much we eat are influenced by a complex interaction of physiological, psychological, genetic, social and environmental factors (Abizaid & Horvath, 2008; Allom & Mullan, 2014; Blundell, 2006; Grimm & Steinle, 2011; Herman et al., 2003). When considering the individual factors – the physiological and psychological mediators of food choice – these occur through complex systems that incorporate physiological need for energy (homeostatic appetite) and the rewarding components of food (hedonic appetite) (Blundell, 2006; Finlayson & Dalton, 2012). While homeostatic mechanisms are important drivers of food seeking behaviour through subjective sensations (e.g., hunger, satiety), food and related cues can stimulate hedonic reward pathways which can override homeostatic mechanisms and contribute to deficits in the control of eating behaviours (Alonso-Alonso & Pascual-Leone, 2007; Boswell & Kober, 2016; Finlayson & Dalton, 2012; Havermans, 2011; Kober & Boswell, 2018).

Controlling eating behaviour can be particularly challenging for some individuals due largely to this stimulation of the brain's reward and motivation circuits elicited by food and related cues (Alonso-Alonso, 2013; Finlayson & Dalton, 2012; Havermans, 2011). Food cues are increasingly prevalent in the obesogenic environment, where high calorie, rewarding foods are readily available (Blundell, 2006; Lowe et al., 2019). This prevalence of rewarding cues often overrides our physiological need for energy, instead promoting overconsumption and weight gain (Boswell & Kober, 2016; Kober & Boswell, 2018). This highlights the importance of dietary self-regulation, with successful self-regulation strongly linked with executive functioning processes (Dohle et al., 2018). These executive functions are the cognitive processes that allow the control of behavioural response to the stimulation of reward-based circuits (Joseph et al., 2011; Miller & Cohen, 2001; Pignatti et al., 2006). For example, these functions inhibit our impulse to consume a craved food in favour of our long-term weight loss goals (Joseph et al., 2011).

There appears a reciprocal relationship between self-regulation and eating behaviour traits; difficulties in maintaining dietary self-regulation has been associated with specific eating behaviour traits (e.g., binge-eating) (Boeka & Lokken, 2011), and individuals displaying these traits appear to have impairment in wider executive functioning (Blume et al., 2019; Cserjési et al., 2009; Michaud et al., 2017). This leads to greater impulsive behaviours, heightened reward response to high-calorie foods, and overconsumption (Gluck et al., 2017; Grundeis et al., 2017; Stice et al., 2008). Much recent work has looked to further identify the role of executive functioning in eating behaviour control (Allom & Mullan, 2014; Cury et al., 2020), and the benefits of interventions implementing executive function training (Hall et al., 2015; Jones et al., 2018; Wyckoff et al., 2017), or the modulation of brain regions controlling executive functioning (e.g., prefrontal cortex) (Beaumont et al., 2023; Beaumont et al., 2021; Burgess et al., 2016; Ray et al., 2017).

As this research area grows, further data on the role of executive functions for the control of eating behaviours are needed. Identifying differences in executive functioning capability, and specifically self-regulation of eating, between different populations will

likely provide important focus and direction. The present study explores whether knowledge of nutrition is linked with the cognitive control of eating behaviours.

LITERATURE REVIEW

Self-regulation is a process through which individuals monitor, control and modify their thoughts, feeling and behaviours in line with a desired goal (Baumeister & Vohs, 2004). When considering the self-regulation of eating behaviour, this refers to the ability to make healthy choices, resist temptation and maintain a healthy diet over the long-term (Dohle et al., 2018). The concept of self-regulation is closely linked with our long-term health-related goals and in particular our dietary habits. This self-regulation of eating behaviour is a complex process, which requires individuals to implement multiple strategies to maintain regulation (Dohle et al., 2018; Reed et al., 2016). For example, temptation-focussed strategies to address immediate impulsive response to palatable foods, or goal-orientated strategies for longer-term behavioural alignment with self-set standards of healthy eating. Through increased self-regulatory capacity, individuals may be better equipped to regulate their eating behaviour and maintain a healthy diet and body weight (Allom & Mullan, 2014; Burke et al., 2011).

The common narrative around self-regulation is the notion that individuals can resist palatable foods by exercising willpower (Baumeister et al., 2007). However, as described by Muraven and Baumeister (2000) (p. 247), "Eating a piece of pie […] requires various muscular movements of arm, fingers, and jaw. Yet most dieters can attest that refraining from such behaviors can seem more difficult and draining than performing them." Self-regulation of such behaviours is beyond passive inaction and instead requires the capacity to begin goal-related behaviour, continuously self-monitor dietary intake, consistently withstand temptation, evaluate goal alignment, and maintain motivation to adhere to healthy eating habits (Baumeister et al., 2007; Meule & Vögele, 2013; Muraven & Baumeister, 2000). This requires a wealth of cognitive functions including cognitive restraint, disinhibition, delayed gratification, self-monitoring, motivation, regulation of mood and emotion, self-efficacy, self-esteem, with social support and appropriate environment to underpin such behaviours (Dohle et al., 2018; Reed et al., 2016).

Strategies such as cognitive restructuring, where an individual consciously changes their thoughts and responses to food (e.g., challenging negative thoughts and beliefs about food), appears to improve eating behaviour and reduce disordered eating patterns (Wolfe & Patterson, 2017). To understand the self-regulation of eating, it is crucial to understand why people eat and the motivations behind food choice. There are clear links between self-regulation and mechanisms of appetite control (e.g., response to satiety cues, reward processing, emotional eating, self-monitoring) (Dakin et al., 2023). Hence, ability to self-regulate is a key driver of healthy eating behaviour and potentially healthy weight. Those engaging in regular self-monitoring appear to have better weight management outcomes (Berry et al., 2021); therefore, developing practical self-regulatory skills can help individuals manage their food intake and make healthier choices over the long-term. While an individuals' capacity to self-regulate their eating is important for controlling dietary intake, the wider environment has substantial influence on food choice (e.g., availability of

healthy foods) and ability to express self-regulation (e.g., abundance of food cues can override self-regulation) (Schwartz et al., 2017).

What is of particular interest is the potential link between nutrition knowledge and the self-regulation of eating behaviour. Nutrition knowledge refers to, for example, an individual's awareness of concepts relating to dietary guidelines, sources of nutrients, determinants of diet-related behaviour (Bhawra et al., 2023). This knowledge is gained through various routes, including dietary guidelines, health and nutrition policy, exposure to nutrition information, and education. Greater nutrition knowledge is correlated with healthier eating behaviour (e.g., increased fruit and vegetable intake; consumption of whole grains) (Spronk et al., 2014), and may be linked with greater focus on dietary intake and improved weight management outcomes (Li et al., 2022; Tsai et al., 2022). Previous studies have highlighted positive correlation between increased self-regulatory capacity and nutrition knowledge (Poddar et al., 2010; Rosenbaum et al., 2018), suggesting those with greater nutrition knowledge are able to better regulate their eating behaviour.

When considering the impact of low self-regulatory capacity on unhealthy dietary patterns, it is important to consider interventions for targeting self-regulation. One such intervention could be focused on improving nutrition literacy, which has potential for improving self-regulatory capacity. Individuals with a good understanding of nutrition may be more likely to make informed food choices, and having appropriate nutrition-based education may be necessary to help regulate behaviour in response to temptation or unhealthy food cues within the environment. However, the link between these factors is still unclear, particularly in context of wider behaviours. Therefore, the present study compares the self-regulation capacity of individuals with knowledge of nutrition versus a lay audience, with the aim of providing further clarification on how different individuals respond to foods. The project will centre around an online survey, providing quantitative data on nutrition knowledge and self-regulation, and looks to:

1. Identify the correlation between nutrition knowledge and the control of eating behaviours.

2. Explore differences in self-regulatory capacity within key demographic characteristic groups (e.g., gender).

RESEARCH METHOD

Study Design and Procedure

This cross-sectional study involved an online questionnaire completed through the Qualtrics platform. Participants were self-identified in response to study advertisements. Individuals were eligible to participate if they were over the age of 18. The study was shared via social media and word of mouth, and directed individuals to the online survey where they could review the participant information sheet. All participants provided informed consent before completing the survey. The survey took around 15 to 20 minutes to complete. The project was reviewed by the Sheffield Hallam University Research Ethics

Committee (approval ID: ER39245445). Due to the sensitive nature of the questions, participants were directed to relevant services and self-help resources should they be worried about eating behaviour or wider mental health and wellbeing.

Measures

Participants self-reported demographic characteristics, including age, gender, ethnicity, level of education, perceived weight category, and issues with weight management.

Nutrition knowledge was measured using the 88-item General Nutrition Knowledge Questionnaire-Revised (GNKQ-R) (Kliemann et al., 2016b). The GNKQ-R measures nutrition knowledge across a series of closed-ended questions. For the present study, only the first four sections (dietary recommendations, food groups, healthy food choices and diet, disease and weight management) were used; the final section which relates to demographic information was omitted. Responses are scored as correct (1) or incorrect (0), with total scores ranging from 0 to 88.

The Short Self-Regulation Questionnaire (SSRQ) (Carey et al., 2004) was used to measure general self-regulation capacity. Participants respond to 31 statements (e.g., "I usually keep track of my progress towards my goals") across five-point Likert scales ranging from "strongly disagree" to "strongly agree". The SSRQ is scored by totalling responses to all questions. To measure eating intention-specific regulatory capacity, we used the Self-Regulation of Eating Behaviour Questionnaire (SREBQ) (Kliemann et al., 2016a). Participants first identify foods they find tempting, then respond to items (e.g., "I give up too easily on my eating intentions") over a five-point scale ranging from "never" to "always". Items are scored 1 to 5, with mean score across the questionnaire suggesting low (<2.8), medium (2.8 to 3.6) or high (>3.6) self-regulatory skills.

The Three-Factor Eating Questionnaire, reduced 18-item form (TFEQ-r18) (Karlsson et al., 2000) was used to identify the participants eating behaviour traits. The TFEQ-r18 measures three aspects of human eating behaviour: cognitive restraint, emotional eating and uncontrolled eating. Participants respond to the items over a series of four-point scales ("definitely true" to "definitely false"), scores are calculated as a percentage with higher percentage signifying greater prevalence of the trait. Finally, the Stunkard body image scale (Stunkard et al., 1983) was used to assess perceived body image. The scale consists of silhouette drawings ranging in size from leanest (1) to largest (9) silhouette, representing weight categories from underweight to obese; participants indicate which silhouette they feel best represents their body size.

Data Analysis

All validated questionnaires were scored in line with relevant instructions. Normality of data was tested using Shapiro-Wilk test. Data were explored descriptively and analysed using Pearson's correlation coefficient (e.g., to test correlation between GNKQ scores and other variables), independent samples t-tests and one way analysis of variance (ANOVA) (e.g., explore difference in self-regulation across demographic groups). Where data were

not normally distributed, Spearman's correlation were used. Means and standard deviation (SD) are presented in arbitrary units (AU). Analyses were performed using JASP version 0.13 (University of Amsterdam, Amsterdam, The Netherlands). Raw data are available from the Sheffield Hallam University Research Data Archive (SHURDA) (https://shurda.shu.ac.uk/id/eprint/187 [NB: link not yet live]).

RESULTS

A total of 79 participants completed the online survey, however there was missing data (n = 8), so a final sample of 71 participants (36.8 ± 13.7 years) were analysed and data are presented in this section. Participant demographic characteristics are displayed in Table 1.

Table 1: Participant demographic characteristics (n = 71)

		n	%
Sex	Female	47	66.2
	Male	21	29.5
	Not reported	3	4.2
Ethnicity	Asian or Asian British	50	70.4
	White	11	15.5
	Mixed or multiple ethnicity	4	5.6
	Black, African, Caribbean or Black British	2	2.8
	Not reported	4	5.6
Level of education	Postgraduate taught degree	29	40.8
	Undergraduate degree	28	39.4
	Postgraduate research degree	8	11.2
	A Level or equivalent	2	2.8
	Some high school education	1	1.4
	Not reported	3	4.2
Perceived weight status group	Healthy weight	43	60.6
	Overweight	19	26.8
	Underweight	5	7.0
	Obese	2	2.8
	Not reported	2	2.8
Perceived struggle to maintain healthy weight	Yes	45	63.4
	No	24	33.8
	Not reported	2	2.8

Females had higher correct GNKQ scores (57.3 ± 12.9 AU) than males (47.7 ± 9.8 AU; $F_{(1,54)} = 7.501$, p = .008) (Table 2). General education level was positively correlated with GNKQ total score ($r = .412$, p = .002), which appeared specific for questions relating to food groups (section 2: $r = .283$, p = .029) and health food choices (section 3: $r = .255$, p = .039). The correlation between general education level and both dietary recommendations ($r = .231$, p = .075) and diet, disease and weight management were not significant ($r = .201$, p = .106). Having received nutrition-related education (e.g., undergraduate degree; 39.4% of participants) was not correlated with SREBQ ($r = .081$, p = .584) or SSRQ scores ($r_s = .184$, p = .215). Interestingly, there was no correlation between SREBQ and SSRQ scores ($r_s = .102$, p = .428).

Table 2: Scores across the GNKQ (mean ± SD)

	Correct answers
Section 1: Dietary recommendations	11.0 ± 2.6
Section 2: Food groups	22.0 ± 6.1
Section 3: Healthy food choices	6.2 ± 3.1
Section 4: Diet, disease and weight management	15.5 ± 3.4
Total score	54.1 ± 12.7

While the self-regulation of eating behaviour (measured through the SREBQ) was not correlated with nutrition knowledge (Table 3), general self-regulation (measured through the SSRQ) was negatively correlated with GNKQ scores. Total GNKQ scores were correlated with emotional eating ($r = .446$, p < .001), where those who presented with higher nutrition knowledge also appear to present with increased emotional eating behaviour. This appeared specific for section 2 (food groups) and section 3 (healthy food choices) (Table 3).

Table 3: Correlation between GNKQ scores and other variables

	GNKQ total score	Section 1	Section 2	Section 3	Section 4
SREBQ	$r = -.064$, p = .634	$r = .115$, p = .378	$r = -.140$, p = .278	$r = -.027$, p = .827	$r = .204$, p = .096
SSRQ	$r = -.320$, p = .017	$r = -.354$, p = .006	$r = -.495$, p < .001	$r = -.396$, p = .001	$r = -.279$, p = .029
TFEQ CR	$r = -.056$, p = .696	$r = .060$, p = .664	$r = .018$, p = .895	$r = -.023$, p = .861	$r = .217$, p = .102
TFEQ UE	$r = .255$, p = .068	$r = .040$, p = .770	$r = .297$, p = .029	$r = .215$, p = .104	$r = -.082$, p = .541
TFEQ EE	$r = .446$, p < .001	$r = .232$, p = .088	$r = .471$, p < .001	$r = .355$, p = .006	$r = .189$, p = .155
BIS	$r_s = .038$, p = .781	$r_s = -.128$, p = .330	$r_s = .085$, p = .517	$r_s = -.080$, p = .523	$r_s = -.078$, p = .536
Perceived weight status	$r_s = .167$, p = .215	$r_s = -.115$, p = .376	$r_s = .248$, p = .054	$r_s = .025$, p = .841	$r_s = .220$, p = .074
Intention to consume healthy diet	$r_s = -.187$, p = .160	$r_s = -.003$, p = .984	$r_s = -.153$, p = .237	$r_s = -.061$, p = .619	$r_s = .008$, p = .947
Intention to restrict tempting foods	$r_s = .073$, p = .589	$r_s = .180$, p = .170	$r_s = -.015$, p = .911	$r_s = .057$, p = .649	$r_s = .159$, p = .199

BIS, body image scale; CR, cognitive restraint; EE, emotional eating; GNKQ, General Nutrition Knowledge Questionnaire; SREBQ, Self-Regulation of Eating Behaviour Questionnaire; SSRQ, Short Self-Regulation Questionnaire; TFEQ, Three Factor Eating Questionnaire; UE, uncontrolled eating

SSRQ scores did not differ significantly between females (99.5 ± 8.8 AU) and males (104.2 ± 17.9 AU; $F_{(1,59)} = 1.861$, $p = .178$). However, eating-specific self-regulation was significantly different, with females showing greater self-regulatory capacity (3.3 ± 0.6 AU) compared with males (3.0 ± 0.6 AU; $F_{(1,65)} = 4.039$, $p = .049$). As expected, BIS scores significantly differed for perceived weight status category ($F_{(3,64)} = 13.881$, $p < 0.001$), with lowest BIS scores in those perceiving themselves to be underweight (3.2 ± 0.8 arbitrary unit [AU]) and highest scores in those perceiving themselves to be obese (8.0 ± 1.4 AU). Perceived weight status was not correlated with either self-regulation of eating ($r = -.198$, $p = .106$) nor general self-regulatory capacity ($r_s = -.043$, $p = .740$). Similarly, use of weight management techniques (Table 4) was not correlated with SREBQ ($r_s = .189$, $p = .128$) or SSRQ ($r_s = -.031$, $p = .814$). However, while perceived struggle to maintain a healthy weight was not correlated with general self-regulation ($r_s = .137$, $p = .287$), it was correlated with eating behaviour-specific self-regulation ($r = -.332$, $p = .006$), where those who struggled with maintaining a healthy weight had lower SREBQ scores. This is potentially explained by these individuals having significantly higher uncontrolled eating ($t_{(56)} = -2.115$, $p = 0.039$).

Table 4: Weight management techniques

	Total (n)
Avoid certain foods or food groups	27
Exercise or physical activity	27
Avoid certain eating practices (e.g., snacking)	19
Skip meals	13
I do not use any method to manage my weight	13
Healthy / Weight loss diet	9
Calorie tracking apps	4
Meal replacement products (e.g., shakes, bars)	2
Weight loss clubs or groups	0
Slimming or diet products (e.g., medications)	0

Finally, general self-regulatory capacity was not correlated with any measure across the TFEQ (cognitive restraint: $r = -.079$, $p = .565$; uncontrolled eating: $r = -.095$, $p = .488$;

emotional eating: $r = -.020$, $p = .886$). In comparison, cognitive restraint was positively correlated with SREBQ scores ($r = .548$, $p < .001$) and negatively correlated with uncontrolled eating ($r = -.326$, $p = .013$). There was no correlation between SREBQ scores and emotional eating ($r = -.185$, $p = .165$).

DISCUSSION

This study looked to further explore the link between nutritional knowledge – relating to an individual's awareness and understanding of nutrition, dietary guidelines and diet-related behaviour (Bhawra et al., 2023) – and the self-regulation of eating behaviour, a process through which an individual monitors, controls and modified their thoughts, feelings and behaviours in line with a health-related goal (Baumeister & Vohs, 2004). The present work additionally looked to explore differences in self-regulatory capacity within key demographic characteristic groups.

Previous studies have highlighted positive correlation between increased self-regulatory capacity and nutrition knowledge (Poddar et al., 2010; Rosenbaum et al., 2018), suggesting those with greater nutrition knowledge are able to better regulate their eating behaviour and have improved weight management outcomes (Li et al., 2022; Tsai et al., 2022). Data from the present study suggests that while general education level is important for improving nutritional knowledge, nutrition-related education itself does not appear to correlate with eating-related self-regulation. Given that self-regulation of eating behaviour is a complex process that requires individuals to implement multiple strategies (Dohle et al., 2018; Reed et al., 2016) and successful self-regulation of eating requires sufficient capacity to enact regulation (Hankonen et al., 2014; Hofmann et al., 2012), greater knowledge of healthy eating alone may not be sufficient to ensuring success. Such a finding is potentially unsurprising. As outlined by Muraven and Baumeister (2000), an individual's experience of controlling dietary intake can be particularly challenging, largely due to the need for active and conscious initiation of goal-related behaviour in order to successfully self-regulate dietary intake (Baumeister et al., 2007; Meule & Vögele, 2013; Muraven & Baumeister, 2000). Eating behaviour is complex – we are constantly making decisions around what to eat, when to eat, and how much to eat – which encapsulates food choice, motives, feeding practices, dietary practices, and eating-related problems (e.g., disordered eating) (LaCaille, 2013). As such, nutrition literacy likely has negligible impact on eating behaviour without sufficient self-regulatory capacity.

A relationship between perceived struggle to maintain a healthy weight and eating-specific self-regulation was demonstrated in this work, whereby those who perceive greater difficulty in maintaining a healthy weight have lower self-regulatory capacity. This appears closely linked with problematic eating behaviours, such as emotional and uncontrolled eating. This relationship is supported by previous research, demonstrating difficulties in maintaining dietary self-regulation where participants present with specific eating behaviour traits (e.g., binge-eating) (Boeka & Lokken, 2011), potentially due to these individuals having impairment in wider executive functioning (Blume et al., 2019; Cserjési et al., 2009; Michaud et al., 2017) and leading to greater impulsive behaviours, heightened

reward response to high-calorie foods, and overconsumption (Gluck et al., 2017; Grundeis et al., 2017; Stice et al., 2008). Conversely, those engaging in regular self-monitoring appear to have better weight management outcomes (Berry et al., 2021); therefore, developing practical self-regulatory skills can help individuals manage their food intake and make healthier choices over the long-term.

While efforts were made to ensure an inclusive recruitment approach, a limitation of the present study is the demographic profile of participants; participants were largely female, well-educated who perceived themselves to be of a healthy weight status. Such issues with representation are not limited to this study and are seen across eating-related research. Ensuring a representative sample is increasingly important given evident differences in nutritional knowledge across sociodemographic groups (Parmenter et al., 2000). Although the intention of this study was to identify a potential link between nutrition literacy and self-regulation, the nature of the study design did not allow the authors to explore how nutrition literacy was used by the participants (e.g., whether nutritional knowledge was embedded into wider self-regulatory behaviours). Such observations were outside the scope of this study but need to be explored to fully understand the role of nutrition literacy in dietary behaviour.

CONCLUSIONS

While the present study did not demonstrate a link between nutrition knowledge and self-regulation, findings do show a link between self-regulation capacity, perceived struggle to maintain a healthy weight and disordered eating behaviour. This suggests that improved self-regulatory capacity may be important for minimising problematic eating behaviours. What is important to consider when interpreting these findings is the intra- and inter-individual differences in eating experiences and self-regulatory capacity. As previously mentioned, the self-regulation of eating behaviour is a complex process requiring individuals to implement multiple strategies to maintain regulation (Dohle et al., 2018; Reed et al., 2016). Controlling eating behaviour can be particularly challenging for some individuals due largely to stimulation of the brain's reward and motivation circuits by food and related cues in the environment (Alonso-Alonso, 2013; Finlayson & Dalton, 2012; Havermans, 2011). It is important that we do not assume parity in these domains across individuals, and particularly assume certain population groups experience the same behaviours (i.e., not everyone living with obesity has deficits in self-regulation, not everyone who is healthy weight is able to self-regulate dietary behaviour).

AUTHOR CONTRIBUTIONS

Jordan D. Beaumont: Conceptualisation, Data curation, Format analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review and editing. **Varsha Nair Sreelekha**: Conceptualisation, Data curation, Investigation, Methodology, Writing – review and editing.

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