

	Journal Code	Manuscript No.	WILEY	No. of pages: 19	PE: Sathya Priya M.
---	--------------	----------------	-------	------------------	---------------------

APPLIED PSYCHOLOGY: HEALTH AND WELL-BEING, 2016
doi:10.1111/aphw.12080

Too Depleted to Try? Testing the Process Model of Ego Depletion in the Context of Unhealthy Snack Consumption

Ashleigh Haynes* and Eva Kemps

School of Psychology, Flinders University, Adelaide, Australia

Robyn Moffitt

*School of Applied Psychology, Griffith University, Queensland, Australia
Menzies Health Institute, Queensland, Australia*

Background: The process model proposes that the ego depletion effect is due to (a) an increase in motivation toward indulgence, and (b) a decrease in motivation to control behaviour following an initial act of self-control. In contrast, the reflective-impulsive model predicts that ego depletion results in behaviour that is more consistent with desires, and less consistent with motivations, rather than influencing the strength of desires and motivations. The current study sought to test these alternative accounts of the relationships between ego depletion, motivation, desire, and self-control. **Methods:** One hundred and fifty-six undergraduate women were randomised to complete a depleting e-crossing task or a non-depleting task, followed by a lab-based measure of snack intake, and self-report measures of motivation and desire strength. **Results and Conclusions:** In partial support of the process model, ego depletion was related to higher intake, but only indirectly via the influence of lowered motivation. Motivation was more strongly predictive of intake for those in the non-depletion condition, providing partial support for the reflective-impulsive model. Ego depletion did not affect desire, nor did depletion moderate the effect of desire on intake, indicating that desire may be an appropriate target for reducing unhealthy behaviour across situations where self-control resources vary.

Keywords: desire, ego depletion, food intake, motivation, self-control

INTRODUCTION

Exertion of self-control over eating behaviour is required on a daily basis, due to the availability and affordability of immediately rewarding, but unhealthy, snack

* Address for correspondence: Ashleigh Haynes, Psychological Sciences, University of Liverpool, Eleanor Rathbone Building, Liverpool L69 7ZA, UK. Email: a.haynes@liverpool.ac.uk

1 foods. These foods present a choice between satisfying urges to consume the
2 food for immediate hedonic gratification, and controlling those urges to act in a
3 manner consistent with longer-term goals, like healthy weight management. Fol-
4 lowing one act of self-control, the ability to enact self-control is temporarily
5 depleted, such that self-control attempts are less likely to be successful, an effect
6 termed “ego depletion” (Baumeister, Bratslavsky, Muraven, & Tice, 1998).
7 However, the size, replicability, and the conditions under which the ego deple-
8 tion effect can be observed are subjects of ongoing enquiry (Carter & McCul-
9 lough, 2014; Hagger et al., 2015; Job, Dweck, & Walton, 2010). Understanding
10 more about the mechanisms underlying ego depletion (including the variables
11 that interact with and mediate the effect) may contribute to an understanding of
12 how to prevent self-control failures and improve outcomes in a variety of beha-
13 vioural domains, including academic and work performance, overspending,
14 smoking, alcohol and drug abuse, relationship problems, as well as unhealthy
15 snacking.

17 The Reflective-Impulsive Model and Ego Depletion

19 According to traditional accounts, self-control involves the effortful inhibition
20 of impulses toward behaviour that is immediately rewarding (e.g. consuming
21 unhealthy food) to enact behaviour consistent with motivations toward long-
22 term goals (e.g. weight management) (Fujita, 2011; Muraven & Baumeister,
23 2000). Ego depletion is thought to alter the relative influence of impulses and
24 goal motivations on behaviour, such that when depleted, behaviour is driven
25 to a greater extent by immediate desires and impulses, and to a lesser extent
26 by motivations toward long-term goals (Hofmann, Friese, & Wiers, 2008;
27 Strack & Deutsch, 2004). For example, the reflective-impulsive model posits
28 that ego depletion affects the relative influence of two opposing systems on
29 behaviour, the impulsive and reflective systems. On the one hand, impulsive
30 influences operate relatively automatically to drive behaviour toward hedo-
31 nically rewarding stimuli, and can include a conscious desire to indulge in
32 unhealthy food (Milyavskaya, Inzlicht, Hope, & Koestner, 2015; Strack &
33 Deutsch, 2004). On the other hand, the reflective system operates in a more
34 reasoned manner, guiding behaviour in line with motivations and long-term
35 goals. However, the reflective system requires sufficient self-control resources
36 to influence behaviour (Deutsch & Strack, 2006; Hofmann et al., 2008; Strack
37 & Deutsch, 2004). In line with this account, ego depletion interacts with both
38 desire for immediately gratifying unhealthy snack food (an impulsive influ-
39 ence) and motivation toward a long-term goal (a reflective influence) to pre-
40 dict self-control of eating behaviour. Specifically, when depleted, behaviour is
41 more strongly predicted by desire, and when not depleted, behaviour is more
42 strongly predicted by motivations.

The Process Model of Ego Depletion

The process model proposed by Inzlicht and Schmeichel (2012) presents an alternative account of how ego depletion operates in relation to motivation and desire in predicting self-control outcomes. According to this model, the detriment to self-control performance following an initial self-control act is due to a shift in priorities and motivation. After one act of self-control, individuals become more motivated to indulge and satisfy immediate desires, and simultaneously become less motivated to control their urges. Inzlicht and Schmeichel argue that it is adaptive for individuals to balance periods of control and leisure, so that after enacting control, they become more motivated toward rest and indulgence of impulses. Thus, according to the process model, ego depletion does not moderate the effect of desire and motivation toward longer-term goals on behaviour (as predicted by traditional accounts of self-control); instead, the model proposes that ego depletion results in a stronger motivation to seek immediate gratification, and a reduced motivation to control those urges.

Relationship between Ego Depletion and Desire for Unhealthy Stimuli

Although Inzlicht, Schmeichel, and Macrae (2014) suggest that depletion increases desire for unhealthy or appetitive stimuli, the evidence in support of an increase in desire or motivation toward indulgence accompanying depletion is mixed. For example, Schmeichel, Harmon-Jones, and Harmon-Jones (2010) showed that depletion increased incentive sensitivity (i.e. increased motivation toward, pursuit of, and positive feeling in response to obtaining incentives) and facilitated the perception of reward-related stimuli (i.e. participants were quicker to detect a dollar sign in an array of symbols when depleted). In addition, Wagner, Altman, Boswell, Kelley, and Heatherton (2013) found that dieters who completed a depletion task showed greater activity in the orbitofrontal cortex (an area of the brain thought to be associated with processing reward value) when viewing pictures of food, than did dieters who were not depleted.

By contrast, other studies have found that rather than depletion resulting in stronger desire, desire is more influential on behaviour when individuals are depleted. Although not quite the same as motivation toward approaching or indulging in unhealthy foods, positive implicit attitudes toward such foods have been shown to predict stronger desire and preference for those foods (e.g. Dube, 2007; Friese, Hofmann, & Wanke, 2008; Haynes, Kemps, Moffitt, & Mohr, 2014; Perugini, 2005). Hofmann, Rauch, and Gawronski (2007) found that for participants in a depletion condition, more positive implicit food evaluations predicted higher intake of candy in a lab-based taste-test, whereas for those in a non-depletion condition, implicit food attitudes did not predict intake. These results therefore suggest that when depleted, individuals lack the ability to

1 overcome impulses or desires toward unhealthy behaviour. Friese et al. (2008)
2 reported similar findings: positive implicit evaluations of potato chips predicted
3 higher consumption in a taste-test, but only when participants were depleted.
4 Furthermore, Hofmann, Vohs, and Baumeister (2012) conducted an experience
5 sampling study requiring participants to respond to smartphone-administered
6 questionnaires multiple times a day over a one-week period. Participants were
7 asked to report whether they had recently experienced a desire from a variety of
8 domains (e.g. food, spending, etc.), whether they had attempted to resist that
9 desire, and whether or not they had enacted behaviour consistent with their
10 desire. Similar to the findings of studies examining implicit food attitudes, depletion
11 (inferred from a recent attempt at self-control of desire) predicted lower suc-
12 cess in overcoming desire. These findings are consistent with traditional
13 accounts of self-control such as the reflective-impulsive model, suggesting that
14 ego depletion allows desire to more strongly influence behaviour, rather than
15 depletion increasing the strength of desire.

17 Relationship between Ego Depletion and Motivation to 18 Control Behaviour

19
20 The reflective-impulsive and process models also make competing predictions
21 about how motivations to control behaviour are involved in ego depletion
22 effects. According to the reflective-impulsive model, ego depletion results in
23 behaviour that is more strongly driven by desires for immediate indulgence, and
24 to a lesser extent by motivations toward long-term goals. By contrast, the process
25 model not only proposes that ego depletion shifts motivation toward indulgence
26 (thus increasing desire), but also that it reduces motivation to control behaviour
27 in line with long-term goals. In support of the reflective-impulsive model, the
28 results of an experience sampling study by Hofmann et al. (2012) showed that
29 depletion did not increase the likelihood of attempting to resist a desire. Instead,
30 depletion was associated with a higher likelihood that an attempt to resist desire
31 would be successful, suggesting that depletion primarily affects the ability to
32 enact behaviour consistent with motivations to control behaviour, rather
33 than increasing the strength of motivation itself (Hofmann et al., 2012). While
34 an “attempt to resist a desire” is not ~~the same as~~ a measure of the strength of
35 motivation to control behaviour, it is likely to be indicative of a certain level of
36 motivation to control behaviour in line with a goal that conflicts with that desire.
37 If ego depletion indeed reduces the motivation to control behaviour, as is sug-
38 gested by the process model, the likelihood of attempting to resist a desire that
39 conflicts with a valued goal would also be reduced by ego depletion. However,
40 this was not the case in the findings reported by Hofmann et al. (2012).

41 In contrast, one study measured a variable related to the motivation to control
42 behaviour, and produced results consistent with the process model of ego deple-
43 tion (D. Walsh, 2014a). In this study, participants were randomised to a

1 condition in which they were primed with the goal of healthy eating or a control
2 condition prior to completing a depleting or a non-depleting task. Participants
3 reported their commitment to a goal of healthy eating following the depletion
4 manipulation. The authors did not report a main effect of depletion on goal com-
5 mitment. However, the effect was moderated by goal priming: in the goal prim-
6 ing condition, depleted and non-depleted participants showed no significant
7 difference in goal commitment; however, in the non-goal priming condition,
8 depletion resulted in lower goal commitment compared to the non-depleted con-
9 dition. Moreover, lowered commitment to the goal of healthy eating mediated
10 the effect of depletion on consumption of an unhealthy snack food, thus suggest-
11 ing that the depletion effect is due to a shift in motivation, in support of the
12 process model.

14 The Current Study

16 To date, no study has tested whether ego depletion affects motivation to control
17 behaviour in a specific self-control situation. D. Walsh (2014a) assessed general
18 commitment to a self-control goal, by asking participants to rate the importance
19 of the goal of healthy eating, and how committed and determined they were to
20 achieve that goal. By contrast, evidence for a difference in motivation to control
21 behaviour in a specific situation (e.g. by asking participants to rate their motiva-
22 tion to control or limit their intake of unhealthy food where there was the oppor-
23 tunity to consume that food) would provide stronger support for the process
24 model of ego depletion. According to this theory, depleted individuals would be
25 expected to experience lower motivation to control behaviour specific to a situa-
26 tion following an initial self-control task compared with non-depleted individu-
27 als. In contrast to Walsh, Hofmann et al. (2012) tested the interaction between
28 depletion, desire, and self-control attempts, in predicting self-control outcomes,
29 and found support for the reflective-impulsive model across various behavioural
30 domains (e.g. tobacco, spending, media use, eating) with a naturalistic, self-
31 report study design. The current study, however, sought to test this interaction
32 specifically in a controlled lab-based study of unhealthy food intake. This
33 allowed for control over aspects of the food environment that may influence
34 desire and intake (e.g. food variety, portion size, allowed eating time, etc.) that
35 was not possible in Hofmann et al.'s naturalistic study design.

36 Specifically, the current study sought to test competing predictions of the
37 reflective-impulsive and process models about the relationships between ego
38 depletion, desire strength, motivation to control behaviour, and self-control.
39 A dual-task paradigm was employed, whereby participants were randomised to
40 complete either an initial depleting or non-depleting task, and then all partici-
41 pants completed a self-control task: a taste-test measure of unhealthy snack con-
42 sumption. Participants then reported the extent to which they experienced a
43 desire to indulge in the snacks when first presented with them, and the extent to

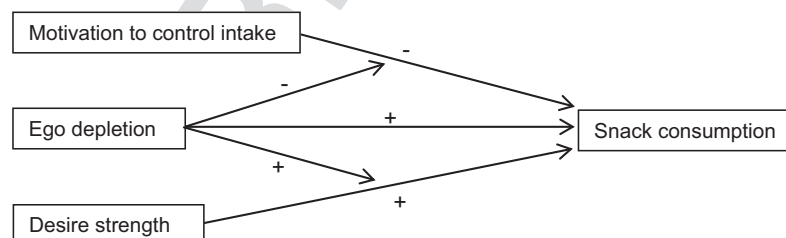
1 which they attempted to control their intake of the snacks during the taste-test.
 2 We specifically recruited a sample of young women who held the goal of healthy
 3 eating for weight management to ensure that the taste-test would represent a
 4 valid test of self-control.

5 If the reflective-impulsive model (Figure 1) were supported, we would expect
 6 that only individuals in a depleted state would show eating behaviour consistent
 7 with desires, such that a stronger desire to consume unhealthy food would pre-
 8 dict higher snack consumption; while individuals in the non-depletion condition
 9 should show eating behaviour consistent with their motivation to control their
 10 intake, such that individuals with a higher motivation to control intake would
 11 consume less snack food. This would suggest that individuals in the non-deple-
 12 tion condition have the resources to control their intake in line with their motiva-
 13 tions and to overcome strong desires to indulge, while the intake of depleted
 14 individuals would be more strongly driven by the desire experienced. In contrast,
 15 if the process model (Figure 2) were supported, we would expect that depletion
 16 would reduce motivation to control snack intake in the taste-test, and that this
 17 motivation would mediate the relationship between ego depletion and intake (i.e.
 18 that ego depletion would indirectly result in higher intake via reduced motiva-
 19 tion). In addition, we would expect that depletion would result in lower self-
 20 reported strength of desire to indulge in the foods in the taste-test, and that desire
 21 would also mediate the relationship between ego depletion and intake (i.e. that
 22 ego depletion would indirectly result in higher intake via increased desire).
 23

24 METHOD

25 Participants

26 A sample of 156 women was recruited from the undergraduate student popula-
 27 tion at Flinders University. An estimate of sample size was determined a priori
 28 based on similar studies conducted in our laboratory (Haynes, Kemps, & Moffitt,
 29 2015a, 2015b). Data collection was conducted over one semester, and
 30
 31
 32



33
 34
 35
 36
 37
 38
 39
 40
 41 **FIGURE 1.** Reflective-impulsive model: Ego depletion interacts with desire
 42 (impulsive factor) and motivation (reflective factor) to predict subsequent snack
 43 consumption.

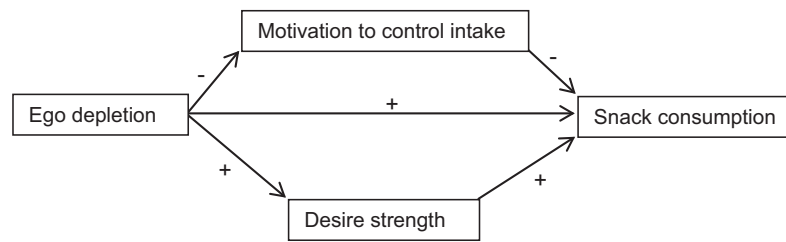


FIGURE 2. Process model: Ego depletion influences snack consumption by increasing desire to indulge, and reducing motivation to control behaviour.

recruitment continued until the end of the semester to offer a buffer for any missing data. Advertisement materials stated that the study aimed to investigate the relationship between attention and taste perception, and asked for female volunteers who were: (a) motivated to eat healthily to manage weight, (b) fluent in English, and (c) had no food allergies or intolerances. The sample was aged between 17 and 25 years ($M = 19.53$, $SD = 2.07$), with a mean body mass index (BMI) of 22.48 ($SD = 3.79$). The majority of participants were first-year psychology student volunteers who participated for course credit ($n = 110$). The remainder of the sample ($n = 46$) were recruited from the wider undergraduate student population, and received a \$10 honorarium for participating.

Design

The experiment employed a between-subject design, with participants randomly assigned to the two depletion conditions (depletion, control). The outcome measures included snack food consumption, and self-reported strength of desire and motivation to control intake.

Materials

Depletion Task. The e-crossing task was used to manipulate ego depletion (Baumeister et al., 1998; DeWall, Baumeister, Stillman, & Gailliot, 2007; D. Walsh, 2014b). Participants were told that the task was designed to measure attention to task-relevant stimuli. Participants in both the depletion and non-depletion conditions initially completed the same crossing out task. They were provided with a page of text, and instructed to cross out each instance of the letter “e”. In line with previous research, the text was taken from a statistics text, selected for its technical style to minimise interest in the content and distraction from the task (Baumeister et al., 1998). Participants were provided with written instructions, and given the opportunity to ask questions of the experimenter before beginning the task. After 5 minutes, participants were provided with a second set of instructions and a new page of text. Participants in the non-depletion condition were instructed to complete the same crossing out task as they did

1 before. Participants in the depletion condition were instructed to cross out each
2 letter “e”, except if the “e” was followed immediately by another vowel in the
3 same word, or if a vowel appeared two letters before the “e” in the same word.
4 The complex rule administered in the depletion condition required participants to
5 exercise self-control to inhibit the crossing-out response practised previously.
6 The second task also lasted 5 minutes.

7
8 *Snack Food Consumption.* A taste-test was used to measure consumption
9 of unhealthy snack food. Participants were presented with four bowls of popu-
10 lar energy-dense snack foods (i.e. cheese Twisties, original salted potato chips,
11 M&Ms, chocolate chip cookies). The placement of the bowls from left to right
12 was counterbalanced across participants using a Latin square procedure with
13 four orders. Participants were instructed to taste some of each of the foods in
14 order to rate their sensory properties (e.g. “How sweet is this product?”) on
15 100 mm visual analog scales on a rating sheet accompanying each bowl. Par-
16 ticipants were informed that they would be given 10 minutes to taste and rate
17 the foods while the experimenter was out of the room, and were advised that
18 they could sample more of the products after the ratings were completed, but
19 were asked not to change their initial ratings. The pre- and post-taste-test
20 weights of the bowls were compared after the participants had left the labora-
21 tory in order to gauge intake. Intake in grams was multiplied by the number
22 of kilojoules (kJ) per gram in each food, and summed for the total measure of
23 snack consumption.

24
25 *Desire Strength.* Participants were asked to indicate the extent to which
26 they felt tempted and how much they wanted to eat each of the foods presented
27 during the taste-test on two 7-point Likert scales ranging from 1 (*Not at all*) to 7
28 (*Completely*) for each of the four foods. Mean responses to each question across
29 the foods were calculated, and then the measure of desire strength was calculated
30 as the mean of the two questions, with higher scores indicating a stronger desire
31 to consume the foods.

32
33 *Motivation to Control Intake during Taste-Test.* Participants were asked to
34 indicate the extent to which they were motivated to control or minimise their
35 intake of the snacks presented during the taste-test. Responses were recorded on
36 a 7-point Likert scale, ranging from 1 (*Not at all*) to 7 (*Completely*) for each of
37 the four foods. A mean motivation to control intake score was calculated.

38
39 *Hunger.* Self-reported hunger was assessed on a single 7-point Likert scale
40 ranging from 1 (*not hungry at all*) to 7 (*extremely hungry*), and was included as
41 a covariate in analyses as it has been shown to affect food consumption (Haynes
42 et al., 2014; Rogers & Hardman, 2015).

1 *Depletion Manipulation Check.* Participants were asked to indicate the
2 extent to which the second crossing-out-letters task was effortful, exhausting,
3 required concentration, and required them to break a habit. Responses were
4 recorded on four 7-point Likert scales ranging from 1 (*Not at all*) to 7
5 (*Completely*).
6

7 Procedure

8
9 Participants completed the experiment individually in a quiet room in the
10 Applied Cognitive Psychology Laboratory. Participants were asked to eat some-
11 thing 2 hours before their scheduled session, and to refrain from eating or drink-
12 ing anything apart from water until the experiment to equalise hunger levels.
13 After obtaining informed consent, the hunger measure was administered, fol-
14 lowed by the e-crossing task and then the taste-test. Finally, the remaining self-
15 report measures (desire, motivation, age, height and weight) were administered.
16 Measures of desire strength and motivation were administered after the taste-test
17 to avoid contamination of the measure of snack consumption. Data from all par-
18 ticipants were included in all analyses.
19

20 RESULTS

21 Preliminary Analyses and Main Effects of Depletion

22
23 Table 1 presents descriptive statistics for the manipulation check variables, hun-
24 ger, BMI, and the main outcome measures between the depletion and non-deple-
25 tion conditions. Independent samples *t*-tests revealed that participants in the
26 depletion condition rated the second e-crossing task as more effortful and
27 exhausting, requiring more concentration, and required them to break a habit to
28 a greater extent than participants in the non-depletion condition. The conditions
29 did not significantly differ on hunger or BMI. Zero-order correlations between
30 all main variables are presented in Table 2. Hunger was significantly positively
31 correlated with both desire strength and motivation to control intake, and was
32 therefore entered as a covariate in subsequent analyses.¹ Desire strength was also
33 positively correlated with snack consumption and motivation to control intake.
34 Contrary to predictions, independent sample *t*-tests showed that the conditions
35
36

37
38
39 ¹ Hunger has also been shown to correlate with both desire to eat and snack intake in previous
40 research (Haynes et al., 2014; Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009). As we
41 were interested in isolating the effects of desire and motivation to control intake, we decided to
42 control for hunger in our main analyses in addition to instructing participants to eat 2 hours before
43 participating to minimise variation in hunger. Excluding hunger as a covariate in analyses did not
change the main pattern of results or their significance, except where indicated in footnotes.

TABLE 1
Difference between Depletion and Non-Depletion Conditions on all Variables

Variable	Condition		t^a	p	d
	Non-depletion	Depletion			
Hunger	3.31 (1.60)	3.21 (1.40)	0.42	.67	0.07
BMI	22.37 (3.83)	22.58 (3.79)	0.34	.74	0.06
Manipulation checks					
Exhausting	3.19 (1.46)	4.01 (1.48)	3.48	.001	0.56
Effortful	4.09 (1.68)	4.83 (1.45)	2.96	.004	0.47
Requires concentration	3.63 (1.68)	4.36 (1.55)	2.82	< .01	0.45
Requires breaking a habit	3.73 (1.71)	4.91 (1.28)	4.87	< .001	0.78
Snack consumption	887.45 (492.30)	847.51 (531.94)	0.49	.63	0.08
Desire strength ^b	4.11 (1.32)	4.16 (1.37)	0.24	.81	0.04
Motivation to control intake ^c	3.53 (1.49)	3.05 (1.35)	2.06	.04	0.34

^adegrees of freedom = 154 for each comparison, except for BMI ($df = 151$) due to missing data.

^bUnivariate ANOVA results including hunger as a covariate, $F(2, 153) < 1, p = .89$, partial $\eta^2 = .00$.

^cUnivariate ANOVA results including hunger as a covariate, $F(2, 153) = 4.83, p = .03$, partial $\eta^2 = .03$.

did not significantly differ on desire strength or snack intake (Table 1). However, in line with the process model of ego depletion, participants in the depletion condition reported significantly lower motivation to control intake than those in the non-depletion condition, even when controlling for hunger.

Interactions between Depletion Condition and Both Motivation to Control Intake and Desire Strength in Predicting Snack Consumption

A moderation analysis was conducted to explore the two-way interactions between depletion and both motivation to control intake and desire strength in predicting snack consumption, using the SPSS macro PROCESS (Hayes, 2012).² The overall model was significant, $R = .38, F(6, 149) = 4.19, p < .001$. Both motivation and desire significantly predicted snack consumption, such that participants with higher motivation to control intake ate less snack food, $B = -134.89, t(149) = 3.22, p = .002$, and those reporting higher desire consumed more snack food, $B = 116.52, t(149) = 2.55, p = .01$. Depletion condition did not predict snack food, $B = -82.14, t(149) = 1.04, p = .30$. As predicted, there was a significant interaction between depletion condition and

² Depletion condition was coded as 0 = control (non-depletion), 1 = depletion condition, and continuous predictors (hunger, motivation, and desire) were mean centred prior to PROCESS analyses.

TABLE 2
Correlations between Hunger, BMI, Snack Consumption, Desire Strength, and Motivation to Control Intake

Variable	1	2	3	4	5
1 Hunger		-.01	.12	.24**	.20*
2 BMI			.05	-.08	.00
3 Snack consumption				.26**	-.07
4 Desire strength					.33***
5 Motivation to control intake					

* $p < .05$; ** $p < .01$; *** $p < .001$.

motivation, $B = 134.88$, $t(149) = 2.26$, $p = .03$, R^2 change = .03, $F(1, 149) = 5.09$.³ Simple slopes analysis exploring the relationship between motivation and intake between depletion conditions revealed that in the non-depletion condition, higher motivation predicted lower snack consumption, $B = -136.25$, $t(149) = 3.228$, $p = .002$, while in the depletion condition, motivation did not significantly predict consumption, $B = -0.01$, $t(1490) = 0.001$, $p = .99$ (Figure 3). However, the interaction between desire and ego depletion was not significant, $B = 6.02$, $t(149) = 0.09$, $p = .92$, R^2 change = .001, $F(1, 149) = .01$, indicating that the relationship between desire and intake did not vary depending on the level of ego depletion.

Indirect Effect of Ego Depletion on Snack Consumption via Both Motivation to Control Intake and Desire Strength

To test whether there was an indirect relationship between ego depletion and intake via motivation to control intake and/or desire, PROCESS (Hayes, 2012) was used to conduct a parallel mediation analysis using 5,000 bootstrap samples. The independent variable (depletion condition) and covariate (hunger) were regressed on both mediating variables separately, indicating ~~that depletion was associated with motivation, showing~~ that depletion was associated with lower motivation to control intake, model $R = .27$, $F(2, 153) = 5.85$, $p = .004$, $B = -0.49$, $t(153) = 2.20$, $p = .03$, but was not associated with desire, model $R = .24$, $F(2, 153) = 4.68$, $p = .01$, $B = .03$, $t(153) = 0.14$, $p = .89$. A second regression model was estimated, regressing the independent variable, mediators,

³ The interaction between motivation and ego depletion was only marginally significant when hunger was not included as a covariate, $B = 114.77$, $t(150) = 1.96$, $p = .05$, R^2 change = .02, $F(1, 150) = 3.86$.

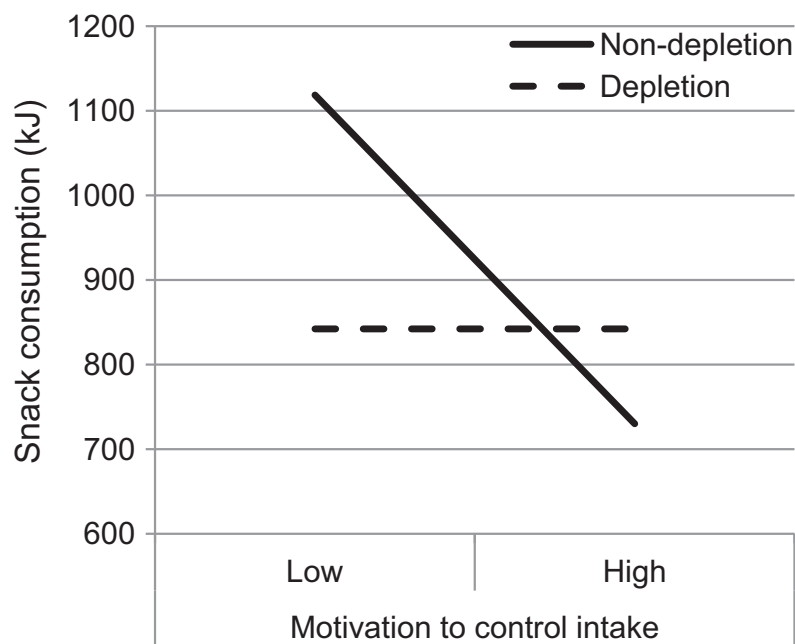


FIGURE 3. Interaction between motivation to control intake and depletion condition in predicting snack consumption.

and covariate on the outcome variable (snack consumption), $R = .33$, $F(4, 151) = 4.64$, $p = .002$. Higher snack consumption was predicted by lower motivation to control intake, $B = -71.51$, $t(151) = 2.41$, $p = .02$, higher desire, $B = 118.00$, $t(151) = 3.73$, $p = .001$, but not by depletion condition, $B = -82.91$, $t(151) = 1.04$, $p = .30$. The indirect effect of depletion on snack consumption through motivation was 35.18 ($SE = 24.32$). The 95% confidence interval around the estimated indirect effect did not contain zero (3.24, 103.40), indicating that ego depletion had an indirect effect on higher intake via motivation to control intake. The indirect effect of depletion on snack consumption through desire was 3.45 ($SE = 26.06$), and the 95% confidence interval around the indirect effect contained zero (-52.31, 54.22), indicating that ego depletion did not have a significant indirect effect on intake via desire strength.

DISCUSSION

The current study sought to test competing predictions of the reflective-impulsive and process models about the relationships between ego depletion, desire strength, motivation to control behaviour, and self-control in an eating domain. Results provided partial support for both models. Specifically, in support of the process model, depletion indirectly resulted in higher snack consumption through the influence of lower motivation to control intake. However, the prediction that depletion would result in stronger desire for the snack foods offered during the taste-test was not supported. The findings were also partially

1 consistent with traditional accounts of self-control such as the reflective-impul-
2 sive model. Specifically, only for participants in the non-depletion condition did
3 higher motivation to control intake correlate with lower snack consumption
4 (although the interaction between motivation and ego depletion was only mar-
5 ginally significant when hunger was not controlled for). In line with the reflec-
6 tive-impulsive model, it was also predicted that desire would predict intake only
7 when participants were depleted; however, on the contrary, desire strength pre-
8 dicted higher snack intake across both conditions.

10 Ego Depletion Effects on Desire and Motivation to 11 Control Behaviour

12 Consistent with the process model of ego depletion, depleted individuals
13 reported lower motivation to control intake than those in the non-depletion con-
14 dition, when controlling for hunger. This reduced motivation also mediated the
15 relationship between depletion and higher snack intake. While Hofmann et al.
16 (2012) found no significant difference in the likelihood of a self-control attempt
17 between depleted and non-depleted participants, Walsh (2014a) did find that
18 depletion decreased participants' ratings of commitment, determination, and
19 importance of the goal of healthy eating. The current findings are consistent with
20 those of Walsh, and extend them in an important way. In contrast to Walsh, we
21 specifically sought to recruit individuals who were motivated to manage their
22 weight through healthy eating to ensure that the taste-test presented a self-control
23 dilemma. Since depletion has a temporary effect on self-control performance, we
24 thought it important to investigate situation-specific motivation by asking partici-
25 pants to rate their motivation to control or limit their intake of unhealthy food
26 during the taste-test. In contrast, Walsh assessed general motivation toward the
27 goal of healthy eating. If the process model is accurate, we would expect a dif-
28 ference in motivation to control behaviour specific to the self-control test pre-
29 sented, which was supported in the current study. Further research which
30 simultaneously examines both general goal commitment and situation-specific
31 motivation would be valuable to test how they interact, and to determine whether
32 they are differentially impacted by ego depletion.

34 The finding that ego depletion did not increase the strength of desire to con-
35 sume the unhealthy foods offered during the taste-test is inconsistent with the
36 process model. Some studies have shown that depletion increases incentive sen-
37 sitivity, and increases neural activity in reward-related centres among dieters
38 when exposed to food cues (Schmeichel et al., 2010; Wagner et al., 2013). How-
39 ever, other studies have revealed differences in the strength of the relationship
40 between hedonic processing of food cues and self-control of eating behaviour
41 between depleted and non-depleted individuals (e.g. Friese et al., 2008; Hof-
42 mann et al., 2007). The current study was the first to assess self-reported desire
43 between depleted and non-depleted participants. Taken together with previous

1 findings, the current results suggest that increased incentive sensitivity and food
2 reward activity in depleted compared to non-depleted individuals may not neces-
3 sarily translate into increased subjective desire to indulge in unhealthy but imme-
4 diately gratifying snack foods.

6 Interactions: Ego Depletion, Desire, and Motivation to 7 Control Behaviour

8
9 Consistent with the reflective-impulsive model, the current study showed that
10 ego depletion interacted with motivation to control intake to predict actual intake
11 during the taste-test (i.e. self-control outcome). Only in the depletion condition
12 did a higher motivation to control intake predict lower snack consumption.
13 These results suggest that when not depleted, individuals have the resources to
14 enact behaviour consistent with the reflective system. However, regarding the
15 moderation of the impulsive system on behaviour (i.e. influence of desire), the
16 reflective-impulsive model was not supported: desire significantly predicted
17 intake regardless of condition assignment. The current pattern of results regard-
18 ing the interaction between ego depletion and motivation to control behaviour
19 (but not desire strength) mirrored that of Hofmann et al.'s (2012) experience
20 sampling study. Specifically, they found that participants who had not recently
21 enacted self-control (i.e. who were not depleted) were better able to enact beha-
22 viour consistent with their attempts to self-control, and to overcome desire. In
23 contrast, when depleted, participants' attempt to control behaviour was not pre-
24 dictive of their behaviour, which was instead more strongly predicted by their
25 immediate desires. The current study adds to this evidence for the interaction
26 between ego depletion and motivation in the eating domain, by testing these
27 interactions using a lab-based study design which allowed experimental control
28 over aspects of the food environment.

30 Other Findings

31
32 Both self-reported hunger and desire for snack food were found to correlate with
33 a higher motivation to control intake. While we had no specific predictions about
34 this relationship, it is nevertheless an interesting finding. Some previous studies
35 have revealed that exposure to a strong "temptation" cue can enhance self-con-
36 trol by bolstering motivation toward the goal that is threatened by that tempta-
37 tion. For example, Kroese and colleagues found that exposure to strong
38 temptations increased the accessibility of a dieting goal, strengthened goal inten-
39 tions and self-reported goal importance, and facilitated goal-focused behaviour
40 (Kroese, Evers, & De Ridder, 2009, 2011). The authors suggested that individu-
41 als may underestimate the potential effect of weak temptations on consumption,
42 while in contrast, strong temptations present a clear threat to a valued goal and
43 therefore activate stronger intentions and motivations to control behaviour.

1 Similarly, the experience of stronger desire in the current study may have facilitated the recognition of the taste-test as a threat to the goal of healthy eating for weight management, thus explaining the correlation between desire and higher motivation to control intake. However, it is difficult to draw conclusions about causal directions as both desire and motivation were measured using retrospective self-report measures. Disentangling the relationship between desire and motivation, and investigating why and under which conditions stronger desire or temptation may benefit motivation toward a conflicting goal, would be a useful direction for future research.

11 Questioning the Ego Depletion Effect

12 The current study did not find a main effect of ego depletion on snack consumption. In addition, when individuals were depleted, snack consumption remained relatively low under both high and low motivation to control behaviour (Figure 3). These observations speak to the current debate about the size and robustness of the ego depletion effect on self-control (Carter & McCullough, 2014; Hagger et al., 2015). A number of studies have failed to show effects of ego depletion on tasks thought to reflect self-control, such as general working memory performance and financial decision-making (Alós-Ferrer, Hügelschäfer, & Li, 2015; Lurquin et al., 2016). Others present caveats to the ego depletion effect. For example, Job et al. (2010) demonstrated that only individuals who believe that willpower is a finite resource are susceptible to ego depletion. These, and the current findings, highlight a clear need for further research on the conditions under which ego depletion affects subsequent self-control. In particular, a focus on the combined effects of ego depletion and other moderating factors might provide a more promising avenue for advancing the literature on self-control.

29 Practical Implications

30 In a practical sense, the findings of the current study suggest that reducing desire for indulgence in unhealthy stimuli may be the best way to facilitate healthy eating behaviour, regardless of self-regulatory resources. Only for participants in the non-depletion condition did a high motivation to control intake reduce snack food consumption. However, desire was a significant predictor of snack consumption across conditions, suggesting that desire may affect behaviour even when individuals possess higher levels of self-regulatory resources. Therefore, individuals might be better placed to deal with daily challenges of self-control by managing desire and temptation (e.g. limiting exposure to foods that are routinely craved, distracting oneself from the desire or craving for unhealthy snack foods) rather than focusing on ways of maintaining strong motivation toward one's goals (e.g. reminding oneself of a valued goal). Likewise, an appropriate focus for interventions that are effective at facilitating healthy behaviour across

1 situations could be to reduce desire for unhealthy stimuli. For example, previous
2 studies have suggested that changing the way appetitive stimuli are processed at
3 an automatic level could reduce desire for, and subsequent intake of, unhealthy
4 food. In particular, chocolate cravings have been shown to be related to an atten-
5 tional bias for chocolate-related cues, and retraining attentional biases away from
6 those cues can reduce both cravings and subsequent intake (Kemps & Tigge-
7 mann, 2009; Kemps, Tiggemann, Orr, & Grear, 2014). Similarly, positive impli-
8 cit evaluations of unhealthy food have been shown to predict stronger
9 experienced temptation to indulge in unhealthy food and subsequent intake
10 (Haynes et al., 2014). While some studies have shown that retraining those
11 implicit evaluations can produce healthier food choices across all individuals
12 (Hollands, Prestwich, & Marteau, 2011; E.M. Walsh & Kiviniemi, 2014), others
13 have shown that retraining implicit food evaluations may only reduce temptation
14 strength and intake of unhealthy food among individuals with low inhibitory
15 control (Haynes et al., 2015a, 2015b). Future research should further explore
16 strategies to reduce the desire for unhealthy but immediately rewarding stimuli,
17 in order to facilitate goal-consistent behaviour.
18

19 Limitations and Future Directions

20
21 Several limitations to the current study should be acknowledged. The study
22 implemented a laboratory-based test with a view to control variables not possible
23 in a previous investigation of the interactions between ego depletion, motivation,
24 and desire in an ecological momentary assessment design (Hofmann et al.,
25 2012). However, it remains to be seen whether the effects reported here gener-
26 alise to the experience of self-control over unhealthy snacking in the “real
27 world”. Furthermore, motivation and desire were assessed using retrospective
28 self-report measures. In future, experimental manipulation of ego depletion and/
29 or motivation and desire might be combined with more ecologically valid
30 approaches to the assessment of self-control of behaviour (e.g. ecological
31 momentary assessment). This would provide insight into whether the same
32 effects found here can be replicated in “real-world” settings, while overcoming
33 some of the limitations of self-report measures of desire and motivation. Finally,
34 future research could extend the current between-subjects design to include a
35 within-subjects comparison of motivation to control behaviour before versus
36 after the ego depletion manipulation. This would enable tracking of within-per-
37 son shifts in motivational priorities as a result of ego depletion in line with pre-
38 dictions of the process model.
39

40 Conclusion

41
42 In conclusion, the current study tested alternative predictions about ego deple-
43 tion drawn from the process and reflective-impulsive models in an eating

1 domain. Findings revealed partial support for the process model: ego depletion
 2 reduced the motivation to control intake, which in turn increased snack intake,
 3 but ego depletion did not increase desire for appetitive stimuli. We also found
 4 partial support for the reflective-impulsive model. Specifically, only when not
 5 depleted were individuals able to act according to their motivation to control
 6 intake. However, depletion did not significantly moderate the relationship
 7 between desire and snack consumption, suggesting that desire may be an
 8 appropriate focus for facilitating healthy behaviour across different self-control
 9 conditions.

11 REFERENCES

- 13 Alós-Ferrer, C., Hügelschäfer, S., & Li, J. (2015). Self-control depletion and decision
 14 making. *Journal of Neuroscience, Psychology, and Economics*, 8 (4), 203–216.
 15 doi:10.1037/npe0000047
- 16 Baumeister, R.F., Bratslavsky, E., Muraven, M., & Tice, D.M. (1998). Ego depletion: Is
 17 the active self a limited resource? *Journal of Personality and Social Psychology*, 74
 18 (5), 1252–1265. doi:10.1037/0022-3514.74.5.1252
- 19 Carter, E.C., & McCullough, M.E. (2014). Publication bias and the limited strength model
 20 of self-control: Has the evidence for ego depletion been overestimated? *Frontiers in*
 21 *Psychology*, 5, 823. doi:10.3389/fpsyg.2014.00823
- 22 Deutsch, R., & Strack, F. (2006). Duality models in social psychology: From dual pro-
 23 cesses to interacting systems. *Psychological Inquiry*, 17 (3), 166–172. doi:10.1207/
 24 s15327965pli1703_2
- 25 DeWall, C.N., Baumeister, R.F., Stillman, T.F., & Gailliot, M.T. (2007). Violence
 26 restrained: Effects of self-regulation and its depletion on aggression. *Journal of*
 27 *Experimental Social Psychology*, 43 (1), 62–76. doi:10.1016/j.jesp.2005.12.005
- 28 Dube, L. (2007). Implicit and explicit influences on spontaneous and deliberate food
 29 choices. *Advances in Consumer Research*, 34, 104–109. doi:10.1037/14333-005
- 30 Friese, M., Hofmann, W., & Wanke, M. (2008). When impulses take over: Moderated
 31 predictive validity of explicit and implicit attitude measures in predicting food choice
 32 and consumption behaviour. *British Journal of Social Psychology*, 47, 397–419.
 33 doi:10.1348/014466607X241540
- 34 Fujita, K. (2011). On conceptualizing self-control as more than the effortful inhibition of
 35 impulses. *Personality and Social Psychology Review*, 15, 352–366. doi:10.1177/
 36 1088868311411165
- 37 Hagger, M.S., Chatzisarantis, N.L., Alberts, H., Anggono, C.O., Birt, A., Brand, R., et al.
 38 (2015). A multi-lab pre-registered replication of the ego-depletion effect. *Perspectives*
 39 *on Psychological Science*, 11 (4), 546–573. doi:10.1177/1745691616652873
- 40 Hayes, A.F. (2012). PROCESS: A versatile computational tool for observed variable
 41 mediation, moderation, and conditional process modeling [White paper]. Retrieved
 42 from <http://www.afhayes.com/public/process2012.pdf>
- 43 Haynes, A., Kemps, E., & Moffitt, R. (2015a). Inhibitory self-control moderates the effect
 of changed implicit food evaluations on snack food consumption. *Appetite*, 90, 114–
 122. doi:10.1016/j.appet.2015.02.039

- 1 Haynes, A., Kemps, E., & Moffitt, R. (2015b). The moderating role of state
2 inhibitory control in the effect of evaluative conditioning on temptation and
3 unhealthy snacking. *Physiology & Behavior*, *152*, 135–142. doi:hof10.1016/
4 j.physbeh.2015.09.020
- 5 Haynes, A., Kemps, E., Moffitt, R., & Mohr, P. (2014). Reduce temptation or resist it?
6 Experienced temptation mediates the relationship between implicit evaluations of
7 unhealthy snack foods and subsequent intake. *Psychology & Health*, *30*, 534–550.
8 doi:10.1080/08870446.2014.984713
- 9 Hofmann, W., Friese, M., & Wiers, R.W. (2008). Impulsive versus reflective influences
10 on health behavior: A theoretical framework and empirical review. *Health Psychology
11 Review*, *2*, 111–137. doi:10.1080/17437190802617668
- 12 Hofmann, W., Rauch, W., & Gawronski, B. (2007). And deplete us not into temptation:
13 Automatic attitudes, dietary restraint, and self-regulatory resources as determinants of
14 eating behavior. *Journal of Experimental Social Psychology*, *43*, 497–504.
15 doi:10.1016/j.jesp.2006.05.004
- 16 Hofmann, W., Vohs, K.D., & Baumeister, R.F. (2012). What people desire, feel conflicted
17 about, and try to resist in everyday life. *Psychological Science*, *23* (6), 582–588.
18 doi:10.1177/0956797612437426
- 19 Hollands, G.J., Prestwich, A., & Marteau, T.M. (2011). Using aversive images to enhance
20 healthy food choices and implicit attitudes: An experimental test of evaluative condi-
21 tioning. *Health Psychology*, *30* (2), 195–203. doi:10.1037/a0022261
- 22 Inzlicht, M., & Schmeichel, B.J. (2012). What is ego depletion? Toward a mechanistic
23 revision of the resource model of self-control. *Perspectives on Psychological Science*,
24 *7* (5), 450–463. doi:10.1177/1745691612454134
- 25 Inzlicht, M., Schmeichel, B.J., & Macrae, C.N. (2014). Why self-control seems (but may
26 not be) limited. *Trends in Cognitive Sciences*, *18* (3), 127–133. doi:10.1016/
27 j.tics.2013.12.009
- 28 Job, V., Dweck, C.S., & Walton, G.M. (2010). Ego depletion—Is it all in your head?
29 Implicit theories about willpower affect self-regulation. *Psychological Science*, *21*,
30 1686–1693. doi:10.1177/0956797610384745
- 31 Kemps, E., & Tiggemann, M. (2009). Attentional bias for craving-related (chocolate) food
32 cues. *Experimental and Clinical Psychopharmacology*, *17* (6), 425–433. doi:10.1037/
33 a0017796
- 34 Kemps, E., Tiggemann, M., Orr, J., & Grear, J. (2014). Attentional retraining can reduce
35 chocolate consumption. *Journal of Experimental Psychology: Applied*, *20* (1), 94–102.
36 doi:10.1037/xap0000005
- 37 Kroese, F.M., Evers, C., & De Ridder, D.T.D. (2009). How chocolate keeps you slim:
38 The effect of food temptations on weight watching goal importance, intentions, and
39 eating behavior. *Appetite*, *53*, 430–433. doi:10.1016/j.appet.2009.08.002
- 40 Kroese, F.M., Evers, C., & de Ridder, D.T.D. (2011). Tricky treats: Paradoxical effects of
41 temptation strength on self-regulation processes. *European Journal of Social
42 Psychology*, *41*, 281–288. doi:10.1002/ejsp.771
- 43 Lurquin, J.H., Michaelson, L.E., Barker, J.E., Gustavson, D.E., von Bastian, C.C., Car-
ruth, N.P., et al. (2016). No evidence of the ego-depletion effect across task character-
istics and individual differences: A pre-registered study. *PLoS ONE*, *11* (2), e0147770.
doi:10.1371/journal.pone.0147770

- 1 Milyavskaya, M., Inzlicht, M., Hope, N., & Koestner, R. (2015). Saying “no” to tempta-
2 tion: Want-to motivation improves self-regulation by reducing temptation rather than
3 by increasing self-control. *Journal of Personality and Social Psychology*, *109*, 677–
4 693. doi:10.1037/pspp0000045
- 5 Muraven, M., & Baumeister, R.F. (2000). Self-regulation and depletion of limited
6 resources: Does self-control resemble a muscle? *Psychological Bulletin*, *126* (2), 247–
7 254. doi:10.1037/0033-2909.126.2.247
- 8 Nederkoorn, C., Guerrieri, R., Havermans, R.C., Roefs, A., & Jansen, A. (2009). The
9 interactive effect of hunger and impulsivity on food intake and purchase in a virtual
10 supermarket. *International Journal of Obesity*, *33* (8), 905–912. doi:10.1038/
11 ijo.2009.98
- 12 Perugini, M. (2005). Predictive models of implicit and explicit attitudes. *British Journal*
13 *of Social Psychology*, *44* (1), 29–45. doi:10.1348/014466604x23491
- 14 Rogers, P.J., & Hardman, C.A. (2015). Food reward. What it is and how to measure it.
15 *Appetite*, *90*, 1–15. doi:10.1016/j.appet.2015.02.032
- 16 Schmeichel, B.J., Harmon-Jones, C., & Harmon-Jones, E. (2010). Exercising self-control
17 increases approach motivation. *Journal of Personality and Social Psychology*, *99* (1),
18 162–173. doi:10.1016/b978-0-12-801850-7.00006-8
- 19 Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behav-
20 ior. *Personality and Social Psychology Review*, *8* (3), 220–247. doi:10.1207/
21 s15327957pspr0803_1
- 22 Wagner, D.D., Altman, M., Boswell, R.G., Kelley, W.M., & Heatherton, T.F. (2013).
23 Self-regulatory depletion enhances neural responses to rewards and impairs top-down
24 control. *Psychological Science*, *24* (11), 2262–2271. doi:10.1177/0956797613492985
- 25 Walsh, D. (2014a). Attenuating depletion using goal priming. *Journal of Consumer*
26 *Psychology*, *24* (4), 497–505. doi:10.1016/j.jcps.2014.05.001
- 27 Walsh, D. (2014b). Can priming a healthy eating goal cause depleted consumers to prefer
28 healthier snacks? *Journal of Consumer Marketing*, *31* (2), 126–132. doi:10.1108/
29 JCM-09-2013-0697
- 30 Walsh, E.M., & Kiviniemi, M.T. (2014). Changing how I feel about the food: Experimen-
31 tally manipulated affective associations with fruits change fruit choice behaviors.
32 *Journal of Behavioral Medicine*, *37* (2), 322–331. doi:10.1007/s10865-012-9490-5
- 33
34
35
36
37
38
39
40
41
42
43