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Associative learning and high-level cognitive processes in the control of food-related behaviors

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We are under constant pressure to make decisions about what, when, and how much to eat. Under these circumstances, the interactions among associative learning, rule-based learning, and cognitive control are critical to predict our food-related behaviors. This selective review summarizes some of the key findings from the last years to provide an introductory overview of the interplay of these constructs in the food context. Evidence from inhibitory-control training suggests that understanding of fundamental associative processes may be a relevant prerequisite for gaining insight into high-level cognitive control. Moreover, investigating associative processes in executive-control paradigms will lead not only to the discovery of novel food-related learning phenomena, but it will also be the central challenge for the next generation of behavior-change interventions targeting disordered eating.

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From associative learning to high-level cognitive control

We are under constant pressure to make decisions about what, when, and how much to eat; in combination with physiological and environmental factors such as hunger, dietary goals, the time of day, or social influences. Under these circumstances, a key characteristic of food-related behaviors is that they are shaped as a result of experience and learning. In the last few decades and in the context of dual-process models [1–5], theorists have focused on the idea that we have two separate systems that produce learning: associative learning versus propositional/rule-based learning [6]. In the first case, learning produces a change in behavior after the establishment of associations between different events (such as stimuli and behaviors) by detecting their contingencies. Associative learning itself encompasses different subclasses: most importantly, Pavlovian learning (i.e. changes in behavior due to the pairing of stimuli), goal-directed instrumental learning (i.e. due to the pairing of responses with stimuli), and habits (i.e. due to the pairing of stimuli with responses). The impact of associative learning in the human dietary context [7] may be observed, for example, during the development of a preference for a new food as a result of liking the novel flavor along with the positive nutritive consequences that derive from eating that particular food. By contrast, rule-based learning comprises hypothesis testing and the induction of sets of rules underlying a problem [8]. It is structured by abstract representations and often with conscious awareness of the step of information processing as, for example, when we are comparing nutrition labels in the grocery store [9] to make healthier food choices. Unfortunately, although it is accepted that both learning systems contribute to eating behaviors, the nature of their interactions to promote food responses is elusive. Indeed, whether both are separate learning systems running independently side-by-side or rather interact in the control of food-related behaviors remains largely unexplored.

Notably, one major traditional distinction between both systems of learning has involved the engagement of executive (or cognitive) control [6]. While the rule-based mechanisms appear to rely heavily on executive control, associative learning mechanisms are traditionally assumed to be independent of resources, effort, and executive control. Although many constructs are related to executive control (e.g. effortful control, top-down control, ego control, or self-control; see [10] for more details), it refers here to the ability to coordinate thought and action and direct them toward obtaining goals. To do so, planning and orchestrating sequences of behavior, overcoming difficulties, and prioritizing goals are required [11]. Executive control is also a multifaceted concept, with inhibitory control as the core component. Inhibitory control also encompasses different subclasses, with response inhibition, considered one's ability to prevent a motor response, and reward-based inhibition, that reflects one's ability to delay gratification [12], as the most relevant.

It has become increasingly more recognized that higher-order cognition and associative learning are not necessarily mutually exclusive [13]. Indeed, associative learning may be mediated by complex cognitive processes such as executive control, although this has been only tenuously connected with food-related behaviors so far [14]. Moreover, to understand mechanisms generating eating behavior, bottom-up associative models are likely to be more illuminating than verbal top-down 'higher-order' cognitive models. Unfortunately, associative learning is often dismissed and neglected as a model for flexible behavior (both humans and nonhuman animals) [15]. Therefore, the first aim of this review was to summarize recent studies that have examined the relationship between associative and rule-based forms of learning (i.e. promoted by external sensory stimuli or internal goals/rules, respectively) to predict behaviors toward food. The second aim was to shed light into the nature of the interactions between associative processes and the response inhibition when a behavioral change is desired. It should be noted that this review was not restricted to a specific period due to the small number of studies addressing this topic. Finally, we focused primarily on the food domain.

The current state of associative versus rule-based learning research in the context of food-related behaviors

Regarding the interplay between associative and rule-based learning processes in the context of food responses, one approach states that both learning processes are sequential through a default-interventionist approach [16]. Simpler associative processes start and then high-level reasoning is recruited when the simpler ones prove inadequate [17], and particularly when conflict is detected. For example, choosing to eat chips and chocolate while maintaining incompatible goals related to health and weight status. Another one is the competition hypothesis between both types of learning, taking into account the balance of the benefits and costs of each process [18,19]. Surprisingly, few studies assessing this question are identified in the literature and little information has been provided about when and how learning to respond to food is mediated by an associative or a rule-based process. To our knowledge, the competitive hypothesis seems to best account for the results in humans [20] and even in rhesus macaques [21]. For instance, Kowaguchi, Patel, Bunnell, and Kralik [21] tested between both possibilities, competitive versus fault-interventionist approaches, using a tool-use paradigm in which rhesus macaques could pull an object (the tool) toward themselves to obtain an otherwise out-of-reach goal item. While the monkeys started to select the option based on associative process that included the tool and reward items, they appeared to make a rapid transition to solving problems. They showed a relational reasoning between the food item and tool, once given an additional problem example and using it to make their selection. Moreover, this study supported the idea that abstraction can promote problem-solving by helping to provide access to an initially nonapparent problem component. Thus, abstraction enabled animals to consider the specific food items as part of a larger class, which in turn helped to separate them from the rest of the visual scene, then making it easier to recognize the relation between the food items.

Does the training enhance inhibition control over food-related responses?

One application of motor-response inhibition is to train individuals to selectively engage control to a given food stimulus, making it possible to develop interventions that help them to manage their eating and food-related behavior, as well as related weight and health outcomes. Models of response inhibition propose that the behavioral expression of associative learning such as classically conditioned reflexes (e.g. pathological craving for appetitive stimuli), goal-directed actions (e.g. compulsive food reward-seeking response), and habits (e.g. unhealthy eating patterns) are traditionally considered the targets of the response-inhibition processes.

The contribution of inhibitory control to performance in food-related inhibition tasks has been reported in comparative psychology. For instance, in a recent animal study using a spatial foraging task (similar to the interference stroop task from the human literature), the results indicated not only that chimpanzees gained inhibitory control within session, but also that their performance was affected by several cognitive abilities such as object knowledge, memory, and previous learning [22]. On the other hand, Kralik [23] reported that rhesus monkeys were able to generalize beyond their specific perceptual experience and use this ability to control learned response tendencies. In particular, rule abstraction and transfer to new problems allowed them to avoid the punishment received if every instance had to be associatively learnt via trial-and-error reinforcement. Evans, Beran, Paglieri, and Addessi [24] assessed the capacity to delay gratification for accumulating food rewards in chimpanzees and capuchin monkeys. In their task, animals were tested with either accumulating food or with accumulating symbolic tokens (which could then be traded for food). Chimpanzees exhibited a similar ability to wait, regardless of which item was accumulating, but capuchins waited significantly longer when tested with food than when tested with tokens. These findings provide evidence that chimpanzees may use forms of abstract representation to facilitate certain types of behavioral inhibition and self-control toward the end of maximizing reward and obtaining the best possible outcomes.

In humans, Kakoschke et al. [25] reported that appetitive food stimuli eliciting automatic approach-action tendencies were inhibited in individuals with a strong control system, while those with a weaker control system were unable to inhibit this response, leading to the consumption of unhealthy food. The evidence is clear in showing that food-specific inhibitory-control training can reduce subsequent consumption or choice of those foods [26,27]. In particular, this was the case using the two most prominent behavioral paradigms employed to examine response inhibitory control at the laboratory [28•]: the Go/No-Go paradigm and the stop-signal paradigm [29•–35]. Unfortunately, none of these studies provided measures of inhibitory control as a dependent variable to discriminate potential mechanisms.

Thus, an important question that needs further exploration is how the training of simple motor responses can result in reduced consumption and choice of foods. Paradoxically, although it is largely assumed that this motoric Go/No-Go training strengthens top-down inhibitory control over food-related responses, the available literature about this training suggests that it works through associative changes [36,37]; and in particular, the development of automatic learning food-stop associations or reduced evaluations of the food items [33,38•–43••]. It should be noted that a recent alternative avenue of behavioral inhibitory control draws on a change in valuation of learned but unhealthy behaviors, leading to self-regulatory shifts that result in sustainable behavior change in a less effortful and more pleasant way. For instance, if chips no longer are attractive (i.e. they acquire a low reward value), people will have less difficulty resisting them than if they apply pressure to refrain from eating them [44]. Altogether, these findings reinforce the importance of automatic associative processes in cognitive control and response inhibition. Unfortunately, fairly little research has focused on the nature of the associative learning structure that underpins food stimulus-stop training.

Some neurobiological dissociations related to behavior inhibitory control

In order to make progress toward the mechanisms underlying response-inhibition training, neurobiological dissociations (in terms of brain areas and neural pathways, see [45]) are useful. Using this strategy, De Pretto et al. [38•] assessed three potential mechanisms by analyzing event-related potentials with electrical neuroimaging during a Go/No-Go task in healthy subjects, including two types of food pictures: rewarding (e.g. pleasant chocolate) versus aversive items (e.g. unpleasant vegetables). They considered that if food stimulus-stop training improves top-down inhibitory control over food-related responses, then modifications during the implementation of the inhibition command, as indexed by the P3 ERP component 300 ms post stimuli onset and within right ventrolateral prefrontal cortices, should be observed. In the case of the second mechanism, direct food item-stop associations should predict modifications during the discriminative/attentional N1/P1 components at 150 ms post stimulus onset and within the parietal areas implementing stimulus-response learning processes. Finally, if reduced evaluations of the food stimulus are the responsible mechanism, modifications during the conflict detection/decisional N2 component at 200–300 ms and within anterior cingulate performance monitoring and orbitofrontal reward-related areas should be expected. Their neurophysiological results showed that response-inhibition training did not reinforce top-down mechanisms. Again, they were in agreement with other mechanisms such as the establishment of food-stop associative forms of inhibition and the reduced valuation of No-Go food pictures. Another interesting finding of this study was the smaller effect of Go/No-Go training for rewarding stimuli and stronger for aversive stimuli. These findings highlight that inhibitory training interacts with the evaluative–affective properties of food cues. Whether automatic stimulus-stop association and downregulation in stimulus-response mechanisms may have a differential impact according to the affective nature of the No-Go stimulus remains to be examined.

Additional remarks

It is surprising that most eating-behavior literature focuses on rule-based and deliberate cognitive-control processes [46–48] when associative learning appears to be a default determinant of behavior. Indeed, a weaker control system, poor inhibitory control, or low availability of cognitive resources (such as during stress) seem to reduce the ability to deliberately pursue goals and increase reliance on Pavlovian-conditioned reflexes and motor habits that result in unhealthy eating. On the other hand, the great difficulty in changing established associatively behavioral patterns must be recognized. This is particularly true in the case of eating habits, where environmental cues come to automatically activate them, regardless of goals once formed. The pathological food-avoidance reactions observed in anorexia nervosa are an extreme example. According to recent advances in cognitive neuroscience, the persistent restriction of food intake in these patients does not reflect continuing desire to perform the old behavior or a failure of willpower to obtain deliberate goals. Rather, it may be understood as maladaptive habits driven by abnormal associative learning processes. Thus, food-related habits become automatic responses very quickly, without depending on patients' current goals or negative consequences, and that little effort is needed to maintain these eating behaviors [49,50].

In relation to relevant gaps in the literature, the lack of a clear conceptualization and operationalization of constructs such as 'rule-based learning', 'propositional learning', 'executive control', or 'cognitive control' is problematic for rigorous experimental investigation in the food domain. Additionally, these constructs are usually described as being reserved uniquely for humans, excluding preclinical animal research, despite the large amount of research conducted with animal models on the control of behavior by competing learning systems (see [51]). On the other hand, many issues remain unsolved, such as the dose-inhibition response relationships between food Go/No-Go training and changes in dietary intake, the impact of individual differences or the long-term outcomes of the behavior inhibitory training in real-life conditions, given that most studies on Go/No-Go training involve single sessions in a laboratory setting. Consequently, more research is needed on the continuance of the training effects as well as on the extent to which effects can be generalized to different populations (e.g. people with weight-related problems or eating disorders). Preliminary evidence suggests that inhibitory-control training may be a feasible and acceptable method of augmenting treatment for people with eating disorders by producing clinically relevant changes in binge-eating frequency and eating-disorder psychopathology [52•]. Finally, variability in the results may be a function of the intensity and/or relevance of the food stimuli used. It should be noted that experimental food stimuli are largely determined by researchers and, therefore, the sets of food stimuli are not tailored to the participants' evaluations and their associative properties are not experimentally established.

Conclusions

In concluding this review, the lack of research on the relationship between associative learning and ruled-based learning processes in the context of food-related behaviors is surprising. In particular, research on how and when both learning systems are utilized to promote responses to food items is still in its early days, despite the fact that the vast majority of the results in the literature are interpreted within the context of associative learning and dual-process theories of cognition. Addressing their interplay will lead not only to the discovery of novel human and animal learning phenomena, but it will also be the central challenge for the next generation of behavior-change interventions, especially to modify resistant habits in populations with food-induced weight problems, disordered eating, and eating disorders.

Conflict of interest statement

Nothing declared.

Data availability

No data were used for the research described in the article.

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References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest.

1. Chaiken S, Trope: **Dual-Process Theories in Social Psychology**. Guilford Press; 1999.
2. Evans JSB: **In two minds: dual-process accounts of reasoning**. *Trends Cogn Sci* 2003, **7**:454-459, https://doi.org/10.1016/j.tics.2003.08.012
3. Evans JStBT: **Dual-processing accounts of reasoning, judgment, and social cognition**. *Annu Rev Psychol* 2008, **59**:255-278, https://doi.org/10.1146/annurev.psych.59.103006.093629
4. Shiffrin RM, Schneider W: **Automatic and controlled processing revisited**. *Psychol Rev* 1984, **91**:269-276, https://doi.org/10.1037/0033-295X.91.2.269
5. Sloman SA: **The empirical case for two systems of reasoning**. *Psychol Bull* 1996, **119**:3, https://doi.org/10.1037/0033-2909.119.1.3
6. McLaren IP, Forrest CLD, McLaren RP, Jones FW, Aitken MRF, Mackintosh NJ: **Associations and propositions: the case for a dual-process account of learning in humans**. *Neurobiol Learn Mem* 2014, **108**:185-195, https://doi.org/10.1016/j.nlm.2013.09.014
7. Brunstrom JM: **Associative learning and the control of human dietary behavior**. *Appetite* 2007, **49**:268-271, https://doi.org/10.1016/j.appet.2006.11.007
8. Bunge SA, Wallis JD: **Neuroscience of Rule-Guided Behavior**. Oxford University Press; 2007, https://doi.org/10.1093/acprof:oso/9780195314274.001.0001
9. Sanjari SS, Jahn S, Boztug Y: **Dual-process theory and consumer response to front-of-package nutrition label formats**. *Nutr Rev* 2017, **75**:871-882, https://doi.org/10.1093/nutrit/nux043
10. Nigg JT: **Annual Research Review: on the relations among self-regulation, self-control, executive functioning, effortful control, cognitive control, impulsivity, risk-taking, and inhibition for developmental psychopathology**. *J Child Psychol Psychiatry* 2017, **58**:361-383, https://doi.org/10.1111/jcpp.12675
11. Miller EK, Wallis JD: **Executive function and higher-order cognition: definition and neural substrates**. *Encycl Neurosci* 2009, **4**:99-104, https://doi.org/10.1016/B978-008045046-9.00418-6
12. Bartholdy S, Dalton B, O'Daly OG, Campbell IC, Schmidt U: **A systematic review of the relationship between eating, weight and inhibitory control using the stop signal task**. *Neurosci Biobehav Rev* 2016, **64**:35-62, https://doi.org/10.1016/j.neubiorev.2016.02.010

13. De Houwer J, Hughes S, Barnes-Holmes D: **Associative learning as higher order cognition: learning in human and nonhuman animals from the perspective of propositional theories and relational frame theory**. *J Comp Psychol* 2016, **130**:215, https://doi.org/10.1037/a0039999

14. Seabrooke T, Wills AJ, Hogarth L, Mitchell CJ: **Automaticity and cognitive control: effects of cognitive load on cue-controlled reward choice**. *Q J Exp Psychol* 2019, **72**:1507-1521, https://doi.org/10.1177/1747021818797052

15. Lind J: **What can associative learning do for planning?** *R Soc Open Sci* 2018, **5**:180778.

16. Evans JSB, Stanovich KE: **Dual-process theories of higher cognition: advancing the debate**. *Perspect Psychol Sci* 2013, **8**:223-241, https://doi.org/10.1177/1745691612460685

17. Kahneman D: **Thinking, Fast and Slow**. Farrar, Straus and Giroux; 2011.

18. Boureau YL, Sokol-Hessner P, Daw ND: **Deciding how to decide: self-control and meta-decision making**. *Trends Cogn Sci* 2015, **19**:700-710, https://doi.org/10.1016/j.tics.2015.08.013

19. Chrysikou EG, Weber MJ, Thompson-Schill SL: **A matched filter hypothesis for cognitive control**. *Neuropsychologia* 2014, **62**:341-355, https://doi.org/10.1016/j.neuropsychologia.2013.10.021

20. Seabrooke T, Hogarth L, Mitchell CJ: **The propositional basis of cue-controlled reward seeking**. *Q J Exp Psychol* 2016, **69**:2452-2470, https://doi.org/10.1080/17470218.2015.1115885

21. Kowaguchi M, Patel NP, Bunnell ME, Kralik JD: **Competitive control of cognition in rhesus monkeys**. *Cognition* 2016, **157**:146-155, https://doi.org/10.1016/j.cognition.2016.08.017

22. Völter CJ, Tinklenberg B, Call J, Seed AM: **Inhibitory control and cue relevance modulate chimpanzees' (*Pan troglodytes*) performance in a spatial foraging task**. *J Comp Psychol* 2022, **136**:105-120.

23. Kralik JD: **Rhesus macaques (*Macaca mulatta*) spontaneously generalize to novel quantities in a reverse-reward contingency task**. *J Comp Psychol* 2012, **126**:255-262, https://doi.org/10.1037/a0026019

24. Evans TA, Beran MJ, Paglieri F, Addessi E: **Delaying gratification for food and tokens in capuchin monkeys (*Cebus apella*) and chimpanzees (*Pan troglodytes*): when quantity is salient, symbolic stimuli do not improve performance**. *Anim Cogn* 2012, **15**:539-548, https://doi.org/10.1007/s10071-012-0482-1

25. Kakoschke N, Kemps E, Tiggemann M: **Combined effects of cognitive bias for food cues and poor inhibitory control on unhealthy food intake**. *Appetite* 2015, **87**:358-364.

26. Jones A, Di Lemma LC, Robinson E, Christiansen P, Nolan S, Tudur-Smith C, Field M: **Inhibitory control training for appetitive behaviour change: a meta-analytic investigation of mechanisms of action and moderators of effectiveness**. *Appetite* 2016, **97**:16-28, https://doi.org/10.1016/j.appet.2015.11.013

27. Stice E, Lawrence NS, Kemps E, Veling H: **Training motor responses to food: a novel treatment for obesity targeting implicit processes**. *Clin Psychol Rev* 2016, **49**:16-27, https://doi.org/10.1016/j.cpr.2016.06.005

28. • Raud L, Westerhausen R, Dooley N, Huster RJ: **Differences in unity: the go/no-go and stop signal tasks rely on different mechanisms**. *NeuroImage* 2020, **210**:116582, https://doi.org/10.1016/j.neuroimage.2020.116582.

In this review and based on the behavioural performance, EMG, and EEG-derived independent component activity, the authors showed that the most commonly used response inhibition tasks, the Go/No-Go Task and stop signal task, recruit different brain mechanisms with distinct temporal dynamics.

29. • Adams RC, Button KS, Hickey L, Morrison S, Smith A, Bolus W, Coombs E, Randolph S, Hunt R, Kim D, *et al.*: **Food-related inhibitory control training reduces food liking but not snacking frequency or weight in a large healthy adult sample**. *Appetite* 2021, **167**:105601, https://doi.org/10.1016/j.appet.2021.105601.

In predominantly healthy-weight sample, the authors reported that, whilst food-related inhibition training may induce devaluation universally, effects on food intake and weight loss may only be observed in those who overeat.

30. Houben K, Jansen A: **Training inhibitory control. A recipe for resisting sweet temptations**. *Appetite* 2011, **56**:345-349, https://doi.org/10.1016/j.appet.2010.12.017

31. Lawrence NS, Verbruggen F, Morrison S, Adams RC, Chambers CD: **Stopping to food can reduce intake. Effects of stimulus-specificity and individual differences in dietary restraint**. *Appetite* 2015, **85**:91-103, https://doi.org/10.1016/j.appet.2014.11.006

32. Oomen D, Grol M, Spronk D, Booth C, Fox E: **Beating uncontrolled eating: training inhibitory control to reduce food intake and food cue sensitivity**. *Appetite* 2018, **131**:73-83, https://doi.org/10.1016/j.appet.2018.09.007

33. Veling H, Aarts H, Papies EK: **Using stop signals to inhibit chronic dieters' responses toward palatable foods**. *Behav Res Ther* 2011, **49**:771-780, https://doi.org/10.1016/j.brat.2011.08.005

34. Veling H, Aarts H, Stroebe W: **Stop signals decrease choices for palatable foods through decreased food evaluation**. *Front Psychol* 2013, **4**:875, https://doi.org/10.3389/fpsyg.2013.00875

35. Aulbach MB, Knittle K, van Beurden SB, Haukkala A, Lawrence NS: **App-based food Go/No-Go training: user engagement and dietary intake in an opportunistic observational study**. *Appetite* 2021, **165**:105315.

36. Bowditch WA, Verbruggen F, McLaren IP: **Associatively mediated stopping: training stimulus-specific inhibitory control**. *Learn Behav* 2016, **44**:162-174, https://doi.org/10.3758/s13420-015-0196-8

37. Veling H, Lawrence NS, Chen Z, van Koningsbruggen GM, Holland RW: **What is trained during food go/no-go training? A review focusing on mechanisms and a research agenda**. *Curr Addict Rep* 2017, **4**:35-41, https://doi.org/10.1007/s40429-017-0131-5

38. • De Pretto M, Hartmann L, Garcia-Burgos D, Sallard E, Spierer L: **Stimulus reward value interacts with training-induced plasticity in inhibitory control**. *Neuroscience* 2019, **421**:82-94, https://doi.org/10.1016/j.neuroscience.2019.10.010.

Using neurophysiological data, for the first time, the authors revealed an interaction between the affective/motivational nature of the stimulus (rewarding/aversive) and motor inhibitory control training in line with the predictions from the Behaviour Stimulus Interaction and associative learning theories.

39. Houben K, Giesen JC: **Will work less for food: Go/No-Go training decreases the reinforcing value of high-caloric food**. *Appetite* 2018, **130**:79-83, https://doi.org/10.1016/j.appet.2018.08.002

40. •• Tzavella L, Lawrence NS, Button KS, Hart EA, Holmes NM, Houghton K, Badkar N, Macery E, Braggins AJ, Murray FC, *et al.*: **Effects of go/no-go training on food-related action tendencies, liking and choice**. *R Soc Open Sci* 2021, **8**:210666, https://doi.org/10.1098/rsos.210666.

In this study, it is highlighted the lack of effect on food liking, while participants were less likely to choose a no-go food compared to a control food after training.

41. Veling H, Holland RW, van Knippenberg A: **When approach motivation and behavioral inhibition collide: Behavior regulation through stimulus devaluation**. *J Exp Soc Psychol* 2008, **44**:1013-1019, https://doi.org/10.1016/j.jesp.2008.03.004

42. Verbruggen F, Best M, Bowditch WA, Stevens T, McLaren IP: **The inhibitory control reflex**. *Neuropsychologia* 2014, **65**:263-278, https://doi.org/10.1016/j.neuropsychologia.2014.08.014

43. •• Yang Y, Qi L, Morys F, Wu Q, Chen H: **Food-specific inhibition training for food devaluation: a meta-analysis**. *Nutrients* 2022, **14**:1363, , https://doi.org/10.3390/nu14071363.

The authors indicated that food-specific inhibition training can lead to statistically significant reductions in food evaluation decreasing participants' explicit food evaluation, but not their implicit food evaluation.

44. Ludwig VU, Brown KW, Brewer JA: **Self-regulation without force: can awareness leverage reward to drive behavior change?** *Perspect Psychol Sci* 2020, **15**:1382-1399.

45. Milton F, Bealing P, Carpenter KL, Bennattayallah A, Wills AJ: **The neural correlates of similarity- and rule-based generalization**. *J Cogn Neurosci* 2017, **29**:150-166, https://doi.org/10.1162/jocn_a_01024

46. Papies EK: **Goal priming in dieters: recent insights and applications**. *Curr Obes Rep* 2012, **1**:99-105, https://doi.org/10.1007/s13679-012-0009-8

47. Shutts K, Kinzler KD, DeJesus JM: **Understanding infants' and children's social learning about foods: previous research and new prospects**. *Dev Psychol* 2013, **49**:419, https://doi.org/10.1037/a0027551

48. Tonelli H, de Siqueira Rotenberg L: **Emotion perception and theory of mind in obesity: a systematic review on the impact of social cognitive deficits on dysfunctional eating behaviors**. *Surg Obes Relat Dis* 2021, **17**:618-629, https://doi.org/10.1016/j.soard.2020.10.016

49. Walsh BT: **The enigmatic persistence of anorexia nervosa**. *Am J Psychiatry* 2013, **170**:477-484, https://doi.org/10.1176/appi.ajp.2012.12081074

50. Steinglass JE, Walsh BT: **Neurobiological model of the persistence of anorexia nervosa**. *J Eat Disord* 2016, **4**:1-7, https://doi.org/10.1186/s40337-016-0106-2

51. Egner T: **The Wiley Handbook of Cognitive Control**. John Wiley & Sons; 2017.

52. • Chami R, Cardi V, Lawrence N, MacDonald P, Rowlands K, Hodsoll J, Treasure J: **Targeting binge eating in bulimia nervosa and binge eating disorder using inhibitory control training and implementation intentions: a feasibility trial**. *Psychol Med* 2020, **52**:874-883, https://doi.org/10.1017/S0033291720002494.

The authors showed that Go/No-Go training paired with implementation intentions has potential in reducing binge eating episodes in participants with bulimia nervosa or binge eating, with the food-specific training resulting in larger effect sizes.