

Taking control

Citation for published version (APA):

Houben, K., Dassen, F., & Jansen, A. (2016). Taking control: Working memory training in overweight individuals increases self-regulation of food intake. *Appetite*, *105*, 567–574.
<https://doi.org/10.1016/j.appet.2016.06.029>

Document status and date:

Published: 01/10/2016

DOI:

[10.1016/j.appet.2016.06.029](https://doi.org/10.1016/j.appet.2016.06.029)

Document Version:

Accepted author manuscript (Peer reviewed / editorial board version)

Document license:

CC BY-NC-ND

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.umlib.nl/taverne-license

Take down policy

If you believe that this document breaches copyright please contact us at:

repository@maastrichtuniversity.nl

providing details and we will investigate your claim.

1 RUNNING HEAD: WM training in overweight individuals

2

3

4

5 Taking control: Working memory training in overweight individuals increases self-

6 regulation of food intake

7

8 Katrijn Houben, Fania Dassen, & Anita Jansen

9

10 Department of Clinical Psychological Science

11 Faculty of Psychology and Neuroscience; Maastricht University

12

13

14

15

16

17

18

19 Correspondence may be sent to: Katrijn Houben, Department of Clinical Psychological

20 Science, Faculty of Psychology and Neuroscience, Maastricht University, P.O. BOX

21 616, 6200 MD Maastricht, The Netherlands. Email:

22 K.Houben@maastrichtuniversity.nl, Phone: +31433881953

23

24

Abstract

25 Working memory (WM) plays a critical role in cognitive control by shielding self-
26 regulatory goals from distraction by desire-related thoughts and emotions. This study
27 examined whether training WM increases self-regulation in overweight participants.
28 It was hypothesized that WM training would decrease psychopathological eating-
29 related thoughts, (over)consumption of food in response to emotions and external
30 cues, food intake and body weight. Overweight participants (n = 50) performed 20-25
31 sessions of WM training or control/sham training. The dependent measures were self-
32 reported eating-related psychopathology, self-reported emotional/external eating
33 behavior, food intake during a bogus taste test, and body weight, assessed before
34 training, immediately following training, and at one-month follow-up. Relative to
35 control, WM training reduced psychopathological eating-related thoughts and
36 emotional eating (but not external eating). These effects were still present at follow-
37 up, one month later. Food intake and body weight did not show an overall effect of
38 training, though WM training did reduce food intake among highly restrained
39 participants. WM training effectively reduced eating-related thoughts, overeating in
40 response to negative emotions, and food intake among participants with strong
41 dietary restraint goals. Hence, these findings indicate that WM training may
42 strengthen self-regulation by shielding dieting goals from distraction by unwanted
43 eating-related thoughts and emotions.

44

45 Keywords: Obesity; Working Memory; Training

46

47

Introduction

48 In the last three decades, the prevalence of obesity has nearly doubled (Finucane et
49 al., 2011; Flegal, 2005; Wang & Beydoun, 2007), placing more and more individuals at
50 risk of developing cardiovascular diseases, diabetes, musculoskeletal disorders and
51 cancer (World Health Organization, 2009). In 2010, overweight and obesity were
52 estimated to cause 3,4 million deaths worldwide (Lim et al., 2012). Research further
53 shows that, unabated, the increase in obesity will lead to dramatic falls in future life
54 expectancy (Olshansky et al., 2005). A key contributor to the rapid weight gain that
55 occurred over the past 30 years is our obesogenic environment, which encourages
56 over-consumption of widely-available, inexpensive, energy-dense food and
57 discourages expenditure of energy through physical activity (Hill, Wyatt, Reed, &
58 Peters, 2003). The solution to the obesity problem therefore may lie in identifying
59 feasible ways to cope with the current food-rich environment and adhere to the
60 simple principles of the energy balance equation.

61 One strategy to reduce over-consumption could be to strengthen cognitive
62 control of consumption and body weight. Cognitive control (or executive functioning)
63 is an umbrella term that refers to three basic cognitive functions that allow for goal-
64 directed action amid the endless possibilities afforded to us in real-life situations
65 (Miyake et al., 2000): Maintaining and updating relevant information ('updating'),
66 inhibition of prepotent impulses ('inhibition'), and mental set shifting (task-switching).
67 According to contemporary dual-process models, overconsumption of palatable,
68 energy-dense foods is the result of unintentional, fast-acting impulses that are not or
69 insufficiently regulated via top-down cognitive control (Hofmann, Friese, & Strack,
70 2009; Strack & Deutsch, 2004): Individuals with both strong behavioral impulses to

71 consume palatable food and low levels of cognitive control are particularly
72 susceptible to over-consumption (Friese, Hofmann, & Wänke, 2008; Hofmann &
73 Friese, 2008; Hofmann, Friese, & Roefs, 2009; Hofmann, Gschwendner, Friese, Wiers, &
74 Schmitt, 2008; Hofmann, Rauch, & Gawronski, 2007) and weight gain (Nederkoorn,
75 Houben, Hofmann, Roefs, & Jansen, 2010) compared to individuals with effective
76 cognitive control. Hence, individual differences in cognitive control may explain why
77 some people do not succeed in resisting the lure of palatable, energy-dense foods
78 and achieving a healthy weight.

79 It has been argued that working memory (WM) may very well lie at the heart
80 of successful cognitive control (Engle et al., 1999; Kane et al., 2001). WM is closely
81 connected to the construct of 'updating' and refers to the ability to maintain an active
82 mental representation of (self-regulatory) goals, and shield those goals from
83 distraction (Engle, Tuholski, Laughlin, & Conway, 1999; Kane, Bleckley, Conway, &
84 Engle, 2001; Hofmann, Schmeichel, & Baddeley, 2012). Moreover, this ability to focus
85 on goal-relevant information should also relate to people's ability to regulate their
86 own thoughts and emotions (Hofmann et al., 2012). Indeed, increased WM capacity is
87 related to less thought intrusions and mind-wandering (Brewin & Beaton, 2002;
88 Brewin & Smart, 2005; Kane et al., 2007) and better emotion-regulation (Schmeichel
89 & Demaree, 2010; Schmeichel, Volokhov, & Demaree, 2008). Importantly, overweight
90 and obesity have been associated with reduced cognitive control, including WM
91 (Smith, Hay, Campbell, & Trollor, 2011), which begs the question whether training
92 cognitive control, and WM in particular, may translate into better behavioral self-
93 regulation in overweight and obese individuals.

94 Previous studies showed that WM can be improved via adaptive training and
95 that such training is effective in reducing clinical symptoms (for reviews see Klingberg
96 2010; Morrison & Chein, 2011). It is important to note, however, that there has also
97 been criticism on the effectiveness of WM training claiming that there is yet
98 insufficient evidence of its efficacy. Specifically, it has been argued that more
99 scientific evidence is needed to support both near transfer of WM training to
100 untrained WM tasks, and far transfer to WM-related abilities and behavior (e.g.,
101 Shipstead, Redick, & Engle, 2012). In the present study, it was examined whether WM
102 training decreases over-consumption and body weight in a sample of overweight
103 participants. Participants either performed WM training or control tasks (sham
104 training) for 25 days. It was expected that WM training would increase self-regulation
105 and cognitive control as evidenced by (1) reduced pathological eating-related
106 thinking, (2) decreased (over-)consumption of food in response to emotions and
107 external cues, (3) reduced consumption of palatable, energy-dense foods, and (4) a
108 decrease in body weight.

109

110 Materials and Methods

111 Participants

112 Participants were recruited via advertisements in local newspapers about the
113 possibility to participate in research exploring WM training as an intervention for
114 overweight. The advertisements specifically asked for individuals who had overweight
115 and who were motivated to lose weight. Eligibility required that participants were
116 aged 18 to 65, and had a Body Mass Index (BMI) higher than 25 (i.e., A BMI above 25
117 indicates overweight). Of the 67 participants who responded to the advertisements

118 and met the eligibility criteria, 62 participants completed the pretest. Twelve
119 participants dropped out after missing too many training sessions ¹. The remaining 50
120 (37 female) participants completed at least 20 training sessions, the pretest, posttest
121 and follow-up. Of the final sample, 6% received primary education, 66% received
122 secondary education, and 28% received higher education. See also Table 1 for
123 participant characteristics. The study was approved by the Ethical Review Committee
124 Psychology and Neuroscience.

125

126 Materials & Measures

127 Working memory training. The WM training (Houben, Wiers, & Jansen, 2011;
128 Klingberg, Forssberg, & Westerberg, 2002) consisted of three tasks: A visuospatial
129 WM task, a backward digit span task, and a letter span task (presented in this order).
130 During the visuospatial WM task, a sequence of squares in a 4x4 grid changed in color
131 on the computer screen. Participants had to reproduce this sequence by clicking the
132 squares that had changed color in the correct order using the computer mouse.
133 During the backward digit span, a sequence of numbers was presented on the
134 computer screen, which participants had to reproduce in reversed order, using either
135 the computer mouse or the keyboard. In the letter span task, a sequence of letters
136 was presented on the computer screen in a circle. One of the positions in this circle
137 was then indicated and participants had to reproduce the corresponding letter using
138 the keyboard. All three tasks consisted of 30 trials (one block).

139 In the training condition, the difficulty level of all three WM tasks was
140 automatically adjusted on a trial-by-trial basis (cf. Houben et al., 2011; Klingberg et
141 al., 2002): Each task initially started with a sequence of three items. When

142 participants correctly reproduced this sequence two times in a row, one item was
143 added to the sequence on the next trial. When participants could not correctly
144 reproduce the sequence on two consecutive trials, the sequence in the next trial was
145 reduced by one item. In the control condition, the difficulty level of the WM tasks
146 remained on the initial easy level (three items in a sequence; cf. Houben et al., 2011;
147 Klingberg et al., 2002). Before and after training, WM was measured using the same
148 three tasks, but these assessment tasks ended when participants were unable to
149 reproduce a sequence on two consecutive trials. The outcome measure for each WM
150 task was the amount of items in the sequence that could be correctly reproduced.
151 These three scores were averaged to calculate a total WM score.

152

153 Eating Disorder Examination Questionnaire (EDE-Q). The EDE-Q (Fairburn &
154 Beglin, 1994; Fairburn & Cooper, 1993) is a 36-item self-report measure of eating
155 disorder psychopathology. The EDE-Q contains 23 items assessing eating disorder
156 psychopathology over the previous 28 days. These items are answered on a 7-point
157 Likert scale (0 = 'not one day'; 6 = 'every day'). The 23 items together comprise one
158 global score (Cronbach's $\alpha = .90$) as well as four subscales: Restrained eating
159 (Cronbach's $\alpha = .73$), preoccupation with food (Cronbach's $\alpha = .67$), weight concern
160 (Cronbach's $\alpha = .78$) and body shape concern (Cronbach's $\alpha = .88$). Higher scores
161 indicate stronger eating disorder psychopathology.

162

163 Dutch Eating Behaviour Questionnaire (DEBQ). The DEBQ (Van Strien, 2005;
164 Van Strien, Frijters, Bergers, & Defares, 1986) is a 33-item self-report measure of
165 emotional eating (Cronbach's $\alpha = .96$), external eating (Cronbach's $\alpha = .77$) and

166 restrained eating (Cronbach's $\alpha = .90$). All items are scored on a 5-point Likert scale (1
167 = 'Never'; 5 = 'Very often'). Item examples: 'Do you have a desire to eat when you are
168 irritated?' (emotional eating), 'If foods smells and looks good, do you eat more than
169 usual?' (external eating) and 'Do you try to eat less at mealtimes than you would like
170 to eat?' (dietary restraint). Means are calculated for the three subscales with higher
171 scores indicating increased emotional, external or dietary restraint.

172

173 Bogus taste test. Food consumption was measured using a bogus taste test.
174 Participants were presented with four bowls containing different palatable energy-
175 dense foods: salted potato chips (541 kcal/100gr), chocolate cookies (465 kcal/100
176 gr), milk chocolate (530 kcal/100gr), coated peanuts (535 kcal/100gr). Participants
177 were told that we were interested in their taste perception of a number of food
178 products. Participants were instructed that they were allowed to consume as much or
179 as little of the food as they wished while completing food ratings: Participants first
180 indicated how much they experienced hunger and desire to eat the food on a 100mm
181 Visual Analogue Scale (0 = 'no desire/not hungry'; 100 = 'strong desire/very hungry').
182 Next, they compared and rated the different food products on a number of taste
183 dimensions. After 15 minutes, the experimenter removed the bowls of food and the
184 amount of food consumed was measured outside the test room. Total amount of
185 calories was calculated as an index of food intake.

186

187 Dietary restraint. Dietary restraint was measured using the revised Restraint
188 Scale (RS; Herman & Polivy, 1980). The RS is a self-report questionnaire consisting of
189 10 items that measure dieting concern/intentions and weight fluctuations

190 (Cronbach's $\alpha = .70$). Higher scores indicate an increased intention to restrict food
191 intake.

192

193 Body Mass Index. Participants' weight and height were assessed in order to
194 calculate participants' Body Mass Index (kg/m^2 ; BMI).

195

196 Procedure

197 After giving consent, participants performed the bogus taste test and the assessment
198 WM tasks. Next, they filled out the Restraint Scale, EDE-Q and DEBQ, and their weight
199 and height were measured. Participants were then randomly assigned to the training
200 or control condition and were informed that they would perform a WM training
201 consisting of 25 sessions via the Internet (so they did not have to come to the lab for
202 the training sessions; participants were sent invitations for each training session via
203 email together with a personalized link to start the session). Participants were given
204 two days to complete a training session. Each session lasted about 30 minutes in
205 total. If participants did not complete a session in time, that session was marked as
206 missed, and participants moved on to the next session. In total, participants could
207 miss up to 5 training sessions. Hence, the total number of training sessions varied
208 between 20 and 25 ($M = 23.02$, $SD = 1.80$; the training sessions were on average
209 completed within 33.92 days, $SD = 8.23$, range: $25 - 66$)². Upon completing the
210 training, the posttest session was scheduled in the lab (on average 9.52 days, $SD =$
211 6.19 , after the last training session). At posttest, participants again performed the
212 bogus taste test and the WM assessment, they filled out the EDE-Q and DEBQ, and
213 their weight was measured. The follow-up session was scheduled one month after the

214 posttest and included the same measures. Upon completing the experiment,
215 participants received a gift certificate of 50€ as remuneration for their participation.

216

217 Design & statistical analyses

218 Participants were randomly allocated to one of two groups: Active working memory
219 training (n = 24) or control training (n = 26). Randomization checks showed no
220 significant differences between conditions for any potential confounding factors
221 (Table 1). Data were analyzed using mixed-effects ANOVA with condition as between-
222 subjects factor (training versus control) and time as within-subjects factor (pretest,
223 posttest and follow-up)³.

224

225 Results

226 Manipulation Check

227 In the control condition, the difficulty of the training tasks always remained on the
228 easiest level with only three to-be-remembered items in each task. Consequently, the
229 performance of participants in the control condition remained at the same level over
230 the course of the training period (see Figure 1). In the training condition, in contrast,
231 the training was adjusted adaptively to participants' performance. As can be seen in
232 Figure 1, participants in the training condition showed a steady increase in working
233 memory performance during the training period.

234

235 Working memory

236 A mixed ANOVA on WM task performance showed significant main effects of time,
237 $F(2,96) = 67.31, p < .001, \eta^2_p = .58$, and condition, $F(1,48) = 7.19, p = .01, \eta^2_p = .13$, as

238 well as a significant time*condition interaction, $F(2,96) = 17.29, p < .001, \eta^2_p = .27$
239 (see Figure 2). Follow-up analyses per condition showed a significant increase over
240 time in WM performance in both the control condition, $F(2,50) = 17.86, p < .001, \eta^2_p =$
241 $.42$, and the training condition, $F(2,46) = 57.14, p < .001, \eta^2_p = .71$. Contrasts
242 indicated that, in both the training and control condition, the increase in WM
243 performance from pretest to posttest was significant, $F(1,23) = 98.68, p < .001, \eta^2_p =$
244 $.81$, and $F(1,25) = 28.20, p < .001, \eta^2_p = .53$, respectively, with a larger increase in the
245 training condition than in the control condition, $F(1,48) = 6.13, p = .02, \eta^2_p = .11$. In
246 addition, both conditions also improved in WM performance from pretest to follow-
247 up, $F(1,23) = 66.63, p < .001, \eta^2_p = .74$, and $F(1,25) = 6.36, p = .02, \eta^2_p = .20$,
248 respectively. At follow-up, WM performance of the training condition was still
249 significantly higher compared to control, $F(1,48) = 23.38, p < .001, \eta^2_p = .33$.

250

251 Eating Psychopathology

252 For the EDE-Q, separate analyses were performed for the global EDE-Q score, and for
253 the four separate subscales: Eating concern, shape concern, weight concern, and
254 dietary restraint. For eating concern, results showed a significant main effect of time,
255 $F(2,96) = 9.54, p < .001, \eta^2_p = .17$ (but no effect of condition, $F(1,48) = .14, p = .71, \eta^2_p =$
256 $< .01$), and a significant time*condition interaction, $F(2,96) = 3.08, p = .05, \eta^2_p = .06$.
257 Follow-up analyses indicated a significant decrease in eating concern over time in the
258 training condition, $F(2,46) = 7.47, p < .01, \eta^2_p = .25$, but not in the control condition,
259 $F(2,50) = 2.47, p = .10, \eta^2_p = .10$ (see Table 2). Contrasts confirmed a significant
260 decrease in the training condition from pretest to posttest, $F(1,23) = 16.26, p < .01,$

261 $\eta^2_p = .41$, that was still significant at one month follow-up, $F(1,23) = 4.27$, $p = .05$, $\eta^2_p =$
262 $.16$.

263 Similarly, analyses for the shape concern subscale also showed a significant
264 time effect, $F(1.77, 84.88) = 10.59$, $p < .001$, $\eta^2_p = .18$ (but not of condition, $F(1,48) =$
265 $.52$, $p = .48$, $\eta^2_p = .01$) that was qualified by a significant time*condition interaction,
266 $F(1.77, 84.88) = 5.17$, $p = .01$, $\eta^2_p = .10$ (see Table 2)⁴. Follow-up analyses indicated a
267 significant decrease in shape concern following training, $F(2,46) = 12.68$, $p < .001$, η^2_p
268 $= .36$, indicating a significant decrease in shape concern from pretest to posttest,
269 $F(1,23) = 19.81$, $p < .001$, $\eta^2_p = .46$, and to follow-up, $F(1,23) = 12.47$, $p < .01$, $\eta^2_p = .35$.
270 In the control condition, there was no significant change in shape concern over time,
271 $F(2,50) = .65$, $p = .53$, $\eta^2_p = .03$.

272 A similar pattern emerged for the weight concern subscale of the EDE-Q (see
273 Table 2), but here the interaction between time and condition did not reach
274 significance, $F(2,96) = 2.02$, $p = .14$, $\eta^2_p = .04$. There was a significant effect of time,
275 $F(2,96) = 5.56$, $p < .01$, $\eta^2_p = .10$, indicating an overall decrease in weight concern. The
276 main effect of condition was not significant, $F(1,48) = .14$, $p = .71$, $\eta^2_p < .01$. For the
277 dietary restraint subscale of the EDE-Q, no effects reached significance (time: $F(1.65,$
278 $79.26) = 2.10$, $p = .13$, $\eta^2_p = .04$; condition: $F(1,48) = .40$, $p = .53$, $\eta^2_p = .01$;
279 time*condition: $F(1.65, 79.26) = .73$, $p = .48$, $\eta^2_p = .02$)⁴.

280 This pattern of results was also illustrated in the analysis of the total EDE-Q
281 score: In addition to a significant main effect of time, $F(1.71, 82.25) = 14.34$, $p < .001$,
282 $\eta^2_p = .23$ (no significant effect of condition, $F(1,48) = .26$, $p = .61$, $\eta^2_p = .01$), the
283 time*condition interaction was significant, $F(1.71, 82.25) = 3.99$, $p = .02$, $\eta^2_p = .08$
284 (see Table 2)⁴, indicating an overall decrease in EDE-Q scores over time in the training

285 condition, $F(1.50, 34.42) = 16.71, p < .001, \eta^2_p = .42$, that was significant at posttest,
286 $F(1,23) = 23.88, p < .001, \eta^2_p = .51$, as well as at follow-up one month later, $F(1,23) =$
287 $15.53, p < .01, \eta^2_p = .40$. No effect of time emerged in the control condition, $F(2,50) =$
288 $2.13, p = .13, \eta^2_p = .08$.

289

290 Emotional and external eating

291 Separate analyses were performed for the three subscales of the DEBO: emotional
292 eating, external eating and dietary restraint. For emotional eating ⁴, the significant
293 main effect of time, $F(1.73, 83.19) = 3.60, p = .04, \eta^2_p = .07$, was qualified by a
294 significant time*condition interaction, $F(1.73, 83.19) = 3.63, p = .04, \eta^2_p = .07$ (see
295 Table 2). The main effect of condition was not significant, $F(1,48) < .01, p = .97, \eta^2_p <$
296 $.01$. Follow-up analyses per condition showed a significant decrease in emotional
297 eating over time in the training condition, $F(2,46) = 5.87, p < .01, \eta^2_p = .20$, but no
298 effect of time in the control condition, $F(2,50) = .81, p = .45, \eta^2_p = .03$. Contrasts
299 confirmed that in the training condition, emotional eating was significantly reduced at
300 posttest, $F(1,23) = 9.35, p < .01, \eta^2_p = .29$, and at follow-up, $F(1,23) = 7.37, p = .01, \eta^2_p$
301 $= .24$, compared to pretest. For external eating only the main effect of time reached
302 significance, $F(2,96) = 7.86, p < .01, \eta^2_p = .14$, indicating a decrease in external eating
303 across both conditions (condition: $F(1,48) = .01, p = .93, \eta^2_p < .01$; time*condition:
304 $F(2,96) = .27, p = .77, \eta^2_p = .01$). For dietary restraint there were no significant effects
305 (time, $F(1.70, 81.43) = 2.63, p = .09, \eta^2_p = .05$; condition, $F(1,48) = .02, p = .89, \eta^2_p <$
306 $.01$; time*condition, $F(1.70, 81.43) = .66, p = .49, \eta^2_p = .01$)⁴.

307

308

309 Food intake

310 Results showed no differences between the training and control condition with
311 respect to hunger (condition: $F(1, 48) = .04, p = .84, \eta^2_p = .00$; time: $F(2, 96) = 1.42, p =$
312 $.25, \eta^2_p = .03$; condition*time: $F(2, 96) = .74, p = .48, \eta^2_p = .02$) or craving (condition:
313 $F(1, 48) = .01, p = .91, \eta^2_p = .00$; time: $F(2, 96) = 61, p = .54, \eta^2_p = .01$; condition*time:
314 $F(2, 96) = 1.06, p = .35, \eta^2_p = .02$). Food intake during the bogus taste test showed no
315 significant time*condition interaction, $F(1.62, 77.52) = .38, p = .64, \eta^2_p = .01$, nor
316 significant main effects (time, $F(1.62, 77.52) = 2.04, p = .15, \eta^2_p = .04$; condition,
317 $F(1,48) = .13, p = .72, \eta^2_p < .01$)⁴.

318 It is important to note here that research in other areas of cognitive control
319 training (i.e., inhibitory control training) indicates a moderating role of dietary
320 restraint on training effects with larger effects on food intake in participants with high
321 levels of dietary restraint (e.g., Houben & Jansen, 2011; see also Jones et al., 2016).
322 Theoretically, stronger cognitive control should result in greater concordance
323 between one's current goals and behavior (Hofmann et al., 2009). Hence, it is unlikely
324 that increasing cognitive control will lead to behavior change when there is no
325 concurrent dieting goal present. Similarly, WM is critical for sustained attention to
326 one's goals (Engle et al., 1999; Kane et al., 2001; Hofmann et al., 2012). Training WM
327 should therefore translate into lower food intake especially for participants with
328 strong dieting goals but not for participants without active dieting goals.

329 We therefore also a post-hoc analysis to examine the effect of baseline dietary
330 restraint (measured with the RS), condition and their interaction on food intake at
331 pretest, posttest and at follow-up. Restraint scores were z-standardized and entered
332 as a continuous predictor in the ANOVA (Aiken & West, 1991). One influential outlier

333 (Cook's > 1.5) was excluded from the analyses. For food intake at pretest, none of the
334 effects reached significance (restraint: $F(1,45) = .48, p = .49, \eta^2_p = .01$; condition:
335 $F(1,45) = 2.58, p = .12, \eta^2_p = .05$; condition*restraint: $F(1,45) = .23, p = .63, \eta^2_p = .01$).
336 At posttest, the expected interaction between dietary restraint and condition was
337 significant, $F(1,45) = 3.91, p = .05, \eta^2_p = .08$. The main effects of restraint and
338 condition did not reach statistical significance (restraint: $F(1,45) = .04, p = .83, \eta^2_p <$
339 $.01$; condition: $F(1,45) = .28, p = .60, \eta^2_p = .01$). We analyzed the effect of training
340 separately for participants scoring high and low on the RS (respectively 1 SD above
341 and 1 SD below the mean score; Cohen, Cohen, West, & Aiken, 2003). For participants
342 with lower dietary restraint (-1 SD), there was no significant difference between
343 training and control with respect to food intake, $F(1,45) = 1.26, p = .27, \eta^2_p = .03$, but
344 among high restrained participants (+1 SD), food intake was reduced in the training
345 condition compared to control, $F(1,45) = 3.49, p = .07, \eta^2_p = .07$ (see Figure 3).
346 Consumption at follow-up showed a similar pattern of results, though the interaction
347 between dietary restraint and condition was not significant, $F(1,45) = 2.11, p = .15, \eta^2_p$
348 $= .05$ (restraint: $F(1,45) = .43, p = .52, \eta^2_p = .01$; condition: $F(1,45) = .61, p = .44, \eta^2_p =$
349 $.01$).

350

351 BMI

352 None of the effects of time or condition were significant for BMI (time: $F(1.50, 71.87)$
353 $= 1.00, p = .35, \eta^2_p = .02$; condition: $F(1,48) = .11, p = .74, \eta^2_p < .01$; time*condition:
354 $F(1.50, 71.87) = .09, p = .86, \eta^2_p < .01$)⁴, indicating no significant change in body
355 weight over time.

356

Discussion

357

358 Given the prominent role of cognitive control in self-regulatory behavior like food
359 intake, the aim of the present study was to examine whether boosting WM via
360 training would lead to better self-regulation in overweight individuals. As expected,
361 participants who received WM training, relative to participants in the control
362 condition, reported overall less eating-related concerns (especially less concern about
363 eating and shape), and less emotional eating (but not external eating), immediately
364 following training and at one-month follow-up. Food intake and body weight did not
365 show an overall effect of training. Results, however, did show the expected effect of
366 WM training on food intake in highly restrained participants, indicating that WM
367 training increased correspondence between dietary goals and food intake.

368 WM supports self-regulation by enabling individuals to resist the attentional
369 capture of tempting stimuli at early stages of information processing, thereby
370 shielding self-regulatory goals from competing goals and distraction (Kane et al.,
371 2001; Hofmann et al., 2012). As such, WM relates to the ability to regulate one's own
372 thoughts and emotions, by focusing attention on goal-relevant information and
373 ignoring irrelevant, distracting information (Hofmann et al., 2012). In line with this
374 idea, WM training reduced pathological ruminative thoughts about food, weight, and
375 body shape. This finding fits with previous research showing an association between
376 preoccupying cognitions and WM impairment in dieters: Preoccupying thoughts
377 about food, weight and body shape seem to consume WM resources with
378 detrimental effects on WM performance (Green, Elliman, & Rogers, 1997; Kemps &
379 Tiggemann, 2005; Kemps, Tiggemann, & Marshall, 2005; Vreugdenburg, Bryan, &
380 Kemps, 2003). The present results add to these findings by demonstrating that WM

381 training alleviates distraction by preoccupying cognitions related to dieting, weight,
382 food, and body shape.

383 Further, WM training decreased self-reported emotional eating indicating that
384 participants who received WM training were better able to regulate their emotions in
385 other ways than by (over)eating compared to participants in the control condition.
386 This finding is consistent with previous studies showing that individuals with higher
387 WM capacity, as opposed to individuals with lower levels of WM, are better able to
388 regulate emotions and appraise emotional stimuli in an unemotional manner
389 (Schmeichel & Demaree, 2010; Schmeichel, Volokhov, & Demaree, 2008). It was also
390 expected that WM training would increase the resilience to temptation by food cues.
391 Unexpectedly, self-reported external eating was reduced over time in both
392 conditions. Previous research, however, has indicated that the external eating
393 subscale of the DEB-Q (but not the emotional eating subscale or the dietary restraint
394 subscale) is affected by visceral states and may thus be a state rather than a trait
395 measure (Evers et al., 2011). It is possible that such fluctuations in visceral states over
396 time have caused this slight, albeit significant, decrease in external eating across
397 conditions.

398 These findings thus indicate that WM training might help overweight and
399 obese individuals to create a more healthy style of thinking about their body and
400 eating behavior. Nevertheless, the present findings did not show the expected effects
401 of WM training on body weight, and effects on food intake were only found among
402 highly restrained eaters. Specifically, highly restrained eaters who received WM
403 training showed a reduction in food intake relative to participants in the control
404 condition. Perhaps this finding is not surprising given that high WM capacity increases

405 the correspondence between dieting goals and eating behavior (Hofmann et al.,
406 2007). Without (dieting) motivation, it is unlikely that cognitive control training will
407 lead to behavioral change. Thus, the strongest effects on food intake are to be
408 expected for participants who hold strong dietary restraint standards. It is interesting
409 to note that training studies which have targeted a different cognitive control ability,
410 namely response inhibition, have also shown stronger effects of inhibition training on
411 food intake among highly restrained eaters (Houben & Jansen, 2011; Veling, Aarts, &
412 Papiés, 2011; see also Jones et al., 2016), indicating that cognitive control training
413 may indeed be more effective for participants with high levels of dietary restraint.

414 While WM training did not influence body weight in the present study, it
415 should be noted that inhibition training has been shown to reduce both food intake
416 (e.g., Houben & Jansen, 2011; 2015; Veling et al., 2011; Lawrence, Verbruggen,
417 Morrison, Adams, & Chambers, 2015; Veling, Aarts, & Stroebe, 2013) and body weight
418 (e.g., Lawrence et al., 2015; Veling, van Koningsbruggen, Aarts, & Stroebe, 2014). As
419 such, inhibition training effects appear to be stronger and more robust compared to
420 effects of WM training. Perhaps this is due to differences in terms of the behavioral-
421 specificity of the training. Inhibition training has been shown to be effective only
422 when the training is focused on strengthening inhibition over food-related responses,
423 but not when general response inhibition is targeted during training (Allom, Mullan, &
424 Hagger, 2016). It might therefore be interesting for future research to contrast the
425 present findings for general WM training with more applied, diet-relevant WM
426 training.

427 A limitation to the present findings is that we did not measure dieting
428 motivations, and as explained above, it is unlikely that WM training will translate into

429 weight loss when participants are unmotivated to lose weight. Future research should
430 therefore screen participants for dieting motivations and test whether WM training
431 might be more effective among overweight participants who are committed to losing
432 weight. A second limitation is that we did not measure beliefs regarding the training
433 in the two conditions. While both conditions received the same instructions, we
434 cannot rule out that participants in the control condition may have become suspicious
435 and did not believe that they were receiving WM training. It is therefore important to
436 include measures of expectancies and beliefs regarding the training and the purpose
437 of the study in future studies to rule out demand artefacts. Another limitation to this
438 study concerns the fact that we did not measure transfer effects of the WM training
439 to other non-trained tasks of executive functions (WM, task-switching, inhibition).
440 Earlier research has shown transfer effects to non-trained tasks (see Klingberg, 2010
441 for a review), though the generalization to non-trained tasks has also raised
442 considerable debate (e.g., Shipstead et al., 2012). Further, it is possible that WM
443 training in isolation is not effective as a weight loss intervention and will only be
444 effective in reducing weight in combination with additional (lifestyle) interventions. In
445 this way, overweight individuals who are highly motivated to diet and who are
446 provided with dieting strategies might profit the most from WM training that boosts
447 self-regulatory abilities. Future research should thus further examine the
448 effectiveness of WM training on weight in combination with other weight loss
449 interventions.

450 In conclusion, WM training successfully reduced emotional eating and
451 psychopathological eating-related concerns in a sample of overweight participants.
452 Moreover, WM training also reduced food intake, but only among highly restrained

453 eaters, underscoring the need to further examine the effectiveness of WM training in
454 target groups of overweight individuals who are highly motivated to lose weight.
455

456

Footnotes

- 457 1. Of the 12 participants who dropped out, 9 participants were in the training
458 condition and 3 participants were in the control condition. The participants who
459 dropped out did not differ from the participants who finished the study in terms
460 of age, or scores on WM, DEBQ, EDE-Q and RS (all $F < 1$). Participants who
461 dropped out, however, did have a lower BMI ($M = 28.84$, $SD = 2.58$, $F(1, 60) =$
462 5.72 , $p = .02$, compared to the rest of the sample ($M = 31.56$, $SD = 3.72$).
- 463 2. Note that the range normally should have been 25 - 50 days because participants
464 were only allowed to do one session per day and had to complete a session every
465 two days. However, two participants were given some extension to these rules
466 due to personal issues.
- 467 3. We also performed an Intention To Treat (ITT) analysis on all dependent variables
468 using the "last observation carried forward method" method. In the ITT analyses,
469 all participants were included, rather than including only the participants who
470 completed the study as in the Per Protocol analyses. Including all participants in
471 the ITT analyses did not change any of the effects compared to the Per Protocol
472 analyses.
- 473 4. Due to violation of the sphericity assumption, degrees of freedom were
474 Greenhouse-Geisser adjusted.
- 475

476

Acknowledgements

477 This study was funded by Maastricht University. The authors declare that they have
478 no conflicts of interest.

479

480

References

- 481 Allom, V., Mullan, B., & Hagger, M. (2016). Does inhibitory control training improve
482 health behaviour? A meta-analysis. *Health Psychology Review*, 10, 168-186.
- 483 Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting*
484 *interactions*. Newbury Park: Sage.
- 485 Borella, E., Carretti, B., Riboldi, F., & De Beni, R. (2010). Working memory training in
486 older adults: evidence of transfer and maintenance effects. *Psychology and Aging*
487 25, 767-778.
- 488 Brewin, C. R., & Beaton, A. (2002). Thought suppression, intelligence, and working
489 memory capacity. *Behaviour Research and Therapy*, 40, 923-930.
- 490 Brewin, C. R., & Smart, L. (2005). Working memory capacity and suppression of
491 intrusive thoughts. *Journal of Behavior Therapy and Experimental Psychiatry*, 36,
492 61-68.
- 493 Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple*
494 *regression/correlation analysis for the behavioral sciences*. New Jersey: Lawrence
495 Erlbaum Associates.
- 496 Engle, R. W., Tuholski, S. W., Laughlin, J.E., & Conway, A. R. A. (1999). Working
497 memory capacity, short-term memory, and general fluid intelligence: A latent-
498 variable approach. *Journal of Experimental Psychology: General*, 128, 309-331.
- 499 Evers, C., Stok, F. M., Danner, U. N., Salmon, S. J., de Ridder, D. T. D., & Adriaanse, M.
500 A. (2011). The shaping role of hunger on self-reported external eating status.
501 *Appetite*, 57, 318-320.
- 502 Fairburn, C. G., & Beglin, S. J. (1994). The assessment of eating disorders: interview or
503 self-report questionnaire? *International Journal of Eating Disorders*, 16, 363-370.

504 Fairburn, C. G., & Cooper, Z. (1993). The Eating Disorder Examination (twelfth
505 edition). In C. G. Fairburn, & G. T. Wilson (Eds), *Binge Eating: Nature, Assessment*
506 *and Treatment* (pp. 317- 360). New York: Guilford Press.

507 Finucane, M. M., Stevens, G. A., Cowan, M. J., Danaei, G., Lin, J. K., Paciorek, C. J., ...
508 Ezzati, M. (2011). National, regional, and global trends in body-mass index since
509 1980: systematic analysis of health examination surveys and epidemiological
510 studies with 960 country-years and 9. 1 million participants. *Lancet*, 377, 557-
511 567.

512 Flegal, K. M. (2005). Epidemiologic aspects of overweight and obesity in the United
513 States. *Physiology & Behavior*, 86, 599-602.

514 Friese, M., Hofmann, W., & Wänke, M. (2008). When impulses take over. Moderated
515 predictive validity of explicit and implicit attitude measures in predicting food
516 choice and consumption behaviour. *British Journal of Social Psychology*, 47, 397-
517 419.

518 Green, M. W., Elliman, N. A., & Rogers, P. J. (1997). Impaired cognitive processing in
519 dieters: Failure of attention focus or resource capacity limitation ? *British Journal*
520 *of Health Psychology*, 2, 259-267.

521 Herman, C. P., & Polivy, J. P. (1980). Restrained eating. In A. J. Stunkard (Ed.), *Obesity*
522 (pp. 208-225). Philadelphia: Saunders.

523 Hill, J. O., Wyatt, H. R., Reed, G. W., & Peters, J. C. (2003). Obesity and the
524 environment: where do we go from here? *Science*, 299, 853-855.

525 Hofmann, W., Friese, M., & Roefs, A. (2009). Three ways to resist temptation. The
526 independent contributions of executive attention, inhibitory control and affect

527 regulation to the impulse control of eating behavior. *Journal of Experimental*
528 *Social Psychology*, 45, 431-435.

529 Hofmann, W., Friese, M., & Strack, F. (2009). Impulse and self-control from a dual-
530 systems perspective. *Perspectives on Psychological Science*, 4, 162-176.

531 Hofmann, W., & Friese, M. (2008). Impulses got the better of me. Alcohol moderates
532 the influence of implicit attitudes toward food cues on eating behavior. *Journal of*
533 *Abnormal Psychology*, 117, 420-427.

534 Hofmann, W., Gschwendner, T., Friese, M., Wiers, R. W., & Schmitt, M. (2008). Working
535 memory capacity and self-regulatory behavior: toward an individual differences
536 perspective on behavior determination by automatic versus controlled processes.
537 *Journal of Personality and Social Psychology*, 95, 962-977.

538 Hofmann, W., Rauch, W., & Gawronski, B. (2007). And deplete us not into temptation.
539 Automatic attitudes, dietary restraint, and self-regulatory resources as
540 determinants of eating behavior. *Journal of Experimental Social Psychology*, 43,
541 497-504.

542 Hofmann, W., Schmeichel, B. J., & Baddeley, A.D. (2012). Executive functions and self-
543 regulation. *Trends in Cognitive Sciences*, 16, 174-180.

544 Houben, K., & Jansen, A. (2015). Chocolate equals stop: Chocolate-specific inhibition
545 training reduces chocolate intake and go associations with chocolate. *Appetite*,
546 87, 318-323.

547 Houben, K., & Jansen, A. (2011). Training inhibitory control: A recipe for resisting
548 sweet temptations. *Appetite*, 56, 345-349.

549 Houben, K., Wiers, R. W., & Jansen, A. (2011). Getting a grip on drinking behavior:
550 Training working memory to reduce alcohol abuse. *Psychological Science*, 22,
551 968- 975.

552 Jones, A., Di Lemma, L. C. G., Robinson, E., Christiansen, P., Nolan, S., Tudur-Smith, C.,
553 & Field, M. (2016). Inhibitory control training for appetitive behaviour change: A
554 meta-analytic investigation of mechanisms of action and moderators of
555 effectiveness. *Appetite*, 97, 16-28.

556 Kane, M. J., Bleckley, M. K., Conway, A. R. A., & Engle, R. W. (2001). A controlled-
557 attention view of working-memory capacity. *Journal of Experimental Psychology:*
558 *General*, 130, 169-183.

559 Kane, M. J., Brown, L. H., McVay, J. C., Silvia, P. J., Myin-Germeys, J., & Kwapil, T. R.
560 (2007). For whom the mind wanders, and when: An experience-sampling study of
561 working memory and executive control in daily life. *Psychological Science*, 18,
562 614-621.

563 Kemps, E., Tiggemann, M., & Marshall, K. (2005). Relationship between dieting to lose
564 weight and the functioning of the central executive. *Appetite*, 45, 287-294.

565 Kemps, E., & Tiggemann, M. (2005). Working memory performance and
566 preoccupying thoughts in female dieters: Evidence for a central executive
567 impairment. *British Journal of Clinical Psychology*, 44, 357-366.

568 Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in
569 children with ADHD. *Journal of Clinical Experimental Neuropsychology*, 24, 781-
570 791.

571 Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive*
572 *Sciences*, 14, 317-324.

573 Lawrence, N. S., O'Sullivan, J., Parslowa, D., Javaid, M., Adams, R. C., Chambers, C. D.,
574 Kos, K. & Verbruggen, F. (2015). Training response inhibition to food is associated
575 with weight loss and reduced energy intake. *Appetite*, 95, 17-28.

576 Lawrence, N. S., Verbruggen, F., Morrison, S., Adams, R. C., & Chambers, C. D. (2015).
577 Stopping to food can reduce intake. Effects of stimulus-specificity and individual
578 differences in dietary restraint. *Appetite*, 85, 91-103.

579 Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., ... Ezzati,
580 M. (2012). A comparative risk assessment of burden of disease and injury
581 attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a
582 systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, 380,
583 2224-2260.

584 Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager T.
585 (2000). The unity and diversity of executive functions and their contributions to
586 complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, 41,
587 49-100.

588 Morrison, A. B., & Chein, J. M. (2011). Does working memory training work? The
589 promise and challenges of enhancing cognition by training working memory.
590 *Psychonomic Bulletin & Review*, 18, 46-60.

591 Nederkoorn, C., Houben, K., Hofmann, W., Roefs, A., & Jansen, A. (2010). Control
592 yourself or just eat what you like?. Weight gain over a year is predicted by an
593 interactive effect of response inhibition and a preference for high fat foods.
594 *Health Psychology*, 29, 389-393.

595 Olshansky, S. J., Passaro, D. J., Hershow, R. C., Layden, J., Carnes, B. A., Brody, J., ...
596 Ludwig, D. S. (2005). A potential decline in life expectancy in the United States in
597 the 21st century. *The New England Journal of Medicine*, 352, 1138-1145.

598 Schmeichel, B. J., & Demaree, H. A. (2010). Working Memory Capacity and
599 Spontaneous Emotion Regulation: High Capacity Predicts Self-Enhancement in
600 Response to Negative Feedback. *Emotion*, 10, 739-744.

601 Schmeichel, B. J., Volokhov, R. N., & Demaree, H. A. (2008). Working memory capacity
602 and the self-regulation of emotional expression and experience. *Journal of*
603 *Personality and Social Psychology*, 95, 1526-1540.

604 Shipstead, Z., Redick, T. S., & Engle, R. W. (2012). Is working memory training
605 effective? *Psychological Bulletin*, 138, 628-654.

606 Smith, E., Hay, P., Campbell, L., & Trollor, J. N. (2011). A review of the association
607 between obesity and cognitive function across the lifespan: implications for novel
608 approaches to prevention and treatment. *Obesity Reviews*, 12, 740-755.

609 Strack, F., & Deutsch, R. (2008). Reflective and impulsive determinants of social
610 behavior. *Personality and Social Psychology Review*, 8, 220-247.

611 Van Strien, T. (2005). *Nederlandse vragenlijst voor eetgedrag [Dutch Eating Behaviour*
612 *Questionnaire, manual]*. Amsterdam: Boom Test Publishers

613 Van Strien, T., Frijters, J. E., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating
614 Behaviour Questionnaire (DEBQ) for assessment of restrained, emotional and
615 external eating behaviour. *International Journal of Eating Disorders*, 5, 295-315.

616 Veling, H., Aarts, H., & Papies, E. K. (2011). Using stop signals to inhibit chronic
617 dieters' responses toward palatable foods. *Behaviour Research and Therapy*, 49,
618 771-780.

619 Veling, H., Aarts, H., & Stroebe, W. (2013). Using stop signals to reduce impulsive
620 choices for palatable unhealthy foods. *British Journal of Health Psychology*, 18,
621 354-368.

622 Veling, H., van Koningsbruggen, G. M., Aarts, H., & Stroebe, W. (2014). Targeting
623 impulsive processes of eating behavior via the internet. Effects on body weight.
624 *Appetite*, 78, 102-109.

625 Vreugdenburg, L., Bryan, J., & Kemps, E. (2003). The effect of self-initiated weight-loss
626 dieting on working memory: The role of preoccupying cognitions. *Appetite*, 41,
627 291-300.

628 Wang, Y., & Beydoun, M. A. (2007). The obesity epidemic in the United States—
629 gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a
630 systematic review and meta-regression analysis. *Epidemiologic Reviews*, 29, 6-28.

631 World Health Organization (WHO) (2009). *Global health risks: mortality and burden of*
632 *disease attributable to selected major risks*. Geneva, Switzerland: World Health
633 Organization.

634

Table 1 Participant characteristics per training condition. Means and standard deviations for baseline characteristics are provided per condition

	Training (N = 24)	Control (N = 26)	Range	F/ χ^2	p
Age	36.08 (11.28)	37.62 (10.65)	18 - 62	.24	.62
Baseline BMI (kg/m ²)	31.76 (3.79)	31.38 (3.72)	26.50 - 41.58	.13	.72
Gender (% female)	79.2%	69.2%	-	.64	.42
Dietary restraint (RS)	17.50 (3.71)	16.69 (5.19)	3 - 27	.40	.53
Working Memory (WM) - baseline	6.15 (1.54)	6.06 (1.32)	3.00 - 9.67	.05	.83

Table 2 Means and standard deviations for the dependent measures at pretest, posttest and one-month follow-up, per condition

	Training (N = 24)			Control (N = 26)		
	Pretest	Posttest	Follow-up	Pretest	Posttest	Follow-up
DEBQ emotional eating	2.90 (.86)	2.66 (.86)*	2.63 (.98)*	2.73 (1.04)	2.80 (1.01)	2.70 (1.18)
DEBQ external eating	3.07 (.54)	2.97 (.51)	2.87 (.59)	3.10 (.63)	2.94 (.51)	2.91 (.64)
DEBQ dietary restraint	3.08 (.82)	3.07 (.66)	2.93 (.63)	3.08 (.78)	2.96 (.75)	2.95 (.89)
EDE-Q eating concern	1.10 (.89)	.57 (.56)*	.74 (.75)*	.96 (.82)	.84 (.78)	.79 (.65)
EDE-Q shape concern	3.04 (1.52)	2.14 (1.28)*	2.23 (1.39)*	2.31 (1.33)	2.18 (1.30)	2.14 (1.44)
EDE-Q weight concern	2.65 (1.37)	2.10 (1.26)	2.02 (1.38)	2.22 (1.42)	2.07 (1.31)	2.08 (1.42)
EDE-Q dietary restraint	2.00 (1.41)	1.70 (.98)	1.80 (1.17)	1.84 (1.05)	1.71 (1.03)	1.45 (1.09)
EDE-Q global	2.19 (1.01)	1.63 (.78)*	1.70 (.89)*	1.83 (.98)	1.70 (.88)	1.61 (.97)
Food intake (kcal)	243.72 (203.60)	309.67 (289.46)	296.83 (233.39)	266.83 (138.19)	299.37 (174.61)	345.40 (348.40)
BMI (kg/m ²)	31.76 (3.79)	31.62 (3.76)	31.63 (3.84)	31.38 (3.72)	31.31 (3.94)	31.25 (3.96)

Note. * = Significantly different from pretest at $p < .05$.

Figure 1 The number of items that could be correctly recalled in a WM sequence at the end of each training/control session, averaged across the three training tasks (working memory span), separately for the training condition and the control condition.

Figure 2 Means and standard errors for WM performance at pretest, posttest and one-month follow-up, per condition.

Note: * indicates significant differences at $p < .05$

Figure 3 Estimated marginal means (with standard errors) for caloric intake at pretest, posttest and one-month follow-up, per condition. Means are shown separately for low restrained versus highly restrained eaters (respectively 1 SD below or above the mean restraint score).

Note: * indicates significant differences at $p < .05$