This is the accepted version of a paper to be published in the Swiss Journal of Psychology.

Please refer to the publisher's website for the final publication (planned for April 2018).

Transfer or Compensation? An Experiment Testing the Effects of Actual and Imagined Exercise on Eating

Jennifer Inauen*

Department of Environmental Social Sciences, Eawag: Swiss Federal Institute of Aquatic Science & Technology, Duebendorf, Switzerland

Department of Psychology, University of Zurich, Zurich, Switzerland

Theda Radtke

Department of Psychology, University of Zurich, Zurich, Switzerland

Laura Rennie

B-Research, Université Paris Ouest Nanterre La Défense, Paris, France

Urte Scholz

Department of Psychology & University Research Priority Program "Dynamics of Healthy Aging", University of Zurich, Zurich, Switzerland

Sheina Orbell

Department of Psychology, University of Essex, United Kingdom

* Correspondence concerning this article should be addressed to Jennifer Inauen, Eawag: Swiss Federal Institute of Aquatic Science & Technology, Department of Environmental Social Sciences, Environmental and Health Psychology, Ueberlandstrasse 133, 8600 Duebendorf, Switzerland, phone: +41 58 765 5780, fax: +41 58 765 5802, email: jennifer.inauen@eawag.ch

Abstract

This study tested the effects of exercise on eating. The transfer hypothesis proposes that exercise leads to generalization of healthy behavior and therefore improved diet. The compensation hypothesis assumes that exercise leads to increased calorie intake to "compensate" for the energy expenditure. We tested these hypotheses both for actual and imagined exercise. Female University members (*N*=227) were randomized to three experimental groups: actual exercise vs. imagined exercise vs. control. After baseline, participants engaged in a 5-minute experimental task. Thereafter, they were left alone with unhealthy snacks. Participants who imagined themselves exercising (*M*=101, *SD*=128 kcal) consumed significantly fewer calories than controls (*M*=129, *SD*=142 kcal), consistent with a transfer effect. Participants who engaged in actual exercise but were distracted from thinking about exercise consumed similar quantities (*M*=127, *SD*=111 kcal) as controls. This study suggests that transfer effects are underpinned by psychological processes, such as goal activation, which should be investigated in the future.

Keywords: Exercise; Physical activity; Imagery; Eating behavior; Spillover

Transfer or Compensation? An Experiment Testing the Effects of Actual and Imagined Exercise on Eating

Overweight and obesity are preventable health threats of growing concern (Houston, Nicklas, & Zizza, 2009). Exercising regularly and eating healthily are crucial factors that must be simultaneously addressed in order to maintain a healthy weight and prevent obesity (Kumanyika et al., 2008), but the interrelation of the two behaviors is not well understood (Leech, McNaughton, & Timperio, 2014). Some research points to the conclusion that performing exercise leads to decreased energy intake (transfer hypothesis; e.g., Mata et al., 2009). In contrast, other research suggests that exercise will be compensated for by increased energy intake (compensatory hypothesis; e.g., Martins, Morgan, Bloom, & Robertson, 2007).

Transfer and Compensatory Effects of Exercise on Eating Behavior

"Transfer is the process when lessons learned in one context are applied to another context." (Lippke, Nigg, & Maddock, 2012, p. 2). This phenomenon is sometimes also referred to as "spillover" (Dolan & Galizzi, 2015; Mata et al., 2009). For health behaviors, the transfer hypothesis predicts that behaving healthily in one behavioral domain leads to behaving healthily in another. This hypothesis has received support from several studies. Mata and colleagues (Mata et al., 2009) presented correlational evidence that increased physical activity predicted increased eating regulation in the context of a weight management intervention. These results were replicated in other correlational studies in the context of interventions that targeted both increased exercise and eating regulation (Annesi & Mareno, 2015; Annesi & Marti, 2011; Annesi & Porter, 2013) as well as in observational studies (Fleig, Kerschreiter, Schwarzer, Pomp, & Lippke, 2014; Fleig, Küper, Lippke, Schwarzer, & Wiedemann, 2015; Lippke et al., 2012; Simms, Bock, & Hackett, 2014). Although these studies lend some support to the assumption of transfer between exercise and eating behavior, causal inferences cannot be drawn due to their correlational nature. Also, a confounding factor of these previous intervention studies is that most of them not only targeted exercise, but also included behavior change techniques to promote eating regulation (Annesi & Mareno, 2015; Annesi & Marti, 2011; Annesi & Porter, 2013; Mata et al., 2009). We found two studies that promoted exercise without simultaneously targeting eating behavior. Halliday and colleagues (2014) reported significant reductions in energy intake and other dietary intake variables in participants of a resistance training. In line with this, Fleig, Lippke, Pomp, and Schwarzer (2011) found that participants of an exercise promoting intervention, compared to a control group, showed increased fruit and vegetable consumption at follow-up. Furthermore, one controlled experiment supports the transfer hypothesis: Oh and Taylor (Oh & Taylor, 2014) revealed that moderate and vigorous physical activity reduced attentional bias for snacks compared to a no-exercise control, and also reduced the desire to snack. Snacking behavior was not assessed, however, which represents a further weakness of most studies testing the transfer hypothesis.

Transfer effects have generally been explained in terms of psychological processes. For example, the compensatory carry-over action model (Lippke, 2014) proposes that engaging in one health behavior (e.g., physical activity), activates higher-level goals (e.g., changing body weight), and—if these goals are emotionally relevant and incorporated into self-identity—this then results in behavior change in a related domain that serves the same higher-level goal (e.g., nutrition). Others have demonstrated that transfer effects are partly mediated by changes in self-regulation, self-efficacy, and mood (Annesi & Mareno, 2015), or cognitions regarding transfer effects (“when I exercise regularly it is easier for me to eat healthily” or “when I exercise regularly it is easier to make plans for my nutrition", Fleig et al., 2014, p. 1365). Furthermore, transfer effects may be explained by a transfer of experienced self-regulatory resources during successful goal pursuit (Paech & Lippke, 2017), or by increased habit strength that may facilitate related behaviors (Tobias, 2009).

In direct opposition to the transfer hypothesis, the compensatory hypothesis proposes that people often compensate for healthy gains in one domain by engaging in unhealthy behaviors in a different domain. For example, people might compensate for energy expended during exercise by subsequently increasing energy intake (e.g., Martins et al., 2007; Verger, Lanteaume, & Louis-Sylvestre, 1994). Martins et al. (2007) found support for this hypothesis in their experimental manipulation of moderate to vigorous exercise, which produced increased post-exercise energy intake. However, accounting for energy expended during the exercise indicated an overall decrease in energy expenditure compared to when persons were resting. The authors explain these effects in physiological terms; increased physical activity generates an energy deficit and therefore an increased desire to eat.

Interestingly, some studies have shown that just thinking about physical activity can increase eating (e.g., Werle et al., 2011), suggesting that the effect may be at least in part psychological instead of physiological, that is, not explained by an actual energy deficit. Such an effect is in line with research on imagery in sport psychology. When persons imagine themselves exercising, they recall past exercise events or imagine new ones (Morris, Spittle, & Watt, 2005), and such cognitive simulations show similar neural activity, heart rate, and breathing as during actual exercise (Moran, Guillot, MacIntyre, & Collet, 2012). For example, Werle and colleagues (2011) demonstrated that participants who imagined themselves going for a walk subsequently helped themselves to more high-calorie snacks than those who did not engage in this mental task.

However, the control group did not engage in any kind of mental task, meaning that the observed effects could be due to task demands. Further support for the idea that compensatory eating is influenced by psychological processes comes from research showing that the way physical activity is understood affects compensatory eating (Fenzl, Bartsch, & Koenigstorfer, 2014; Werle, Wansink, & Payne, 2015).

In summary, there is some support for both the transfer and the compensatory hypothesis. Furthermore, there are some studies showing no effects of exercise on eating behavior (Bozinovski et al., 2009; Ottevaere et al., 2011; Wilcox, King, Castro, & Bortz, 2000). This is clearly an area of research that warrants further investigation. Also, many previous studies are correlational (e.g., Leech et al., 2014) or lack appropriate control groups to determine the direction of the effects (e.g., Werle et al., 2015). What is more, actual eating behavior was often not assessed (e.g., Mata et al., 2009). Finally, an open question concerns whether the effects of exercise on eating behavior occur for both actual and imagined exercise. Knowledge on this would help clarify whether the effects are mainly psychological or physiological. The results of studies on imagined exercise and presenting exercise-related information indicates a psychological effect, but these studies did not simultaneously investigate actual exercise. The studies with actual exercise, in turn, did not clearly disentangle physiological from psychological processes (e.g. by ensuring that persons did not think about exercise). This may be one reason for the inconsistent effects of exercise on eating behavior found in the literature.

The Present Study

Given the contradictory findings and methodological limitations in previous research we decided to conduct a controlled test of the effects of brief exercise on subsequent, objectively assessed eating behavior that might clarify transfer versus compensatory effects. Further, given recent evidence that thinking about exercise and actual exercise may operate via different processes, we included both an imagined exercise condition and an actual exercise condition with a distractor task. Thus, there were three experimental groups: an actual exercise group in which participants were cognitively occupied with a non-exercise-related distractor task, a group who imagined themselves exercising, and a control group who imagined themselves participating in a non-exercise-related activity. This allowed us to test the effect of exercise (vs. no exercise) on subsequent consumption, both for imagined exercise and for actual exercise. Due to the equivocal results of previous research, we tested both the transfer and the compensatory hypothesis. Support for the transfer hypothesis is found if persons who engage in actual (H1a) or in imagined exercise (H1b) subsequently eat fewer unhealthy snacks than persons in a no-exercise control condition. In contrast, the compensatory hypothesis is supported if persons who engage in actual (H2a) or in imagined exercise (H2b) subsequently eat more unhealthy snacks than persons in a no-exercise control condition. Besides the insights into the directionality of the effects of brief exercise on subsequent eating, this research may also have potential implications for practice. If the transfer hypothesis is supported, for example, brief actual or imagined exercise prompts (e.g. via text messages) may be used as ecological momentary interventions (Heron & Smyth, 2010) to prevent snacking related self-regulation failure that is known to occur in daily life (Inauen, Shrout, Bolger, Stadler, & Scholz, 2016).

Methods

Participants

In this controlled experiment, participants were randomly assigned to one of three groups: actual exercise, imagined exercise, or the control group. Participants were recruited by email invitations advertising a study on how sensory experiences impact on human imagination. As an incentive, the invitation stated that participants would be entered in a lottery to win an iPad (app. USD 550) or one of two travel vouchers of app. USD 160.

A priori sample size estimation with G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) indicated that 210 participants would be required to detect a small effect (d = 0.25) at 95% power and an Alpha error probability of p = 0.05. In total, 227 female employees or students of two German Universities responded to an email invitation, and met all inclusion criteria: being between 14-70 years old, speak German, not studying psychology, no allergies to the study foods, no diabetes. Of the enrolled participants, 12 were excluded: four indicated at baseline that they were fasting or otherwise unable to eat, six persons suspected that the snacks were part of the study, and in two cases, procedural errors occurred. The 215 analyzed subjects were aged 18-61 (M = 28.4, SD = 9.6), and had a mean body mass index (BMI) of 23.2 (SD = 3.9). The majority (67.1%) were undergraduate or Master's students, 11.4% were PhD students, 19.0% were employed or self-employed, and 2% were unemployed or other.

Procedures

This study was approved by the Ethics Committee of the University of Konstanz. All participants gave their written consent before participating in the study, and were thoroughly debriefed at the end of their appointments.

An initial online survey assessed the above mentioned inclusion criteria and control variables: age, intention to eat fewer sweet and salty snacks ("I resolved to eat fewer sweet and salty snacks [e.g., cake or peanuts]"; 1 = not at all to 9 = very strongly), and time engaged in physical activity the week before the study, using the validated physical activities frequency questionnaire (PAFQ; Bernstein et al., 1998). At the subsequent individual lab appointments, participants were randomly assigned to one of the three conditions using a block-randomized list. The scheduling of appointments and randomization was done by different researchers. The randomization list was concealed until the arrival of each participant. The participants were blind to condition.

Participants took part in the study in the mornings, at lunch time, or in the afternoon (except two participants who came in the evening). The number of participants was equally distributed across the day times, and the time of participation did not differ significantly across conditions. On arrival at the lab, after signing a consent form, participants filled in a brief survey, including items assessing hunger and thirst (“At the moment I am feeling hungry/thirsty”; 1=not at all true to 9=exactly true) to be used as control variables. To minimize the chance that participants may be prompted that food consumption was part of the study, these items were mixed with questions that assessed positive and negative affect. Furthermore, participants were asked if they would mind filling in a brief questionnaire for a colleague of the investigators directly after the present study. This favor was later used as an excuse to present the participants with snacks. All participants agreed to this additional favor. Then, participants were instructed to engage in their assigned task.

Experimental Manipulations

The task for participants in the actual exercise condition was to step on an aerobic step while focusing on a white poster to imagine colors and shapes appearing on it. This latter part of the task was to ensure that participants did not think about exercise while stepping[1]. The task in the imagined exercise condition, in an effort to keep the exercise activity similar to the stepping

---

[1] We chose this as the imagination task rather than paralleling the task with the control group to ascertain that participants did not imagine music that enhanced their exercise experience (e.g., an up-tempo classical concert).

condition, was to imagine walking upstairs. To support this scenario, participants were asked to focus on a poster of the Empire State Building, and to imagine participating in the Empire State Building Run-Up. Finally, the participants in the control condition were asked to focus on a poster of a philharmonic orchestra in a concert hall, and to imagine attending a classical concert.

All experimental tasks were set at 5-minute duration; a bearable amount of time to imagine colors, exercise, and music with little sensory input according to pretest. After the 5-minute task, participants completed a thought-listing task as a manipulation check. Participants were instructed to write down the thoughts they had encountered during the imagination task in detail. This was done to ascertain that participants in the actual exercise and control conditions had not thought of exercise, and that participants in the imagined exercise condition had. The number of exercise related thoughts was later coded by two independent raters (Intraclass correlation: .884 [CI_{95} = .840, .916]).

Assessment of Eating Behavior

After completing these measures, participants called the experimenter in the next room, as instructed. The experimenter checked the questionnaire for completeness, and then ostensibly discovered with horror that the questionnaire was missing the last pages. Under the pretext of having to go to print the missing pages in another building, the experimenter asked the participant to fill in the questionnaire for the investigators' colleague, which participants had previously agreed to. To "thank" participants for their help, the experimenter offered snacks: pre-weighed crisps (100g) and mini chocolate cookies (140g), served in two separate bowls[2]. These snacks were selected because they were rated as the most appetitive in a pilot study. After 10

[2] We aimed at visually matching the volume of the sweet and the salty snack option, rather than standardizing the weight. Therefore, more sweet snacks were served to match the greater volume of the crisps.

minutes, the experimenter returned and presented the participant with final questions, measured participants' height and weight for assessing their BMI, and finally debriefed and thanked them. After the participant had left, the experimenter weighed the remaining snacks and calculated the calories of the snacks consumed as an objective behavioral measure.

Data Analysis

To assess whether the experimental manipulations were successful, the texts from the thought-listing task were coded to determine whether the imagination experiences reflected the experimental manipulations.

To detect effects of actual and imagined exercise on the calories consumed, an ANOVA with two planned contrasts was conducted: comparing the actual exercise group to the control group, and comparing the imagined exercise group to the control group. Prior to analyses, the dependent variable, calories consumed, was log transformed to correct for the skewed distribution. For ease of interpretation raw means are reported in descriptive statistics. As a sensitivity test, we re-ran the analyses adjusting for number of exercise related thoughts reported in the thought listing task, age, BMI, baseline physical activity, baseline intention to eat less sweet and salty food, hunger and thirst (in parallel to Radtke et al., 2014).

Results

The baseline descriptive statistics for the three experimental conditions, and the randomization check are presented in Table 1, the intercorrelations between the study variables can be found in Table 2. Overall, participants were on average 28.4 years old (*SD*=9.3 years), of normal BMI (*M*=23.2, *SD*=3.9), and physically active for *M*=9.6 (*SD*=5.8) hours the week prior to T1. On arrival at the lab, participants reported that they were moderately hungry (*M*=4.2, *SD*=2.5 on a 9-point scale), and hardly thirsty (*M*=2.2, *SD*=1.9). There were no significant between-group differences at baseline regarding age, BMI, intention to eat less sweet and salty food, thirst, or hunger.

<<<<< ENTER TABLE 1 AND 2 ABOUT HERE >>>>>

Manipulation Check

Results from the thought-listing task indicated that the manipulation was successful. 96.0% of control group participants mentioned no exercise-related thoughts, 2.7% had one thought, and 1.3% had two thoughts. The predominant emotion in the control group was relaxation, and the focus lay on the acoustic experience. In the imagined exercise condition, 7.9% reported no exercise-related thoughts, and 92.1% participants reported between 1-9 exercise-related thoughts (*M* = 3.2, *SD* = 2.1). Of the participants in the actual exercise condition, in line with our aims, 96.1% reported no exercise related thoughts, and 3.9% had one or two thoughts. 23.7% reported relaxation or calming down as the predominant emotion.

Effects of Actual and Imagined Exercise on Subsequent Eating Behavior

Control group participants consumed *M*=129 kcal (*SD*=142), whereas actual exercise participants consumed *M*=127 kcal (*SD*=111), and imagined exercise participants consumed *M*=101 kcal (*SD*=128). See Figure 1. There was a significant main effect of condition on log-transformed calorie consumption ($F[2, 215]=5.481$, $p=.005$). Planned contrasts with the control group revealed a significant difference in energy intake for imagined exercise compared to the control group. Participants in the imagined exercise group consumed fewer calories than control group participants ($B=-.84$, $SE=.34$, $p=.015$, $d=0.39$). No effects of actual exercise on eating behavior was found (H1a, and H2a): participants in the actual exercise group and the control group did not significantly differ in energy intake (*B*=.22, *SE*=.34, *p*=.529, *d*=0.12). Two sensitivity analyses were computed (see Tables S1-S4 in the appendix). First, the model was re-run, adjusting for age, BMI, baseline physical activity, baseline intention to eat less sweet and salty food as well as current hunger and thirst. In a second analysis, participants of the exercise and control conditions who had reported exercise-related thoughts, and those of the imagined exercise condition who had not reported exercise-related thoughts were excluded. In both analyses, the results remained substantively unchanged, providing further confidence in the findings.

<<<<< ENTER FIGURE 1 ABOUT HERE >>>>>

Discussion

The goal of the present experiment was to provide a controlled test of the hypothesis that exercise influences eating behavior. We compared both actual and imagined exercise to a no-exercise group in a controlled experiment, with an objective dependent measure. Findings showed that participants in the imagined exercise condition consumed significantly fewer calories than controls. In our study, this finding, which is consistent with a transfer effect hypothesis, was observed only for imagined exercise, and not for actual exercise. Participants in the exercise condition who were also distracted from thinking about exercise, ate as many snacks as controls. Effects could not be attributed to differences in baseline physical activity, baseline intention to avoid unhealthy snacks, nor to thirst, hunger, age or BMI across experimental conditions.

The result that imagined exercise leads to decreased eating compared to controls corroborates findings from several previous studies that indicated a transfer effect of exercise on eating behavior (Annesi & Marti, 2011; Annesi & Porter, 2013; Fleig et al., 2014; Fleig, Küper et al., 2015; Fleig et al., 2011; Lippke et al., 2012; Mata et al., 2009; Oh & Taylor, 2014; Simms et al., 2014). It is the first to find the transfer effect for imagined exercise on subsequent eating. The transfer finding contrasts with previous research that reported compensatory effects of imagined exercise on eating behavior (Werle et al., 2011, 2015), and research showing that exercise-related information can increase food consumption (Albarracin, Wang, & Leeper, 2009). One reason for these discrepancies may be that some previous studies lacked appropriate control groups. In Werle and colleagues' study (2015), for example, exercise was compared to an exercise-framed-as-fun condition. The results were interpreted as indicating that framing exercise increased consumption, even though it could have been the other way round: Fun may have decreased consumption. The present study does not confound this, because our control group did not exercise or think about exercise during the task. Also, one could criticize the use of taste tests as a behavioral measure in some of the past studies (Albarracin et al., 2009; Koenigstorfer, Groeppel-Klein, Kettenbaum, & Klicker, 2013), which have limited ecological validity. In turn, our study used a believable cover story to "license" participants to indulge, yet the group who had imagined exercise did not do so as much as the control group.

A number of psychological explanations may account for the transfer effect of imagined exercise observed here. For example, in line with construal-level theory, thinking about exercising might have activated higher-level goals of being healthy, which should have enhanced self-control and thus decreased eating (Trope & Liberman, 2010). This idea has also been proposed by the compensatory carry-over action model that proposes a link of physical activity and eating behavior through higher-level goals (Lippke, 2014). Another possible explanation for the effect is that persons may have transfer-facilitating cognitions (e.g., “If I stick to a balance diet on a regular basis . . . I automatically feel like being active”; Fleig, Ngo et al., 2015; Fleig et al., 2014). Also, the transfer effect may be understood with the concept of goal commitment (Fishbach & Dhar, 2005). Thinking about exercise may foster commitment to a health goal, rather than goal progress, depending on the attentional focus. Freund and Hennecke’s (2015) research suggests that focusing on the process, rather than the outcome, may make the difference. Whereas focus on the outcome can be considered goal progress, focusing on the process may indicate goal commitment. Participants in our study, according to their thought lists, experienced the process of running up the Empire State Building very vividly and in much detail, which may thus have indicated goal commitment. This commitment to exercise, in turn, may have activated other health behavior goals, causing transfer to eating behavior (Rennie & Uskul, 2014). Future research should test some of these explanations using controlled research designs.

In contrast to some studies, we found no effects of actual exercise on eating behavior. This is in line with several studies that did not find effects of exercise on eating behavior (Bozinovski et al., 2009; Ottevaere et al., 2011; Wilcox et al., 2000). One possible interpretation of our finding is that effects of exercise on eating behavior may be psychological rather than physiological. Our study is the first to distinguish actual exercise from thinking about exercise, by ensuring that participants in the exercise condition did not think about exercising during the task. Thereby, the activation of the health goal during exercise should have been inhibited and should not have been active at the time of food presentation. However, we did not test this mechanism here, and future studies are needed to investigate whether the health goal activation is indeed successfully impeded by this manipulation.

Limitations and Future Research

The interpretation of the effect being psychological rather than physiological is in line with the findings that imagining exercise (Werle et al., 2011) and presenting exercise-related information (Albarracin et al., 2009; Koenigstorfer et al., 2013) can affect eating behavior, without actually exercising. However, an alternative explanation of our finding is that our exercise condition was not strenuous enough to produce effects on eating. Participants in our study exercised on an aerobic step for five minutes. This duration was chosen to keep the task length parallel in all experimental conditions. Future studies should replicate this finding using longer exercise durations. Also, future studies should empirically test the potential mechanisms of transfer (e.g., health goal activation, transfer of self-regulatory resources).

Further limitations of our study relate to external validity. To provide a strong causal test of the exercise-eating relationship, we conducted a controlled lab experiment, and showed that briefly imagining exercise can reduce subsequent unhealthy eating. It is a question to be addressed by future research whether this brief task can promote healthier eating choices in real life, and in the longer term. This can be investigated using brief actual or imagined exercise prompts (e.g. via text messages) as ecological momentary interventions (Heron & Smyth, 2010) to prevent snacking related self-regulation failure that is known to occur in daily life (Inauen, Shrout, Bolger, Stadler, & Scholz, 2016).

Furthermore, our sample consisted of healthy individuals on average. It is therefore possible that the transfer effect is only found for persons with relatively normal BMI, as was the case in our sample. In contrast, compensatory effects may be found for persons with less healthy eating habits. Although our data did not indicate an effect of BMI or intention to avoid unhealthy snacks on the exercise-eating relationship, future studies should investigate this with a sample of overweight and obese individuals, and also test for interactive effects of eating related intentions and exercise on eating.

Conclusions

Exercise and regulating eating behavior are central to maintaining a healthy weight and prevent disease (Kumanyika et al., 2008). A growing literature addresses how these two behaviors may interact. The present research showed that asking persons to imagine themselves exercising had beneficial effects on subsequent eating behavior, by reducing consumption of high-calorie snacks. This finding emphasizes the importance of psychological processes in health behavior change, and hints that a more mindful approach when engaging in health behaviors can benefit related behaviors. However, the processes underlying these effects and its preconditions need further study before definitive recommendations can be made that can improve behavior change interventions to prevent overweight and obesity.

Author Note

The authors thank Milena Kost and further student assistants for their support in carrying out the data collection. This research received financial support from the Konstanz/Essex Development Fund. While writing this paper, the first author was supported by a fellowship of the Swiss National Science Foundation (Fellowship P2ZHP1_155103).

References

Albarracin, D., Wang, W., & Leeper, J. (2009). Immediate increase in food intake following exercise messages. *Obesity*, *17*(7), 1451–1452. https://doi.org/10.1038/oby.2009.16

Annesi, J. J., & Mareno, N. (2015). Indirect effects of exercise on emotional eating through psychological predictors of weight loss in women. *Appetite*, *95*, 219–227. https://doi.org/10.1016/j.appet.2015.07.012

Annesi, J. J., & Marti, C. N. (2011). Path analysis of exercise treatment-induced changes in psychological factors leading to weight loss. *Psychology & Health*, *26*(8), 1081–1098. https://doi.org/10.1080/08870446.2010.534167

Annesi, J. J., & Porter, K. J. (2013). Reciprocal effects of treatment-induced increases in exercise and improved eating, and their psychosocial correlates, in obese adults seeking weight loss: A field-based trial. *The International Journal of Behavioral Nutrition and Physical Activity*, *10*. https://doi.org/10.1186/1479-5868-10-133

Bernstein, M., Sloutskis, D., Kumanyika, S., Sparti, A., Schutz, Y., & Morabia, A. (1998). Data-based approach for developing a physical activity frequency questionnaire. *American Journal of Epidemiology*, *147*(2), 147–154.

Bozinovski, N., Bellissimo, N., Thomas, S., Pencharz, P., Goode, R., & Anderson, G. H. (2009). The effect of duration of exercise at the ventilation threshold on subjective appetite and short-term food intake in 9 to 14 year old boys and girls. *International Journal of Behavioral Nutrition and Physical Activity*, *6*(1), 66. https://doi.org/10.1186/1479-5868-6-66

Dolan, P., & Galizzi, M. M. (2015). Like ripples on a pond: behavioral spillovers and their implications for research and policy. *Journal of Economic Psychology*, *47*, 1–16. https://doi.org/10.1016/j.joep.2014.12.003

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Fenzl, N., Bartsch, K., & Koenigstorfer, J. (2014). Labeling exercise fat-burning increases post-exercise food consumption in self-imposed exercisers. *Appetite*, *81*, 1–7. https://doi.org/10.1016/j.appet.2014.05.030

Fishbach, A., & Dhar, R. (2005). Goals as excuses or guides: The liberating effect of perceived goal progress on choice. *Journal of Consumer Research*, *32*(3), 370–377. https://doi.org/10.1086/497548

Fleig, L., Kerschreiter, R., Schwarzer, R., Pomp, S., & Lippke, S. (2014). ‘Sticking to a healthy diet is easier for me when I exercise regularly’: Cognitive transfer between physical exercise and healthy nutrition. *Psychology & Health*, *29*(12), 1361–1372. https://doi.org/10.1080/08870446.2014.930146

Fleig, L., Küper, C., Lippke, S., Schwarzer, R., & Wiedemann, A. U. (2015). Cross-behavior associations and multiple health behavior change: A longitudinal study on physical activity and fruit and vegetable intake. *Journal of Health Psychology*, *20*(5), 525–534. https://doi.org/10.1177/1359105315574951

Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. (2011). Intervention effects of exercise self-regulation on physical exercise and eating fruits and vegetables: A longitudinal study in orthopedic and cardiac rehabilitation. *Special Section: Breast Cancer Screening*, *53*(3), 182–187. https://doi.org/10.1016/j.ypmed.2011.06.019

Fleig, L., Ngo, J., Roman, B., Ntzani, E., Satta, P., Warner, L. M.,. . . Brandi, M. L. (2015). Beyond single behaviour theory: Adding cross‐behaviour cognitions to the health action process approach. *British Journal of Health Psychology.* Advance online publication. https://doi.org/10.1111/bjhp.12144

Freund, A. M., & Hennecke, M. (2015). On means and ends: The role of goal focus in successful goal pursuit. *Current Directions in Psychological Science*, *24*(2), 149–153. https://doi.org/10.1177/0963721414559774

Halliday, T. M., Davy, B. M., Clark, A. G., Baugh, M. E., Hedrick, V. E., Marinik, E. L.,. . . Winett, R. A. (2014). Dietary intake modification in response to a participation in a resistance training program for sedentary older adults with prediabetes: Findings from the Resist Diabetes study. *Eating Behaviors*, *15*(3), 379–382. https://doi.org/10.1016/j.eatbeh.2014.04.004

Heron, K. E., & Smyth, J. M. (2010). Ecological momentary interventions: Incorporating mobile technology into psychosocial and health behaviour treatments. *British Journal of Health Psychology*, *15*, 1–39. https://doi.org/10.1348/135910709X466063

Houston, D. K., Nicklas, B. J., & Zizza, C. A. (2009). Weighty concerns: The growing prevalence of obesity among older adults. *Journal of the American Dietetic Association*, *109*(11), 1886–1895. https://doi.org/10.1016/j.jada.2009.08.014

Inauen, J., Shrout, P. E., Bolger, N., Stadler, G., & Scholz, U. (2016). Mind the gap? An intensive longitudinal study of between-person and within-person intention-behavior relations. *Annals of Behavioral Medicine*, 1–7. https://doi.org/10.1007/s12160-016-9776-x

Koenigstorfer, J., Groeppel-Klein, A., Kettenbaum, M., & Klicker, K. (2013). Eat fit. Get big? How fitness cues influence food consumption volumes. *Appetite*, *65*, 165–169.

Kumanyika, S. K., Obarzanek, E., Stettler, N., Bell, R., Field, A. E., Fortmann, S. P.,. . . Poston, W. C. (2008). Population-based prevention of obesity: The need for comprehensive promotion of healthful eating, physical activity, and energy balance. *Circulation*, *118*(4), 428–464.

Leech, R., McNaughton, S., & Timperio, A. (2014). The clustering of diet, physical activity and sedentary behavior in children and adolescents: a review. *International Journal of Behavioral Nutrition and Physical Activity*, *11*(1), 4. https://doi.org/10.1186/1479-5868-11-4

Lippke, S. (2014). Modelling and supporting complex behavior change related to obesity and diabetes prevention and management with the compensatory carry-over action model. *Journal of Diabetes and Obesity*, *1*, 1–5. https://doi.org/10.15436/2376-0494.14.009

Lippke, S., Nigg, C. R., & Maddock, J. E. (2012). Health-promoting and health-risk behaviors: Theory-driven analyses of multiple health behavior change in three international samples. *International journal of behavioral medicine*, *19*(1), 1–13. https://doi.org/10.1007/s12529-010-9135-4

Martins, C., Morgan, L. M., Bloom, S. R., & Robertson, M. D. (2007). Effects of exercise on gut peptides, energy intake and appetite. *Journal of Endocrinology*, *193*(2), 251–258. https://doi.org/10.1677/JOE-06-0030

Mata, J., Silva, M. N., Vieira, P. N., Carraça, E. V., Andrade, A. M., Coutinho, S. R.,. . . Teixeira, P. J. (2009). Motivational “spill-over” during weight control: Increased self-determination and exercise intrinsic motivation predict eating self-regulation. *Health Psychology*, *28*(6), 709. https://doi.org/10.1037/a0016764

Moran, A., Guillot, A., MacIntyre, T., & Collet, C. (2012). Re‐imagining motor imagery: Building bridges between cognitive neuroscience and sport psychology. *British Journal of Psychology*, *103*(2), 224–247. https://doi.org/10.1111/j.2044-8295.2011.02068.x

Morris, T., Spittle, M., & Watt, A. P. (2005). *Imagery in sport*. Champaign, IL: Human Kinetics.

Oh, H., & Taylor, A. H. (2014). Self-regulating smoking and snacking through physical activity. *Health Psychology*, *33*(4), 349–359. https://doi.org/10.1037/a0032423

Ottevaere, C., Huybrechts, I., Beghin, L., Cuenca-Garcia, M., Bourdeaudhuij, I. de, Gottrand, F.,. . . HELENA Study Group. (2011). Relationship between self-reported dietary intake and physical activity levels among adolescents: The HELENA study. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 8. https://doi.org/10.1186/1479-5868-8-8

Paech, J., & Lippke, S. (2017). Put two (and two) together to make the most of physical activity and healthy nutrition – A longitudinal online study examining cross-behavioural mechanisms in multiple health behaviour change. *Research in Sports Medicine*, 1–16. https://doi.org/10.1080/15438627.2017.1314287

Rennie, L. J., & Uskul, A. K. (2014). *Imagining exercise from a third- versus a first-person perspective: Implications for healthy and unhealthy behaviour*. Paper presented at International Conference of Applied Psychology, July 2014, Paris, France.

Simms, K., Bock, S., & Hackett, L. (2014). Do the duration and frequency of physical education predict academic achievement, self-concept, social skills, food consumption, and body mass index? *Health Education Journal*, *73*(2), 166–178. https://doi.org/10.1177/0017896912471040

Tobias, R. (2009). Changing behavior by memory aids: A social psychological model of prospective memory and habit development tested with dynamic field data. *Psychological review*, *116*(2), 408–438. https://doi.org/10.1037/a0015512

Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological review*, *117*(2), 440–463. https://doi.org/10.1037/a0018963

Verger, P., Lanteaume, M. T., & Louis-Sylvestre, J. (1994). Free food choice after acute exercise in men. *Appetite*, *22*(2), 159–164.

Werle, C. O. C., Wansink, B., & Payne, C. R. (2011). Just thinking about exercise makes me serve more food. Physical activity and calorie compensation. *Appetite*, *56*(2), 332–335. https://doi.org/10.1016/j.appet.2010.12.016

Werle, C. O. C., Wansink, B., & Payne, C. R. (2015). Is it fun or exercise? The framing of physical activity biases subsequent snacking. *Marketing Letters*, *26*(4), 691–702. https://doi.org/10.1007/s11002-014-9301-6

Wilcox, S., King, A. C., Castro, C., & Bortz, W. (2000). Do changes in physical activity lead to dietary changes in middle and old age? *American Journal of Preventive Medicine*, *18*(4), 276–283. https://doi.org/10.1016/S0749-3797(00)00117-3

Table 1

Baseline Descriptive Statistics for the Three Experimental Conditions and Randomization Check

	Actual physical activity *n*=73			Imagined physical activity *n*=73			Control *n*=69			ANOVA	
	M	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range	*F*(df1, df2)	*p*
Age	28.4	9.3	19, 52	29.1	10.6	18, 61	27.8	8.9	18, 57	0.32(2, 212)	0.724
BMI	22.9	3.7	16, 36	23.0	3.7	13, 36	23.6	4.3	18, 36	0.66(2, 208)	0.520
Behavioral intention[1]	5.4	3.2	1, 9	5.6	2.9	1, 9	5.5	3.0	1, 9	0.08(2, 209)	0.927
Physical activity[2]	8.9	5.9	0.6, 19.1	9.0	5.6	.1, 19.1	10.8	5.9	1.3, 19.1	2.29(2, 211)	0.104
Thirst	4.6	2.4	1, 9	4.1	2.5	1, 9	4.0	2.5	1, 9	1.53(2, 211)	0.219
Hunger	2.3	1.9	1, 8	2.1	1.8	1, 9	2.3	2.3	1, 9	0.38(2, 212)	0.683

Note. BMI=Body Mass Index. [1]Intention to consume fewer sweet and salty snacks. [2]Hours per week.

Table 2

Pearson Correlations of the Study Variables

	1	2	3	4	5	6
1. Calories consumed[1]						
2. Age	-0.26***					
3. BMI	-0.12	0.11				
4. Behavioral intention[2]	0.06	0.01	0.28***			
5. Physical activity[3]	-0.12	0.10	0.13	-0.04		
6. Hunger	0.06	-0.19**	-0.02	0.04	0.16*	
7. Thirst	0.10	-0.08	-0.11	0.07	0.02	0.33***

Note. BMI=Body Mass Index. [1]Log transformed due to skewed distribution. [2]Intention to consume fewer sweet and salty snacks. [3]Hours per week.

* p<.05, **p<.01, ***p<.001.

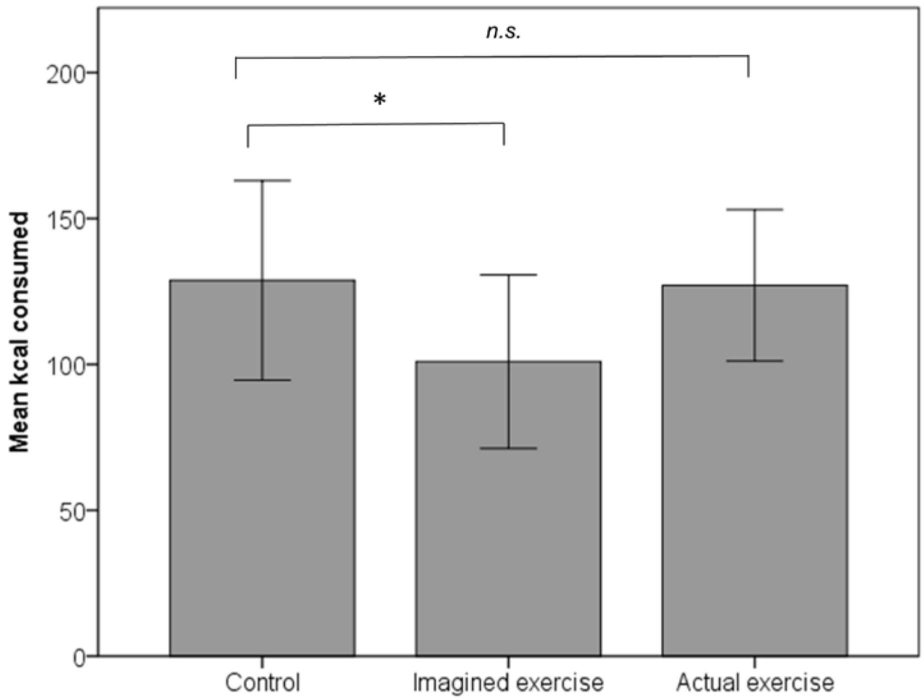

Figure 1. Calories (kcal) consumed by condition. Note that the mean values of the calories consumed are displayed, but the ANOVA was calculated using the logarithmically transformed calories to account for the skewed distribution,* p = .015; n.s. p = .529.