

### Highlights (van Strien et al.):

- Mediation analyses addressed relations between eating, palatability and mood
- In non-obese women, eating tasty snacks improved mood after sadness induction
- Mood improvement after eating was mediated by eating satisfaction
- For eating after stress, tastiness mediated comfort only for high emotional eaters
- This clarifies that eating palatable food is comforting for emotional eaters

1 **Is comfort food actually comforting for emotional eaters? A (moderated) mediation**  
2 **analysis**

3

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## 22 Abstract

23 An important but unreplicated earlier finding on comfort eating was that the association  
24 between food intake and *immediate* mood improvement appeared to be mediated by the  
25 palatability of the food, and that this effect was more pronounced for high than for low  
26 emotional eaters (Macht and Mueller, 2007a). This has not yet been formally tested using  
27 mediation and moderated mediation analysis. We conducted these analyses using data from  
28 two experiments on non-obese female students ( $n=29$  and  $n=74$ ). Mood and eating  
29 satisfaction in Study 1, and mood, tastiness and emotional eating in Study 2 were all self-  
30 reported. In Study 1, using a sad mood induction procedure, emotional eaters ate more food,  
31 and when mood was assessed immediately after food intake, ‘eating satisfaction’ acted as  
32 mediator between food intake and mood improvement (decrease in sadness or increase in  
33 happiness). In Study 2, where we measured the difference in actual food intake after a control  
34 or a stress task (modified Trier Social Stress Test), and assessed mood *during* the food intake  
35 after stress, we found significant moderated mediation. As expected, there was a significant  
36 positive mediation effect of tastiness between food intake and mood improvement in the high  
37 emotional eaters, but also a significant negative mediation effect of tastiness between food  
38 intake and mood improvement in the low emotional eaters. This suggests that tastiness  
39 promotes ‘comfort’ from food in female emotional eaters, but conflicts in non-emotional  
40 eaters with a tendency to eat less when stressed. In conclusion, palatable food may indeed  
41 provide comfort specifically for high emotional eaters during eating.

43 Keywords: Food, mood, emotional eating; tastiness; eating satisfaction.

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121 47 1. Background  
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123 48 The typical adaptive response to negative mood or distress is loss of appetite (Gold &  
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125 49 Chrousos, 2002), because distress is normally associated with physiological responses that  
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127 50 mimic physiological correlates of satiety, e.g. inhibition of gastric motility and release of  
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129 51 glucose into the bloodstream. However, so called emotional eaters show the atypical response  
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131 52 to distress of eating energy-dense food, and thus additional calories (Oliver, Wardle &  
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133 53 Gibson, 2000; Van Strien, Herman, Anschutz, Engels & de Weerth, 2012; van Strien &  
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135 54 Ouwens, 2003; Wallis & Hetherington, 2004), which may result in weight gain and,  
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137 55 ultimately, obesity (Gibson, 2012; Koenders & van Strien, 2011). According to  
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139 56 psychosomatic theory as advocated by Bruch (1973), this atypical stress response of  
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141 57 emotional eating is learned in early childhood when the child is fed in response to emotional  
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143 58 rather than to hunger cues. The child then gradually “learns” to eat in response to negative  
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145 59 emotions as an anxiety reducing mechanism (Slochower & Kaplan, 1980). Though emotional  
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147 60 eating is perceived to be an emotion regulation strategy (Macht & Simons, 2000), there is as  
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149 61 yet no conclusive experimental evidence that emotional eating indeed helps to reduce  
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151 62 negative emotions, so-called “affect reduction”, with any efficacy (Macht & Mueller, 2007a).  
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155 63 Ecological momentary assessment (EMA) research on the affect regulation model of  
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157 64 binge eating, a type of overeating that, similar to emotional eating, is preceded by negative  
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159 65 emotions, showed contradictory findings depending on differences in statistical approaches  
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161 66 (Berg et al., 2017). When studying the trajectory of the mood before and after an eating binge  
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163 67 over time, mood tended to improve over time after a binge (e.g., Berg et al., 2015). When  
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165 68 assessing the difference in negative affect right before and right after an eating binge, mood  
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167 69 showed a deterioration right after the eating binge (e.g., Hilbert & Tuschen-Caffier, 2007;  
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169 70 Stein et al., 2007; Wegner et al., 2002). An advantage of EMA, where the variables of interest  
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171 71 are assessed in the natural environment and in real time by using computerized assessments, is  
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180 72 the ecological validity of the data. However, as pointed out by Haedt-Matt & Keel (2011), a  
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182 73 key problem of EMA, apart from its possible reactivity (Stone & Shiffman, 1994), is that it  
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184 74 does not permit causal conclusions, for example that the mood improvement in the study by  
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186 75 Berg et al., (2015) was *caused* by the eating binge, as it could also, simply, be explained by  
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188 76 the passage of time.

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191 77 Furthermore, experiments in (predominantly) women with obesity, binge eating  
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193 78 disorder or loss of control over eating showed mixed evidence in regard to the mood  
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195 79 improving effects of food intake after negative emotions (e.g., Agras & Telch, 1998;  
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197 80 Ranzenhofer et al., 2013). In the study by Agras and Telch (1978) on women with binge  
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199 81 eating disorder, negative mood after a mood induction (negative vivid imagery) was  
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201 82 significantly reduced after food intake, but the study design did not permit disentangling  
202  
203 83 whether this reduction in distress was due to the intake of food or, simply, the passage of  
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205 84 time. In their study on adolescent girls with loss of control over eating, Ranzenhofer et al.  
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207 85 (2013) similarly found that the (non-manipulated) negative mood was significantly reduced  
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209 86 from pre- to post-meal, but here there was no significant association between the decrease in  
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211 87 negative mood and the amount of food eaten. Using EMA, a similar observation was made by  
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213 88 Goldschmidt et al. (2012) in their subgroup of persons who combined obesity with binge  
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215 89 eating disorder: the post-meal reduction in negative affect was found to be unrelated to the  
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217 90 amount of food consumed. Only in the subgroup of individuals with obesity but without binge  
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219 91 eating disorder was there a significant association between the post-meal reduction in  
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221 92 negative affect and the amount of food eaten (Goldschmidt et al., 2012).

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225 93 In addition to the palatability of the food offered (Macht & Mueller, 2007a), the timing  
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227 94 of the measurement of negative affect may also play a role (Daever et al., 2003). In the study  
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229 95 by Daever et al. (2003), one of the few EMA studies where participants (women with binge  
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231 96 eating) rated their mood *throughout the course* of a binge meal, there was only an  
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239 97 improvement in mood during, but not following the binge meal. In the same line, Macht and  
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241 98 Mueller (2007a) found in experiments on men and women that eating chocolate reduced  
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243 99 negative mood (induced by a sad film clip), but that this effect only had a short duration and  
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245 100 was no longer present after three minutes. A further interesting finding in that same study was  
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247 101 that eating palatable chocolate (milk chocolate) improved the negative mood more than eating  
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249 102 the unpalatable chocolate (dark chocolate) or no food, and that the palatable chocolate-  
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251 103 induced mood improvement was associated with emotional eating. The mood elevation  
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253 104 immediately after eating the palatable chocolate was more pronounced in the high than in the  
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255 105 low emotional eaters (as determined by a median split of the emotional eating scale of the  
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257 106 DEBQ (Dutch Eating Behaviour Questionnaire; van Strien, Frijters, Bergers & Defares,  
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259 107 1986): “This difference disappeared 2 min after eating . . . , but was manifest again 3 min after  
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261 108 eating” (Macht & Mueller, 2007a, p. 672).

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263 109         The findings by Macht and Mueller (2007a) were taken as the starting point for the  
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265 110 present two studies. The importance of the palatability of the test food for mood improvement  
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267 111 in the study by Macht and Mueller (2007a) suggests that the palatability of the test food may  
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269 112 act as a mediator between food intake and mood improvement. This is supported by the  
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271 113 finding that experimentally induced stress elicited greater intake specifically of sweet fatty  
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273 114 foods, which were the most liked, from a buffet lunch in emotional eaters, not of lunch intake  
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275 115 overall (Oliver et al., 2000). However, palatability is not a fixed facet, and the degree to which  
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277 116 a particular food is perceived as tasty or pleasant may differ across individuals (Wagner,  
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279 117 Ahlstrom, Redden, Vickers & Mann, 2014), and can be context-dependent (Booth, 1990),  
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281 118 with, for example, restrained eaters rating the plain chocolate (70% and 85% cocoa) as more  
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283 119 pleasant (Macht & Mueller, 2007b), and men preferring savoury over sweet foods (Wansink,  
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285 120 Cheney & Chan, 2003). Therefore, it is perhaps the *experienced* palatability, pleasantness or  
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287 121 taste of the food offered that acts as a mediator between the food intake and mood  
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298 122 improvement. Further, the moderator effect of emotional eating in the studies by Macht and  
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300 123 Mueller (2007a) and of Oliver et al. (2000) suggest that this mediation effect may be  
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302 124 contingent on emotional eating status, with stronger mediation effects of experienced good  
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305 125 taste or palatability likely for high than for low emotional eaters.  
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307 126 We tested these possible mediation and moderated mediation effects by re-analyzing  
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309 127 data from two earlier studies on food intake after a mood induction in high versus low  
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311 128 emotional eaters where we found a significant improvement of mood during or after the food  
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313 129 intake after a negative mood induction (Van Strien, Herman, Anschutz, Engels & de Weerth,  
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315 130 2012; Van Strien et al., 2013). Both studies included only females, because of the greater  
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317 131 prevalence of stress-induced food intake in females (O'Connor, Jones, Conner, McMillan and  
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319 132 Ferguson, 2008). In Study 1, we assessed the mediation effect of experienced pleasantness  
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321 133 ('eating satisfaction') between food intake and mood improvement after the food intake. In  
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323 134 Study 2, we investigated whether a mediation effect of experienced palatability is contingent  
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326 135 on emotional status, predicting stronger positive mediation effects for high than for  
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328 136 intermediate or low emotional eaters.  
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## 332 138 2. Study 1

### 334 139 2.1. Overview of Study 1

336 140 In this study we wanted to determine whether experienced pleasantness acts as a mediator  
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338 141 between food intake and mood improvement. The pleasantness of the food intake was  
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341 142 assessed with a concept that covers the hedonic experience of eating, namely 'eating  
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343 143 satisfaction' (Andersen & Hylding, 2015), i.e. more precisely representing the pleasantness of  
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345 144 the overall intake experience rather than a more general palatability of the food. Because the  
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347 145 study used a between-subject design, with half of the participants receiving a happy and the  
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357 146 other half a sad mood induction (Van Strien et al., 2013), only the data from the participants  
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359 147 in the sad mood condition could be used for the present study.  
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361 148 Earlier, we found with the entire dataset that self-reported emotional eating status  
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363 149 significantly moderated the relation between the mood condition and snack intake (van Strien,  
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365 150 Cebolla, et al., 2013): high emotional eaters ate significantly more after the sad than after the  
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367 151 happy condition. A further finding was that the sad mood induction was associated with a  
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369 152 significant increase in sadness compared to pre-test, but that sadness was significantly  
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371 153 reduced after the food intake (see Figure 2 in van Strien, Cebolla et al., 2013). Similarly, the  
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373 154 sad mood induction was associated with a significant decrease in happiness compared to pre-  
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375 155 test (Figure 3 in van Strien, Cebolla et al., 2013), but after food intake, happiness was  
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377 156 significantly increased. However, whether eating satisfaction acts as a mediator between food  
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379 157 intake and any decrease in sadness, or conversely increase in happiness, has not yet been  
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381 158 determined with the data in the sad mood condition.  
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## 385 159 386 387 160 2.2. Method 388

### 389 161 390 391 162 2.2.1. Participants 392

393 163 This is a new analysis of existing data from female participants in a virtual reality mood  
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395 164 induction experiment who had been recruited from a pool of students taking courses at the  
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397 165 Universities of Valencia and Barcelona (Spain) and who had completed in class the Spanish  
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399 166 (Castilian) version of the Emotional Eating scale of the Dutch Eating Behaviour  
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401 167 Questionnaire (DEBQ), (Cebolla, Barrada, Van Strien, Oliver & Baños, 2014). Students with  
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403 168 emotional eating scores below or equal to 1.8, or above 2.6, had been invited by phone to  
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405 169 participate in the study. Details on the exclusion criteria and the design and the procedure of  
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407 170 the experiment can be found in van Strien, Cebolla et al. (2013).  
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416 171 Participants in the present study were 29 women (15 low and 14 high emotional  
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418 172 eaters), who had been subjected to the sad mood induction, a virtual reality (VR-MIP) system  
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421 173 situated in an urban park, with music and movie scenes (an excerpt of the movie “The  
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423 174 Champ”) designed to induce sadness. The women had a mean BMI of 22.32 (SD=3.35) kg/m<sup>2</sup>  
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425 175 and a mean age of 24 (SD=6) years. The study protocol was approved by the ethics board of  
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427 176 the University of Valencia, and all participants gave signed informed consent.  
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#### 431 178 2.2.2. Procedure

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433 179 Participants were instructed to refrain from food intake for at least 2 h prior to arrival.  
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435 180 Experimental sessions were scheduled well before lunch or dinner. After the mood induction  
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437 181 procedure using the VR-MIP system (for details, see van Strien, Cebolla et al., 2013) (30 min)  
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439 182 the participants were taken to a separate room with a choice of various foods on individual  
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441 183 plates, providing a range of sweet, salty, or savoury high- or low-fat foods: apple, banana,  
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443 184 salty peanuts, sweet peanuts, chips, jelly sweets, cereal bar, chocolate, rice diet bar and  
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445 185 rosquilla (Valencian toasted salty bread). Participants were left alone for 5 min to eat as  
446  
447 186 much from the food as they wanted (see van Strien, Cebolla et al., 2013 for details).  
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#### 452 188 2.2.3. Measures

453  
454 189 *Happiness and sadness*: these emotions were measured with a 7-point visual analogue scale  
455  
456 190 (VAS; Gross & Levinson, 1995) with responses to the question “How happy/sad do you feel  
457  
458 191 at the moment” ranging from 1 ‘not at all’ to 7 ‘totally true’ at three time-points: upon arrival  
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460 192 (T1), immediately after the mood induction (T2) and immediately after the food intake (T3).  
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463 193 *Food intake*: Before and after the participants ate, the individual plates with food were  
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465 194 weighed with a professional scale. We then translated weight into energy (kcal) for each food  
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467 195 type and summed the caloric intake over all types of food.  
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196 *Level of satisfaction*: satisfaction with what was eaten ('eating satisfaction') was measured  
197 immediately after the food intake (but after the assessment of happiness and sadness at T3)  
198 with one question: How satisfied are you with what you have eaten? (Spanish: ¿Cómo de  
199 satisfecho estás respecto a lo que has comido?). This question had a 6-choice response format  
200 ranging from 1= 'not at all' to 6= 'totally'.

201 *Guilty*: feeling guilty after eating was measured immediately after the food intake and eating  
202 satisfaction question (but also after the assessment of happiness and sadness at T3) with one  
203 question: How guilty do you feel about what you have eaten? (Spanish: ¿Cómo de culpable te  
204 has sentido por lo que has comido?). This question had a 6-choice response format ranging  
205 from 1= 'not at all' to 6= 'totally'.

#### 207 2.2.4. Data analysis

208 With repeated measures GLM we assessed the effects of the mood induction and food intake  
209 on the values for sadness and happiness in the sad mood induction condition. Mediation of  
210 eating satisfaction was assessed with model 4 of the PROCESS macro of SPSS version 23.0,  
211 developed by Hayes (2013). We used bootstrapping with 5,000 samples. We conducted  
212 separate analyses for change in sadness and change in happiness (Y): change in sadness and  
213 change in happiness were calculated by assessing respectively, T3 sadness and T3 happiness,  
214 and using respectively, T2 sadness and T2 happiness as covariates. It should be noted that  
215 decrease in sadness is reflected by a negative score, whereas increase in happiness is reflected  
216 by a positive score. In both cases, the independent variable (X) was food energy intake (kcal)  
217 and the mediator (M) was eating satisfaction. In additional analysis we controlled for  
218 sadness/happiness at baseline (Mood-pre), as well as 'guilt' (because of the possible  
219 suppressing effect of guilt on eating satisfaction).

220

221 2.3. Results

222 2.3.1. Manipulation check

223 The mean (SD) of the sad mood values upon arrival (T1), immediately after the mood  
 224 induction (T2) and after the food intake (T3) were, respectively, 1.55 (.87), 4.66 (.94) and  
 225 2.41 (1.09). The mean (SD) of the happiness mood values upon arrival (T1), immediately  
 226 after the mood induction (T2) and after the food intake (T3) were, respectively, 5.14 (1.16),  
 227 2.93 (1.31) and 4.76 (.99). So, immediately after the mood induction (T2), sadness showed a  
 228 sharp peak and happiness a sharp decline, but after the food intake (T3) both sadness and  
 229 happiness returned to near baseline levels. For both sadness and happiness there was a  
 230 significant effect of time (respectively:  $F(2,56)=118.574, p<.001, \eta_p^2=.81$ , and  $F(2,56)$   
 231  $=53.957, p<.001, \eta_p^2=.66$ ), and for both sadness and happiness the quadratic model reached  
 232 the highest significance ( $F(1,28)=138.075, p<.001, \eta_p^2=.87$  and ( $F(1,28)=78.672, p<.001, \eta_p^2$   
 233  $=.74$ ).

234 2.3.2. Simple associations and descriptives of variables

235 Table 1 shows the Pearson correlations, means and standard deviations of the variables in  
 236 Study 1. Eating more energy and being more satisfied with the meal was associated with  
 237 becoming less sad from T2 (after the mood induction) to T3 (after the meal). Being sadder  
 238 before the mood induction was associated with a lower decrease in sadness after eating.  
 239 Becoming happier after eating was significantly associated with greater satisfaction from  
 240 eating, and being happier before the mood induction. Energy intake was also positively  
 241 associated with eating satisfaction.

242 It should further be noted (not shown in Table 1) that high emotional eaters ate  
 243 significantly more food in energy and in grams than low emotional eaters (energy: mean:  
 244 204.91 (SD=126.22) vs 113.07 (SD=71.79) ( $p=.022$ ); grams: mean=53.86 (SD=46.39 vs

245 21.80 (SD=17.88) ( $p=.019$ ), and that high emotional eaters ate marginally more ( $p=.055$ )  
 246 highly processed food (the sum of the intake of salty peanuts, sweet peanuts, chips, jelly  
 247 sweets, cereal bar, chocolate, rice bar, and rosquilla) and significantly more chocolate  
 248 ( $p=.003$ ) than low emotional eaters (respectively, highly processed food: mean=185.81  
 249 (SD=114.46) vs 115.16 (SD=74.66); chocolate: mean=57.20 (SD=44.96) vs 14.30  
 250 (SD=23.59). Intake of other individual foods did not differ between groups. Further, high  
 251 emotional eaters also reported feeling more guilty after the food intake than did low emotional  
 252 eaters (mean=2.43 (SD=1.50) versus 1.00 (.00) ( $p=.004$ ). Notably, there were no differences  
 253 between high and low emotional eaters in eating satisfaction (mean: 2.50 (SD=1.23) vs 2.33  
 254 (SD=.98) ( $p=.289$ ).

256 Please insert table 1 about here

### 258 2.3.3. Mediation effects

259 With PROCESS, we examined whether the relationship between food intake (X) and decrease  
 260 in sadness (Model 1) or increase in happiness (Model 2) (Y) was mediated by eating  
 261 satisfaction (M). We first elaborate on the results for Model 1 (decrease in sadness). In line  
 262 with the hypothesis, the indirect effect through eating satisfaction was significant ( $B=-0.003$ ;  
 263 95% CI=-0.007,-0.0008). The full model, containing food intake, the mediator and the  
 264 covariate, sadness at T2 (after the mood manipulation), was significant ( $F(3,25)=8.37$ ,  
 265  $p<.001$ ) and explained 50% of the variance in sadness at T3 (post food intake). See Figure 1  
 266 for the regression coefficient B (95%CI) associated with the various paths in the model. Very  
 267 similar results were obtained when we also included baseline sadness as confounder (indirect  
 268 effect:  $B=-0.002$  (SE=0.001), 95% BC CI [-0.006, -0.0007]), or, additionally, guilt as  
 269 confounder (indirect effect:  $B=-0.002$  (SE=0.001), 95% BC CI [-0.007, -0.0006]).

270 Highly similar results were obtained for intake of food in grams, instead of kcal  
271 (indirect effect:  $B=-0.007$  ( $SE=0.003$ ), 95% BC CI [-0.02, -0.003]). Very similar results were  
272 also obtained for intake by kcal of high energy-dense food, low-energy dense food, intake by  
273 kcal of sweet food or intake by kcal of salty food, or intake of processed food. Only for intake  
274 of unprocessed food (apple and banana) was the indirect effect not significant (data available  
275 on request).

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277 Please insert Figure 1 and Figure 2 about here  
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279 For increase in happiness (Figure 2), we found the following results: In line with the  
280 hypothesis, the indirect effect through eating satisfaction was significant ( $B=0.003$ ; 95% CI=  
281 0.008, 0.007). The full model, containing food intake, the mediator and the covariate:  
282 happiness at T2 (after the mood manipulation) was significant ( $F(3,25)=7.18$ ,  $p<.001$ ) and  
283 explained 46% of the variance in happiness at T3 (post food intake). See Figure 2 for the B  
284 (95% CI) associated with the various paths in the model. Very similar results were obtained  
285 when we also included baseline happiness as confounder (indirect effect:  $B=0.003$   
286 ( $SE=0.001$ ), 95% BC CI [0.008, 0.007]), or, additionally, guilt as confounder (indirect effect:  
287  $B=0.003$  ( $SE=0.002$ ), 95% BC CI [0.001, 0.009]).

288 Highly similar results were obtained for intake of food in grams, instead of kcal  
289 (indirect effect:  $B=.34$  ( $SE=.26$ ), 95% BCCI [.02, 1.133]). Very similar results were also  
290 obtained for kcal of intake of energy-dense food, intake of low-energy food, intake by kcal of  
291 sweet food or intake by kcal of salty food, intake of processed foods (salty peanuts, sweet  
292 peanuts, chips, jelly sweets, cereal bar, chocolate, rice bar, and rosquilla). Only for intake of  
293 unprocessed food (apple, banana) was the indirect effect not significant (results available on  
294 request).

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## 296 2.4. Summary of Study 1

297 Eating was associated with a clear reduction in sadness and increase in happiness.

298 Furthermore, in support of Macht and Mueller (2007a), eating satisfaction acted as a mediator  
299 between food intake and i) decrease in sadness and ii) increase in happiness.

300

## 301 3. Study 2

### 302 3.1. Overview of Study 2

303 For Study 2, we used data from an ongoing so called ‘health and physiology’ investigation

304 (van Strien et al., 2012; van Strien, Roelofs & de Weerth, 2013; van Strien, Ouwens, Engel &

305 de Weerth, 2014). The data for the additional participants in the present study had been

306 collected between October 2012 and May 2013. Using a within-subject design in females

307 varying in emotional eating, we measured the difference in food intake following a laboratory

308 control task or a stress task, the Trier Social Stress Test (TSST; Kirschbaum, Pirke &

309 Hellhammer, 1993). We further assessed negative affect during various time points, most

310 importantly *during the food intake*. For all types of food offered, we assessed, after food

311 intake, the degree to which it was rated as ‘lekker’ (a typically Dutch word meaning

312 something like ‘tasty’ or ‘yummy’; i.e. measuring ‘tastiness’).

313 Earlier analyses on a subsample of the present study revealed that emotional eating

314 status significantly moderated the association between distress and food intake, with low

315 emotional eaters eating less after the stress than after the control task and high emotional

316 eaters eating more (van Strien et al., 2012, 2013, 2014). Furthermore, the significant increase

317 in negative mood after the stressor showed a substantial reduction during food intake.

318 However, whether the tastiness of the food acts as mediator between food intake and the

319 reduction of negative mood during food intake was not yet assessed and also not whether such

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770 320 a mediation effect is contingent on degree of emotional eating. We expected that the mediation  
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772 321 effect of tastiness would be stronger for high than for intermediate or low emotional eaters.  
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776 323 3.2. Method  
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781 325 3.2.1. Design  
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783 326 This study is part of an ongoing within-subject experimental study. Results on the  
784  
785 327 respectively first 47 and 60 participants of the present sample have been reported earlier (van  
786  
787 328 Strien, Herman, Anschutz, Engels, & de Weerth, 2012; Van Strien, Roelofs & de Weerth,  
788  
789 329 2013; van Strien, Ouwens, Engel & de Weerth, 2014).<sup>1</sup>  
790

791 330 Of the additional women that participated in the present study, a total of 17 did not  
792  
793 331 fulfill the requirement of having extreme values on the pre-test of emotional eating (scores  
794  
795 332 below 1.82 or above 3.25, corresponding to the 20th and 80th percentile of the Dutch norm  
796  
797 333 group of females). The reason is that we had increasing difficulties in finding participants  
798  
799 334 with extremely low values on emotional eating (extreme high values were not so much of a  
800  
801 335 problem). Nevertheless, with over 75% of our sample having extreme values on emotional  
802  
803 336 eating we followed the advice of Whisman & McClelland (2005) to oversample participants  
804  
805 337 with extreme scores (p.118), to enhance the chance of finding possible interaction effects  
806  
807 338 (McClelland & Judd, 1993). Following Preacher (2015) to preserve ... “the individual  
808  
809 339 differences within each extreme” (o.c. p2), we kept the data on emotional eating in the present  
810  
811 340 study in their original, continuous form, instead of using the earlier dichotomy of low versus  
812  
813 341 high emotional eating.  
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815  
816  
817

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818  
819 <sup>1</sup>Footnote 1. The data of these previous publications had been collected in spring and autumn  
820 of 2010, and respectively spring 2012 (van Strien et al, 2012; Van Strien et al., 2013; van  
821 Strien et al., 2014). They address the moderation of distress induced eating by emotional  
822 eating scores, cortisol reactivity and distress induced emotional eating and hunger, inhibitory  
823 control and distress-induced emotional eating.  
824  
825  
826

827  
828  
829 342 The participants were subjected to a control task and a stress task (TSST) on two  
830  
831 343 consecutive days. The TSST involves speaking in front of a jury coupled with an arithmetic  
832  
833 344 challenge. Because the stress condition is perceived by some subjects as very stressful, we  
834  
835 345 deliberately started with the control condition and did not counterbalance the order of the two  
836  
837 346 conditions. We were concerned that we would lose too many subjects when we started with  
838  
839 347 the stress condition because they would refuse to come back the following day for the control  
840  
841 348 condition. We were also concerned that the control condition would suffer from carry over  
842  
843 349 effects if we started with the stress condition (see also footnote 4 in van Strien, Ouwens,  
844  
845 350 Engel & de Weerth, 2014).

848 351 The study protocol was approved by the ethical board of the Faculty of Social  
849  
850 352 Sciences of the Radboud University Nijmegen (ECG 29042010). Before participating, the  
851  
852 353 participants filled out informed consent forms.  
853  
854 354

### 856 355 3.2.2. Participants

858  
859 356 Participants were recruited from a pool of female students taking introductory psychology or  
860  
861 357 pedagogy courses who had completed the emotional eating scale in class or on our research  
862  
863 358 participant portal. Eighty-four females participated but complete information was only  
864  
865 359 obtained from 74 women: 22 low emotional eaters, 35 high emotional eaters and 17 women  
866  
867 360 with intermediate scores on the scale for emotional eating. Their mean age was 23.08  
868  
869 361 (SD=2.29) years and their mean BMI (body mass index; weight/height\* height) was 21.05  
870  
871 362 (SD=2.57) kg/m<sup>2</sup>.

873  
874 363

### 875 364 3.2.3. Procedure

876  
877  
878 365 The sessions were scheduled on consecutive weekdays between 11 a.m. and 3 p.m. In the  
879  
880 366 control condition, participants had to rate various fabrics (e.g. fur and silk) on various  
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886  
887  
888 367 attributes (e.g. softness and warmth) for 15 minutes. After this, they were led to a separate  
889  
890 368 room to fill out questionnaires, the first one being a questionnaire on mood, at a table which  
891  
892 369 also held a glass of water and four bowls filled with, respectively, white grapes, pieces of  
893  
894 370 carrot, M&Ms (small sugar-coated chocolate sweets) and pieces of buttercake (dense, buttery,  
895  
896 371 sweet baked cake). Participants were invited to help themselves to the water and the food with  
897  
898 372 the words: “Please help yourself to the water and the food. You have earned it”. In the stress  
899  
900 373 condition, the participants were subjected to a modified version of the TSST (Kirschbaum et  
901  
902 374 al., 1993), which consisted of preparing (5 min) and delivering (5 min) a videotaped speech,  
903  
904 375 followed by a serial subtraction task (5 min). The speech and subtraction task were presented  
905  
906 376 in front of a two-person jury who sat behind a table and wore white doctor’s coats. Because  
907  
908 377 the TSST originally has a three-person jury (instead of our present two-person jury), to  
909  
910 378 enhance the stress, the participant had to stand without shoes on a Wii© balance board, in  
911  
912 379 front of the jury. After the stress task, the experimenter asked the participant to wait for the  
913  
914 380 jury’s judgment of the participant’s performance—in this manner the stressfulness of the  
915  
916 381 public speaking task was extended by a prolonged period of waiting for the results—and to  
917  
918 382 fill out a set of questionnaires. After 15 min the experimenter returned to communicate a  
919  
920 383 positive judgment by the jury, after which the participants were led to the separate room to fill  
921  
922 384 out a further set of questionnaires, the first one being the questionnaire on mood. This  
923  
924 385 questionnaire measured mood during the food intake: participants were invited to help  
925  
926 386 themselves to the water and the food on the table with the same words as on the previous day.  
927  
928 387 After 20 min the experimenter returned to administer the questions on ‘lekker’ (tastiness). The  
929  
930 388 final task for the experimenter was to measure the weight and height of the participant, and  
931  
932 389 debrief, thank and pay the participants with course credits. Before debriefing, the participants  
933  
934 390 were questioned on the perceived purpose of the study and none of the participants was aware  
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945  
946  
947 391 that their food intake was being measured. It should further be noted that the experimenter  
948  
949 392 was kept blind to the emotional eating status of the participants.  
950

951 393

## 952 394 3.2.4. Measures

953  
954  
955 395 *Emotional eating* was assessed with the Dutch Eating Behaviour Questionnaire  
956 396 (DEBQ; Van Strien, 2010; Van Strien, Barrada & Cebolla, 2016). The DEBQ emotional  
957  
958 396 (DEBQ; Van Strien, 2010; Van Strien, Barrada & Cebolla, 2016). The DEBQ emotional  
959  
960 397 eating scale has 13 items (e.g., “Do you have a desire to eat when you are irritated”) and has  
961  
962 398 to be rated on a 5-point scale with response categories that range from 1 ‘never’ to 5 ‘very  
963  
964 399 often’. The DEBQ has been rated as ‘up to the mark’ or ‘good’ by the Dutch Committee on  
965  
966 400 Tests and Testing (COTAN) on all EFPA (European Federation of Psychologists'  
967  
968 401 Association) criteria (e.g. norms, reliability (internal consistency, test-re-test) and validity  
969  
970 402 (dimensional validity, construct validity and criterion validity) (COTAN, 2013). See for the  
971  
972 403 internal consistency, factorial, construct and predictive validity: Van Strien, 1996; Van Strien,  
973  
974 404 Herman & Anschutz, 2012; Van Strien & van de Laar, 2008; Van Strien et al., 2012; Barrada,  
975  
976 405 van Strien & Cebolla, 2016.  
977  
978

979 406 *Mood* was measured on both days, upon arrival and at three more time points:  
980  
981 407 immediately after the task, after the message of having to wait for the jury’s judgement on the  
982  
983 408 performance, and during the food intake using the Positive and Negative Affect Schedule  
984  
985 409 (PANAS; Watson, Clark, & Tellegen, 1988). This instrument measures, on a 5-point (1= ‘not  
986  
987 410 at all’ to 5= ‘extremely’) scale, the degree to which participants experienced 10 positive and  
988  
989 411 10 negative emotions, thus generating orthogonal measures of positive and negative affect.  
990

991 412 *Hunger* was also measured on both the control and the stress day, by inserting the item  
992  
993 413 ‘hungry’ among the 5-point PANAS items. For the present study only the hunger assessment  
994  
995 414 *during* the food intake on the control and stress days was of relevance.  
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1006 415 *Tastiness ('Lekker')*. For each of the food types (carrots, grapes, M&M's and  
1007  
1008 416 buttercake) 'lekker' (equivalent to tastiness, i.e. rated palatability) was assessed with a 5-point  
1009  
1010 417 (1= 'not at all' to 5= 'extremely') scale. The questions on 'lekker' were assessed after the  
1011  
1012  
1013 418 food consumption on the stress day.

1014  
1015 419 For all scales, scale scores were obtained by calculating the mean of the items of a  
1016  
1017 420 scale.

1018  
1019 421 *Food intake*. For both the control and the stress day, before and after the participants  
1020  
1021 422 ate, the individual plates with food (grapes, carrots, buttercake and M&M's) were weighed  
1022  
1023 423 with a professional scale. We then translated weight into energy (kcal) for each food type and  
1024  
1025 424 summed the caloric intake over the four types of food. Since hardly any grapes and carrots  
1026  
1027 425 were eaten on average (see Table 2), in additional analyses we also used the kcal of the snack  
1028  
1029  
1030 426 food (the sum in kcal of cake and M&M's). This allowed us to test for changes specifically in  
1031  
1032 427 intake of sweet fatty 'comfort food'.  
1033

### 1034 428 1035 1036 429 3.2.5. Data analysis

1037  
1038 430 With repeated measures GLM we conducted manipulation checks by assessing the effect of  
1039  
1040 431 time on the negative and positive mood values in the stress condition, in addition to the effect  
1041  
1042 432 of condition (control vs stress) on the mood values over time. Greenhouse-Geisser corrections  
1043  
1044 433 were applied where appropriate. Mediation and moderated mediation were assessed with the  
1045  
1046 434 PROCESS macro of SPSS version 23.0, developed by Hayes (2013 (model 4 and model 7)).  
1047  
1048  
1049 435 Moderated mediation was tested with Hayes' index of moderated mediation (Hayes, 2015).  
1050  
1051 436 We used bootstrapping with 5,000 samples. All variables were centred before computing  
1052  
1053 437 interaction terms. Because the manipulation check (see 3.3.1) revealed no condition x time  
1054  
1055 438 interaction on positive affect we only conducted analyses for negative affect. Because the  
1056  
1057 439 manipulation check (3.3.1) revealed that the quadratic model reached the highest significance  
1058  
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1063  
1064  
1065 440 in the stress condition, we assessed the affect reactivity during the stress condition (the  
1066  
1067 441 dependent variable Y) with the area under the curve with respect to the ground  
1068  
1069 442 (AUCg-stress).<sup>2</sup>  
1070

1071  
1072 443 The dependent variable (Y) was affect reactivity during the stress condition (AUCg),  
1073  
1074 444 the independent variable (X) was the difference in food intake between the stress and the  
1075  
1076 445 control condition in kcal (henceforth delta kcal; a positive value meaning more food intake in  
1077  
1078 446 the distress than in the control condition), the mediator (M) was tastiness and the moderator  
1079  
1080 447 (W) was degree of emotional eating (assessed well before the study in class or at our research  
1081  
1082 448 portal).  
1083

1084 449 In additional analyses we controlled for affect reactivity in the control condition:  
1085  
1086 450 because the manipulation check (3.3.1) revealed that the linear model reached the highest  
1087  
1088 451 significance in the control condition, affect reactivity during the control condition was  
1089  
1090 452 calculated by computing the difference between negative affect at baseline (T1) and during  
1091  
1092 453 food intake (T4). Because we had one-sided hypotheses regarding the direction of our results,  
1093  
1094 454 we additionally could test significance with 90% CI (alpha two-tailed =.10; alpha one-tailed  
1095  
1096 455 =.05), along with the conventional 95% CI.  
1097  
1098

1099 456 Finally, despite the strong correlation between overall negative affect AUCg and the  
1100  
1101 457 single mood measure during food intake, we acknowledge that using the overall AUGg  
1102  
1103 458 measure of mood can confound stress-dependent and eating-dependent mood effect.  
1104  
1105 459 Therefore, in additional post-hoc analyses we used a different and potentially more specific  
1106  
1107 460 measure for ‘mood recovery during eating’ by replacing our dependent variable (AUCg)  
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1115 <sup>2</sup> Footnote: AUCg is a well-known summary indicator of repeated measurements (e.g. the four  
1116 negative affect values during stress and food intake in the present study). In the present study  
1117 the AUCg\_stress showed a correlation,  $r=0.87$ , with the negative affect value during food  
1118 intake.  
1119  
1120  
1121

1122  
1123  
1124 461 with the negative affect value during the food intake (T4) and using the highest negative  
1125  
1126 462 affect value after the stressor (T2 or T3) as a covariate.  
1127  
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1129 463

### 1130 464 3.3. Results

1131  
1132 465

#### 1133 466 3.3.1. Manipulation check.

1134  
1135 466 3.3.1. Manipulation check.  
1136  
1137 467 *Negative mood.* Figure 3 shows the values for negative mood in the control and the stress  
1138  
1139 468 condition upon arrival (T1), immediately after the task (T2), after the message of having to  
1140  
1141 469 wait for the jury's judgement on the performance (in the stress condition) (T3), and during the  
1142  
1143 470 food intake (T4). In both conditions the values on negative mood were significantly affected  
1144  
1145 471 by time (control condition:  $F(2.482, 181.202) = 9.266, p < .001, \eta_p^2 = .113$ ; stress condition:  $F$   
1146 472  $(2.010, 146.704) = 47.946, p < .001, \eta_p^2 = .40$ ). In the control condition, negative mood showed  
1147  
1148 472  $(2.010, 146.704) = 47.946, p < .001, \eta_p^2 = .40$ ). In the control condition, negative mood showed  
1149  
1150 473 slow improvement; here the linear model reached the highest significance ( $F(1, 73) = 17.026,$   
1151  
1152 474  $p < .001, \eta_p^2 = .19$ ). In the stress condition, negative mood showed a sharp peak immediately  
1153  
1154 475 after the stressor but markedly improved during food intake; here, the quadratic model  
1155  
1156 476 reached the highest significance ( $F(1, 73) = 68.721, p < .001, \eta_p^2 = .49$ ). As could be expected,  
1157  
1158 477 there were significantly higher values of negative mood in the stress than in the control  
1159  
1160 478 condition on all time points except T1 (Figure 3). The overall moderator effect of the stress  
1161  
1162 479 condition on the mood values over time was significant ( $F(3, 69) = 23.950, p < .001, \eta_p^2 = .51$ ).  
1163  
1164 480 In regard to positive mood, there was no significant effect of time in the control condition ( $F$   
1165  
1166 481  $(1.051, 75.638) = 2.246, p = .137, \eta_p^2 = .030$ ) and a borderline non-significant effect of time in  
1167  
1168 482 the stress condition ( $F(1.826, 133.297) = 3.107, p = .053, \eta_p^2 = .041$ ); there also was no  
1169  
1170 483 significant overall moderator effect of the stress condition on the positive mood values over  
1171  
1172 484 time ( $F(1.102, 79.322) = 1.860, p = .177, \eta_p^2 = .026$ ).  
1173  
1174  
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1177 485  
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1181  
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1183 486 Please insert Figure 3 about here  
1184  
1185 487  
1186  
1187 488 3.3.2. Simple associations between variables  
1188  
1189  
1190 489 Table 2 shows the Pearson correlations, means and standard deviations of the variables in  
1191  
1192 490 Study 2. Negative mood reactivity during stress (AUCg stress) showed no significant  
1193  
1194 491 association with total energy intake (kcal), nor from the sweet fatty snack food (butter cake  
1195  
1196 492 plus M&M). It was only significantly associated with decrease in negative affect in the  
1197  
1198 493 control condition (participants with a larger fall in negative affect in the control condition had  
1199  
1200 494 a bigger increase in negative affect in the stress condition, suggesting a mood lability pattern)  
1201  
1202 495 and with hunger during food intake in the stress condition (Table 2). Intake of energy (total  
1203  
1204 496 intake and intake from snacks) was significantly positively associated with hunger during  
1205  
1206 497 food intake in the stress condition. Not shown in Figure 3 is that tastiness showed a  
1207  
1208 498 significant positive association with the intake of snack food in the control condition ( $r=0.29$ ,  
1209  
1210 499  $p=.012$ ) but no significant association with the intake of snack food in the stress condition  
1211  
1212 500 ( $r=0.004$ ,  $p=.971$ ). However, these simple associations do not account for level of emotional  
1213  
1214 501 eating.  
1215  
1216 502  
1217  
1218  
1219 503 Please insert Table 2 about here  
1220  
1221 504  
1222  
1223 505 3.3.3. Mediation effects  
1224  
1225  
1226 506 Using the PROCESS (model 4), we examined whether the relationship between food intake  
1227  
1228 507 (delta kcal; X) and negative mood reactivity during stress (AUCg stress; Y) was mediated by  
1229  
1230 508 tastiness (M). The 90% CI indicated that the indirect effect through tastiness was not  
1231  
1232 509 significant ( $B=-.0004$  ( $SE=.0005$ ), 90% BC CI  $[-.002,.0002]$ ), and was also not significant  
1233  
1234  
1235  
1236  
1237  
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1240  
1241  
1242 510 when we controlled for affect reactivity in the control condition ( $n=72$ ) ( $B=-.0004$ ,  
1243  
1244 511 ( $SE=.0005$ ) 90% BC CI  $[-.002, .0003]$ ).

1246 512  
1247  
1248  
1249 513 3.3.4. Moderated mediation analyses

1250  
1251 514 Figure 3 shows the B (95% CI) associated with the various paths in the moderated mediation  
1252  
1253 515 analysis (PROCESS, model 7) with emotional eating as moderator variable of the mediation  
1254  
1255 516 model of tastiness (M) between food intake (delta kcal; X) and negative mood reactivity  
1256  
1257 517 during distress (AUCg stress; Y). The index of moderated mediation was significant at 95%  
1258  
1259 518 CI ( $B=.0007$ , ( $SE=.0005$ ) 95% BC CI  $[.00001, .00234]$ ). Inspection of the conditional indirect  
1260  
1261 519 effects for low , intermediate and high emotional eaters revealed that there was a 90% CI  
1262  
1263 520 significant *positive* mediation effect for tastiness for the high emotional eaters ( $B=.0006$   
1264  
1265 521 ( $SE=.0005$ ), 90% BC CI  $[.00001, .002]$ ), a non-significant mediation effect for the  
1266  
1267 522 intermediate emotional eaters ( $B=-.0003$  ( $SE=.0004$ ), 90% BC CI  $[-.001, .0002]$ ), and a 90%  
1268  
1269 523 CI significant *negative* mediation effect of tastiness for the low emotional eaters ( $B=-.0011$   
1270  
1271 524 ( $SE=.0009$ ), 90% BC CI  $[-.003,- .00001]$ ). Also, when in an additional analysis we controlled  
1272  
1273 525 for affect reactivity in the control condition ( $n=72$ ), the index of moderated mediation was  
1274  
1275 526 significant at 95% CI ( $B=.0008$  ( $SE=.0005$ ) 95% BC CI  $[.00007, .002]$ ). Moreover, here there  
1276  
1277 527 was a 90% CI significant positive mediation effect of tastiness for the high emotional eaters, a  
1278  
1279 528 non-significant effect for tastiness for the intermediate emotional eaters, and a 90% BC CI  
1280  
1281 529 significant negative mediation effect of tastiness for the low emotional eaters.  
1282  
1283  
1284

1285 530  
1286  
1287 531 Please Insert Figure 4 about here  
1288

1289 532  
1290  
1291 533 In further additional moderated mediation analyses, we controlled for hunger during  
1292  
1293 534 food intake in the control and stress condition (in addition to affect reactivity in the control  
1294  
1295  
1296  
1297  
1298

1299  
 1300  
 1301 535 condition). The index of moderated mediation was significant at the 90% CI ( $B=.0005$   
 1302  
 1303 536 ( $SE=.0004$ ) 90% BC CI [ $.0003, .003$ ]). The results went in the same direction (negative  
 1304  
 1305 537 effects in low, no effects in the intermediate and positive effects in the high emotional eaters),  
 1306  
 1307 538 but the mediation effect of tastiness was significant only for the low emotional eaters at 90%  
 1308  
 1309 539 CI:  $B=-.0008$  ( $SE=.0007$ ) 90% BC CI [ $-.003, -.00001$ ]. Highly similar results were obtained  
 1310  
 1311  
 1312 540 for intake of food in grams, instead of kcal, though the index of moderated mediation was  
 1313  
 1314 541 only significant at 90% CI ( $B=.0008$ , ( $SE=.0008$ ) 90% BC CI [ $.000003, .003$ ]).

1316 542 We also conducted moderated mediation analyses where we replaced the total amount  
 1317  
 1318 543 of kcal with the amount of kcal from intake of cake plus M&M's (i.e. the sweet and fatty  
 1319  
 1320 544 foods). The index of moderated mediation of the full model (controlling for affect reactivity in  
 1321  
 1322 545 the control condition, ( $n=72$ )), was significant at 95% CI ( $B=.0008$  ( $SE=.0006$ ) 95% BC CI  
 1323  
 1324  
 1325 546 [ $.0006, .002$ ]), with a 90% CI significant *positive* mediation effect of tastiness between snack  
 1326  
 1327 547 intake and mood improvement for high emotional eaters ( $B=.0007$  ( $SE=.0005$ ) 90% BC CI  
 1328  
 1329 548 [ $.00004, .002$ ]), a non-significant effect for tastiness for the intermediate emotional eaters  
 1330  
 1331 549 ( $B=-.0002$  ( $SE=.0004$ ) 90% BC CI [ $-.001, .0002$ ]) and a 90% CI significant *negative*  
 1332  
 1333 550 mediation effect for low emotional eaters ( $B=-.0012$  ( $SE=.0009$ ) 90% BC CI [ $-.004, -.0007$ ]).

1335 551

### 1337 552 3.3.5. Post-hoc mediation of hunger

1339 553 In additional post hoc analyses we also assessed mediation and moderated mediation with  
 1340  
 1341 554 hunger instead of tastiness as mediator (hunger during the food intake in the stress condition,  
 1342  
 1343 555 controlling for hunger in the control condition). In the full model (additionally controlling for  
 1344  
 1345 556 affect reactivity in the control condition ( $n=72$ )), the indirect effect through 'hunger' was  
 1346  
 1347 557 significant at the 90% CI ( $B=.0009$  ( $SE=.0008$ ), 90% BC CI [ $.00004, .003$ ]), indicating  
 1348  
 1349  
 1350 558 borderline significant mediation. There was no moderated mediation, because the index of

1351  
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1358  
1359  
1360 559 moderated mediation was, in this full model, not significant at 90% CI ( $B=.0004$  ( $SE=.0005$ ))  
1361  
1362 560 90% BC CI  $[-.00001, .002]$ ).

1363  
1364 561  
1365  
1366  
1367 562 3.3.6. Post-hoc analysis with a single point measure for ‘mood recovery during eating’

1368  
1369 563 In additional post-hoc analyses we calculated a different and potentially more sensitive  
1370  
1371 564 but single point measure for ‘mood recovery during eating’ by replacing our dependent  
1372  
1373 565 variable (AUCg) with only the negative affect value during food intake (T4), and using the  
1374  
1375 566 highest negative affect value after the stressor (T2 or T3) as a covariate. The results went in  
1376  
1377 567 the same direction.

1378  
1379 568 In the moderated mediation analysis with total amount of intake (kcal), the index of  
1380  
1381 569 moderated mediation of the full model (controlling for affect reactivity in the control  
1382  
1383 570 condition ( $n=74$ )) was significant at 95% CI ( $B=.1183$  ( $SE=.08187$ )) 95% BC CI  $[.0001,$   
1384  
1385 571  $.3182]$ ), with a 95% CI significant *positive* mediation effect of tastiness between food intake  
1386  
1387 572 and mood improvement for high emotional eaters ( $B=.0647$  ( $SE=.0484$ )) 95% BC CI  $[.0007,$   
1388  
1389 573  $.2139]$ ), and non-significant effects (also not significant at 90% CI) for tastiness for the  
1390  
1391 574 intermediate and low emotional eaters (respectively,  $B=-.0671$  ( $SE=.0637$ )) 95% BC CI  $[-$   
1392  
1393 575  $.2149, .0257]$  and  $B=-.1990$  ( $SE=.1498$ )) 95% BC CI  $[-.5481, .0119]$ ). Highly similar results  
1394  
1395 576 were obtained when we did not control for affect reactivity in the control condition.

1396  
1397 577 In the moderated mediation analysis with amount of intake of kcal from intake of cake  
1398  
1399 578 plus M&M’s (i.e. the sweet and fatty foods), the index of moderated mediation of the full  
1400  
1401 579 model (controlling for affect reactivity in the control condition ( $n=74$ )) was also significant at  
1402  
1403 580 95% CI ( $B=.1367$  ( $SE=.0870$ )) 95% BC CI  $[.0030, .3378]$ ), with a 95% CI significant *positive*  
1404  
1405 581 mediation effect of tastiness between snack intake and mood improvement for high emotional  
1406  
1407 582 eaters ( $B=.0755$  ( $SE=.0524$ )) 95% BC CI  $[.0034, .2368]$ ), and non-significant effects (also not  
1408  
1409 583 significant at 90% CI) for tastiness for the intermediate and low emotional eaters  
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1419 584 (respectively,  $B = -.0768$  ( $SE = .0697$ ) 95% BC CI  $[-.2353, .03146]$  and  $B = -.2291$  ( $SE = .1606$ )  
1420  
1421 585 95% BC CI  $[-.5666, .0094]$ ). Highly similar results were obtained when we did not control for  
1422  
1423 586 affect reactivity in the control condition.  
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### 1428 588 3.4. Summary and conclusion for Study 2

1429  
1430 589 In this study, where negative affect was assessed during the food intake, we found that the  
1431  
1432 590 mediation effect of tastiness between food intake and distress induced mood reactivity was  
1433  
1434 591 contingent on (moderated by) emotional eating scores. Whereas high emotional eaters showed  
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1436 592 a significant positive mediation effect of tastiness, low emotional eaters showed a significant  
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1438 593 negative mediation effect of tastiness. The negative mediation effect of tastiness in the low  
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1440 594 emotional eaters (though not significant in the additional post-hoc analysis) means that  
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1442 595 tastiness acted in this subgroup as a suppressor variable: inclusion of tastiness in the  
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1444 596 regression model of the low emotional eaters increased the effect of food intake on mood  
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1446 597 reactivity during distress.  
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### 1451 599 4. General discussion

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1453  
1454 601 In two studies, we assessed the possible mediating effect of eating satisfaction or ‘lekker’  
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1456 602 (tastiness) between food intake and mood improvement respectively after or during the food  
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1458 603 intake. In one study (Study 2) we additionally assessed whether the mediation effect of  
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1460 604 ‘lekker’ is contingent on emotional eating, with expected stronger mediation effects in high  
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1462 605 than in intermediate or low emotional eaters. In Study 1, where mood was assessed after the  
1463  
1464 606 food intake, we found, as expected, significant mediation, i.e. the satisfaction from eating  
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1466 607 explained the impact of eating snack foods on both reduced sadness and increased happiness.  
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1468 608 In Study 2, we did not find significant overall mediation of ‘lekker’ or tastiness between food  
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1478 609 intake and mood improvement. Instead we found that the mediation effect of tastiness was  
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1480 610 contingent on emotional eating, with a significant positive mediation effect of tastiness in the  
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1482 611 high emotional eaters, no significant mediation effect of ‘tastiness’ in the intermediate  
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1484 612 emotional eaters and a significant negative mediation effect of tastiness in the low emotional  
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1486 613 eaters on the change in negative affect.

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1489 614 The effects for high versus low emotional eaters in Study 2 thus went in opposing  
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1491 615 directions, which may explain the absence of a mediation effect of tastiness between food  
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1493 616 intake and mood improvement in the entire sample (the combined sample of high,  
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1495 617 intermediate and low emotional eaters). We found a similar moderated mediation when we  
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1497 618 replaced the energy intake from all foods with the energy intake from solely the sweet fatty  
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1499 619 snack food (cake plus M&M). The positive mediation effect of tastiness in the high emotional  
1500  
1501 620 eaters is in line with the finding by Macht and Mueller (2007a). In that study, the mood  
1502  
1503 621 elevation immediately after eating the palatable chocolate was more pronounced in the high  
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1505 622 than in the low emotional eaters (as determined by a median split of the emotional eating  
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1507 623 scale of the DEBQ). The negative mediation effect of tastiness in the low emotional eaters  
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1509 624 that we found with both food intake and intake of cake plus M&M, means that tastiness acted  
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1511 625 as a suppressor variable in this subgroup: inclusion of tastiness in the regression model of the  
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1513 626 low emotional eaters increased the effect of food intake on negative affect reactivity during  
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1515 627 distress.

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1519 628 The post-hoc finding that there was no significant moderated mediation when we  
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1521 629 replaced the mediator tastiness with ‘hunger during food intake’ is in line with the observation  
1522  
1523 630 by Reichenberger et al. (2018, p.61) “that it is the hedonic, not the homeostatic system that is  
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1525 631 affected by emotional eating”. In other words, for people with a high tendency towards  
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1527 632 emotional eating, palatability/taste may be more important than hunger/satiety in influencing  
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1529 633 their mood after eating. Furthermore, this uncoupling of the hedonic from the homeostatic  
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1537 634 exposes emotional eaters to greater risk of overconsumption (Hetherington et al., 2013).  
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1539 635 However, this finding does not support the earlier psychosomatic proposal (Bruch, 1973) that  
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1541 636 comfort eating may arise from confusion of hunger with affect.  
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1543  
1544 637 The positive mediation effect of tastiness between food intake and mood improvement  
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1546 638 during food intake in the high emotional eaters is in line with the results of a functional  
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1548 639 magnetic resonance imaging (fMRI) study (Bohon, Stice & Spoor, 2009): increased activation  
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1550 640 of brain reward pathways in female emotional eaters in response to anticipation and  
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1552 641 consumption of a chocolate milkshake during negative mood indicates that for emotional  
1553  
1554 642 eaters food may be more rewarding or pleasurable when they are in a negative mood state. A  
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1556 643 further remarkable finding in that same study was that there were no changes in affect in  
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1558 644 response to the anticipation or taste of the food. This suggests that the eating did not actually  
1559  
1560 645 alleviate negative affect, a result that would be in line with the studies showing that the  
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1562 646 improvement in mood is at best only short lived (Macht & Mueller, 2007a, Daever et al.,  
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1564 647 2003), and may even become worse after some time (Haedt-Matt et al., 2014).  
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1567 648 In Study 1, we assessed the improvement in mood immediately after food intake:  
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1569 649 baseline-adjusted decrease in sadness (but not increase in happiness) was significantly  
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1571 650 positively associated with energy intake from food: the more the participants ate, the greater  
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1573 651 was their reduction in sadness. Moreover, the decrease in sadness and increase in happiness  
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1575 652 were both significantly associated with eating satisfaction. Furthermore, high emotional eaters  
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1577 653 ate more of the highly processed snack foods, and chocolate, than low emotional eaters,  
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1579 654 replicating earlier findings (Gibson, 2012), although this group difference was not apparent  
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1581 655 for intake unprocessed apple and banana. It is thus worth noting that the mediation by eating  
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1583 656 satisfaction of the reduction in sadness after snack intake was only significant for the  
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1585 657 processed foods, suggesting that the manufactured palatability of processed foods may be  
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1587 658 more effective in comforting than at least unprocessed fruit.  
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1596 659 The sample size of Study 1 ( $n=29$ ) did not permit us to determine whether the  
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1598 660 mediation effect in Study 1 is also contingent on emotional eating status, but in a future study  
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1600 661 it would be of interest to determine whether similar results are obtained when mood is  
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1602  
1603 662 assessed immediately after versus during the food intake.

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1605 663 One possible explanation for the finding in low emotional eaters in Study 2 (though  
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1607 664 not significant in the additional post hoc analysis) is that during stress, low emotional eaters  
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1609 665 would normally have less appetite for food, but very tasty food could counteract this  
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1611 666 tendency, so might set up a motivational conflict that could worsen their mood (Gibson,  
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1613 667 2012). To put it another way, low emotional eaters reflect their enjoyment or satisfaction from  
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1615 668 eating the meal in their mood changes (Hetherington, Cunningham, Dye, Gibson et al., 2013),  
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1617 669 whereas high emotional eaters may have a more complex relationship with their post-meal  
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1619 670 mood states that uncouples them from the level of satisfaction arising from eating the meal.  
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1621 671 For example, habitual use of palatable food for emotional comfort may focus attention of high  
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1623 672 emotional eaters away from the satisfaction of eating and towards post-meal mood change.  
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1625 673 Alternatively, emotional eaters may experience improved mood induced by ‘eating  
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1627 674 satisfaction’ only during and not after eating. For example, in a study where only brief tastes  
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1629 675 of food samples were allowed, so that meaningful eating satisfaction could not occur, tasting  
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1631 676 energy-dense foods induced negative emotions in women who were overweight and  
1632  
1633 677 emotional eaters (Macht, Gerer & Ellgring, 2003). Similarly, self-confessed ‘chocolate  
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1635 678 addicts’ reported increased negative affect after eating chocolate (Macdiarmid &  
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1637 679 Hetherington, 1995). Moreover, in 931 Californians, greater habitual chocolate consumption  
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1639 680 was strongly associated with more depressive symptoms, particularly in women (Rose,  
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1641 681 Koperski & Golomb, 2010), implying that chocolate may provide only transient relief from  
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1643 682 negative affect, as the experimental study of Macht and Mueller (2007a) also found.  
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1645 683 Furthermore, it has been observed that, in chocolate cravers, images of chocolate  
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1655 684 simultaneously induced appetitive and aversive motivational states (assessed by physiological  
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1657 685 responses; Rodriguez, Fernandez, Cepeda-Benito, & Vila, 2005). Indeed, a recent theoretical  
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1659 686 model for stress-induced eating, in contrast to the “affect reduction” model, proposed that  
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1661 687 stress may actually *reduce* the pleasure of eating highly palatable foods, at least in susceptible  
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1663 688 individuals, instead amplifying learned motivational and attentional responses to the presence  
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1665 689 of such foods, at the expense of more cognitively demanding goal-dependent control on  
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1667 690 eating (Pool, Delplanque, Coppin & Sander, 2015). In other words, when stressed, our  
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1669 691 habitual and long-established food preferences are evoked, predominantly for energy-rich  
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1671 692 sweet and/or fatty foods. It is therefore worth noting that in Study 2, whereas tastiness was  
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1673 693 positively associated with snack intake in the control condition, it was unrelated to intake after  
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1675 694 stress (3.3.2).

1678  
1679 695 A major limitation of both study 1 and study 2 is that the assessment of the mediating  
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1681 696 variables eating satisfaction (Study1) and tastiness (Study 2) between food intake and change  
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1683 697 in mood took place **after** the last assessment of mood. For an assessment of mediation  
1684  
1685 698 potentially allowing assessment of causal connections, eating satisfaction and tastiness would  
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1687 699 need to be assessed well before the last measurement of mood. For both study 1 and study 2,  
1688  
1689 700 it is therefore also possible that the change in mood after or during the food intake affected the  
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1691 701 eating satisfaction or tastiness ratings, whilst they also could have been reciprocally  
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1693 702 associated. However, our model of mediation was theory driven, and inspired by earlier  
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1695 703 results by Macht & Mueller (2007a). Furthermore, the participants’ postprandial judgement of  
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1697 704 both eating satisfaction and tastiness are likely to involve some reflection on and recollection  
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1699 705 of the experience of the foods they have just eaten, so are not merely assessments of their  
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1701 706 impressions at that exact moment somehow independent of recent experience. Therefore,  
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1703 707 though our results preclude causality, they are nonetheless informative and may provide a  
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1705 708 good basis for future studies that are able to identify the unfolding of the associations over  
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1714 709 time.<sup>3</sup> In the same line, a further limitation of Study 2 is that ‘lekker’, though assessed at the  
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1716 710 end of the study, may have influenced the amount of food eaten, so that the reverse direction  
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1718 711 of the mediation model could be true; however, tastiness was not associated with intake after  
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1721 712 stress, making this explanation unlikely.  
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1723 713 Another limitation is that we cannot rule out the possibility that, for reasons of social  
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1725 714 desirability, people may have denied emotional eating. Still, scores on the emotional eating  
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1727 715 scale earlier showed predictive validity for greater eating during stress in the same datasets,  
1728  
1729 716 reducing this concern. In addition, different measures of pleasantness of the food were used in  
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1731 717 the two studies (e.g., eating satisfaction versus ‘lekker’), and an important difference between  
1732  
1733 718 the two studies is that Study 1 used a sadness induction whereas Study 2 used a stress  
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1735 719 procedure.  
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1739 720 A limitation to generalization is that the experiments were conducted in predominantly  
1740  
1741 721 normal-weight young female students, and that the number of participants in Study 1 was  
1742  
1743 722 rather small. Therefore, our results need replication in overweight participants and may not be  
1744  
1745 723 applicable to men. Finally, the present findings could benefit from replication in larger  
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1747 724 samples in more natural settings.  
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## 1750 725

### 1751 726 5. General Conclusion

1752 727 In non-obese young women, food experienced as highly palatable and satisfying may provide  
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1754 728 comfort, i.e. reduce negative affect, specifically for high emotional eaters, at least during  
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1756 729 eating.  
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1763 <sup>3</sup> This may, however, not be as easy as it sounds. For study 2, where this last mood assessment took place during  
1764 the food intake, this would for example mean that also the assessment of tastiness should have taken place during  
1765 the food intake (for example with a bogus taste test). A problem with such a taste test is that it could make  
1766 people aware that their food intake is being measured, which could affect the amount of food consumed. This  
1767 could be particularly true for people with high scores on emotional eating (Van Strien et al., 2012, p283, footnote  
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1773 730  
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1775 731 Conflict of interest  
1776  
1777 732 Tatjana van Strien has a copyright and royalty interest in the Dutch Eating Behaviour  
1778  
1779  
1780 733 Questionnaire (DEBQ) and manual.  
1781  
1782 734  
1783  
1784 735 Role of funding source  
1785  
1786 736 Study 1 was funded in part by the Ministerio de Ciencia e Innovación (Plan Nacional de  
1787  
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1793  
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1804 744 Contributors  
1805  
1806 745 RB and AC oversaw the data collection of Study 1. TvS oversaw the data collection of Study  
1807  
1808 746 2, conducted all analyses and prepared the first draft of the manuscript. LG was responsible  
1809  
1810 747 for the second and final drafts of the manuscript. LW prepared the manuscript for submission.  
1811  
1812 748 All authors commented and contributed on drafts of the manuscript and approved the final  
1813  
1814 749 manuscript.  
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Table 1. Pearson correlations for associations between variables in Study 1 and descriptive statistics ( $n=29$ )

	Decrease in sadness <sup>a</sup>	Increase in happiness <sup>a</sup>	Energy intake (kcal)	Eating satisfaction	Pre-sad	Pre- joy	Guilty	BMI
Increase in happiness <sup>a</sup>	-							
Energy intake	-0.42*	0.20						
Eating satisfaction	-0.65**	0.58*	0.50**					
Baseline sad	0.50*	-0.26	-0.12	-0.33				
Baseline happy	-0.25	0.48*	0.15	0.06	-0.22			
Guilty	0.38	-0.37	0.23	-0.18	0.36	-0.29		
BMI	-0.15	-0.18	-0.14	0.19	-0.27	-0.04	-0.06	
mean	-	-	157.41	4.52	1.55	5.14	1.69	22.32
SD	-	-	110.25	1.64	0.87	1.16	1.23	3.35

\*  $p < .05$ ; \*\*  $p < .01$ ; <sup>a</sup> partial correlations (T3 sadness, or happiness, respectively controlling for T2 sadness, or T2 happiness); decrease in sadness is reflected by a negative score; increase in happiness is reflected by a positive score.



Table 2. Pearson correlations for associations between variables in Study 2 and descriptive statistics ( $n=74$ )

	AUCg stress	Total Energy (kcal)	“Lekker” (tastiness)	Emotional eating	Negative Affect - control	Hunger control	Hunger stress	Snack Energy (kcal)
Total energy (kcal)	0.15							
“Lekker” (tastiness)	0.13	-0.20						
Emotional eating	0.18	0.14	0.09					
Negative Affect-control	-0.31**	-0.02	0.06	-0.01				
Hunger control	0.18	-0.10	0.03	0.06	0.01			
Hunger stress	0.31*	0.30**	0.16	0.17	0.05	0.42**		
Snack energy (kcal)	0.15	0.99	-0.22	0.14	-0.04	-0.08	0.27*	
Mean	5.05	44.41	3.68	2.84	-0.11	5.77	4.82	40.37
SD	1.98	187.04	0.59	1.11	0.24	2.35	2.37	180.17

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

Figure Captions.

**Figure 1.** Statistical pathway diagram of the mediation analysis of eating satisfaction (M) between food intake (X) and decrease in sadness (Y) in Study 1 ( $n=29$ ). Unstandardized beta coefficients (with bias-corrected and accelerated bootstrap 95% confidence intervals) are shown on the arrows. The coefficients are negative because greater food intake, or eating satisfaction, are associated with a larger decline in sadness. For details of these and additional pathway tests, see 2.3.3.

**Figure 2.** Statistical pathway diagram of the mediation analysis of eating satisfaction (M) between food intake (X) and increase in happiness (Y) in Study 1 ( $n=29$ ). Unstandardized beta coefficients (with bias-corrected and accelerated bootstrap 95% confidence intervals) are shown on the arrows. For details of these and additional pathway tests, see 2.3.3.

**Figure 3.** The values for negative mood in the control and the stress condition upon arrival (T1), immediately after the task (T2), after the message of having to wait for the jury's judgement on the performance (in the stress condition) (T3), and during the food intake (T4).

**Figure 4.** Statistical pathway diagram of the moderated mediation analysis of emotional eating (W) as moderator variable of the mediation model of tastiness (M) between food intake (X) and negative mood reactivity during distress (AUCg\_stress; Y) in Study 2 ( $n=74$ ). Unstandardized beta coefficients (with bias-corrected and accelerated bootstrap 95% confidence intervals) are shown on the arrows. For details of these and additional pathway tests, see 3.3.4.

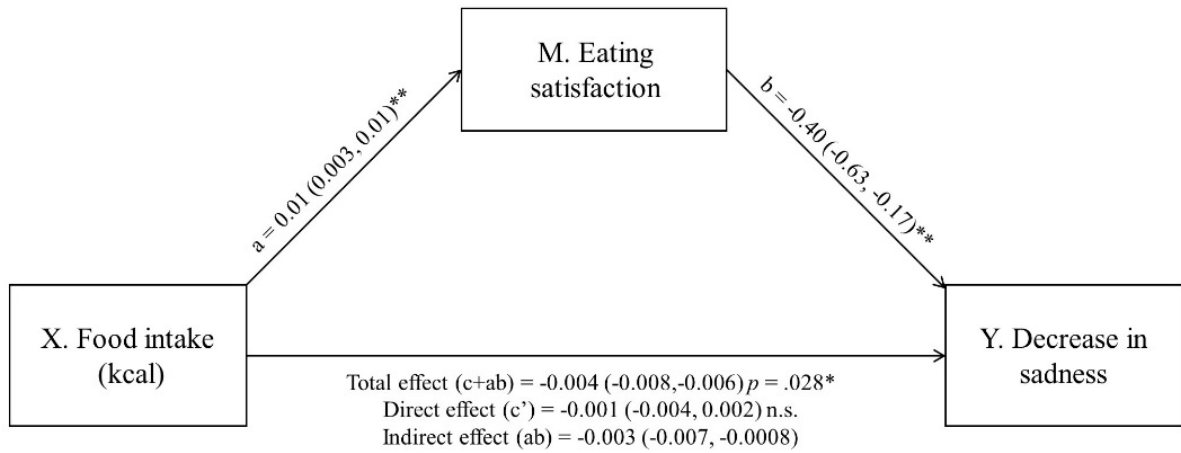


Figure 1.



Figure 2.

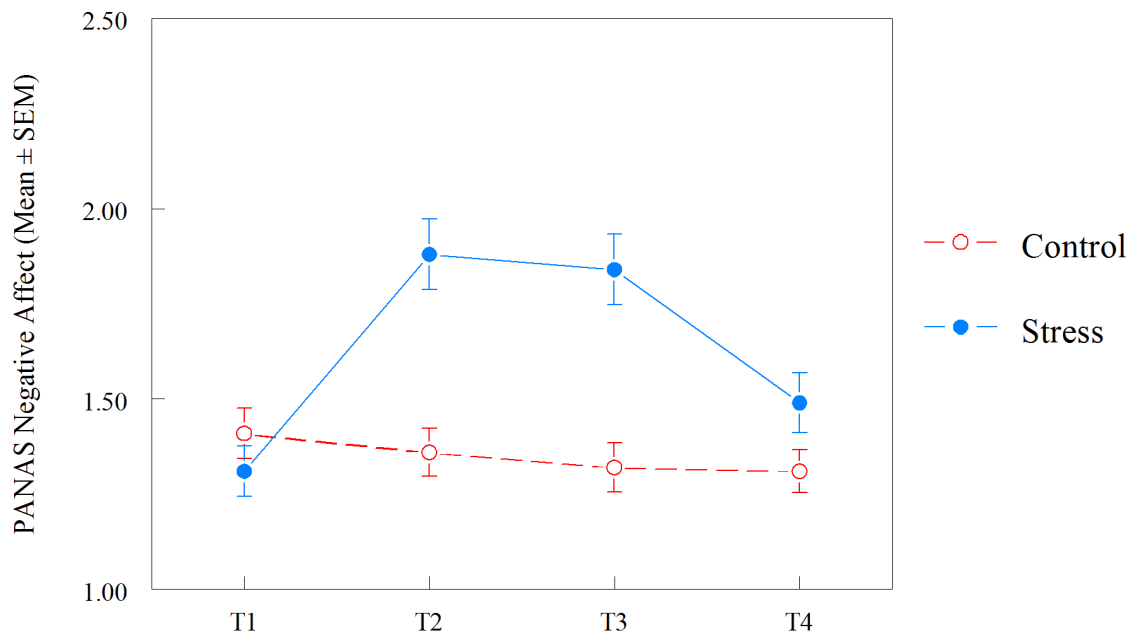


Figure 3.

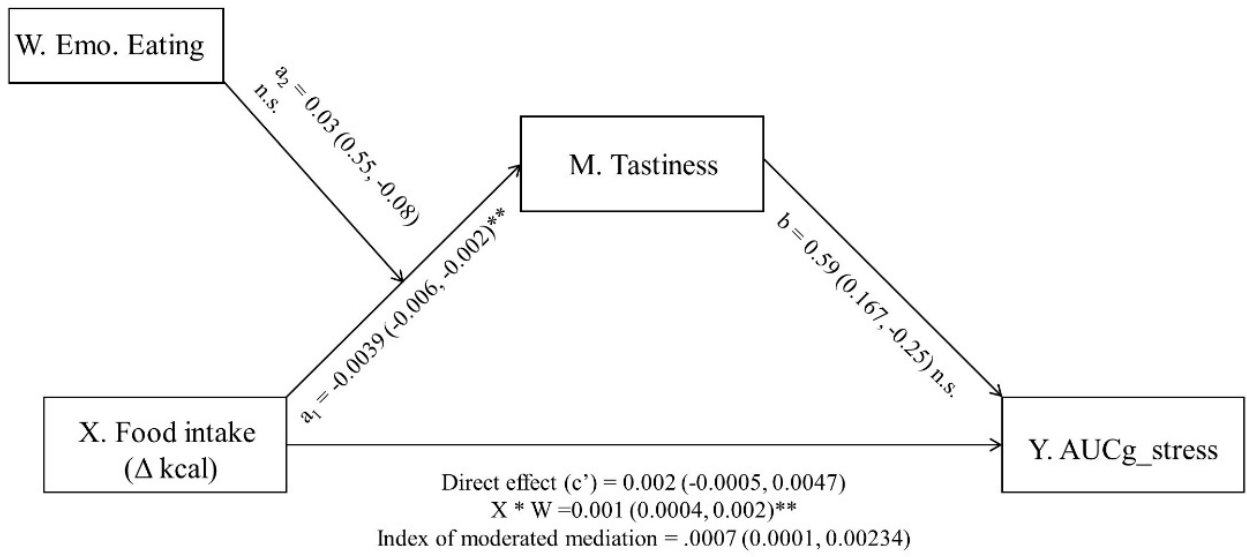


Figure 4.

