HABIT CHANGE

LITERATURE REVIEW

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INTRODUCTION

Habits are incredibly powerful. Good habits can make people highly successful, and bad habits can ruin people's lives. Still, it is important to go beyond the anecdotal evidence of the many self-help books on habit, and to take stock of the scientific evidence.

According to **DAVID NEAL, WENDY WOOD, AND JEFFRY QUINN (2006)**, habits are "response dispositions that are activated automatically by the context cues that co-occurred with responses during past performance". Habits are based on links between cues and responses. For instance, I walk into the bathroom, and I take my toothbrush; I see a red light, and I stop; etcetera. If cues and responses co-occur regularly, we form a habit. This is how we can program our system 1--the automatic, intuitive processes in our brain--to do tasks that would be too effortful for our system 2--the conscious, reflective processes in our brain--to keep doing.

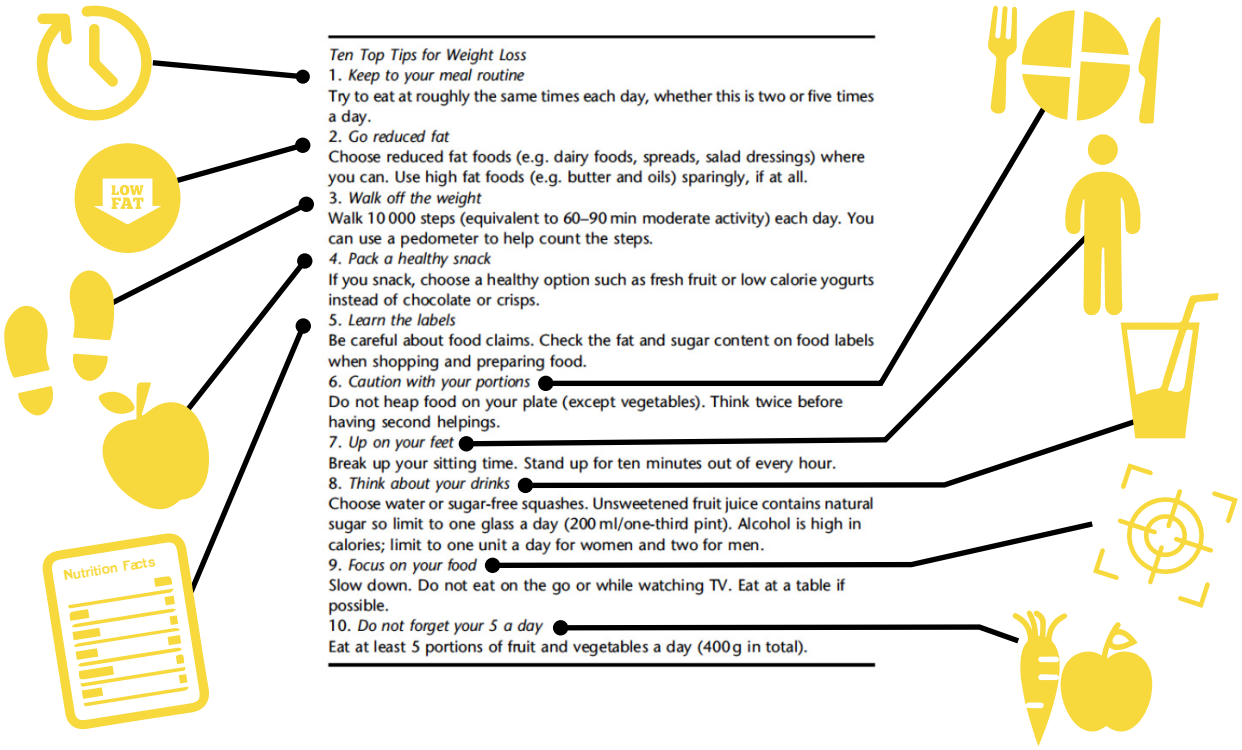
In the following paragraphs we discuss how habits are formed, how bad habits can be abandoned, how approach-avoidance training can help adopting good habits and abandoning bad habits, and, finally, how habits can be measured properly.

KUASHAL AND RHODES (2017) found that the reward involved with exercise, as well as how consistently one exercises, are the largest predictors of initial exercise habit formation. The researchers recruited 111 participants between the ages of 18-65 who had joined a gym within the preceding 2 weeks. Participants answered an initial demographics questionnaire, and completed questionnaires 6, 9, and 12 weeks later. The questionnaires measured self-reported how frequently and intensely they exercised and for how long, as well as how many times per week they intended to exercise. Habit was measured through the Self-Report Behavioral Automaticity Index (SRBAI), which included 4 items (e.g., "I [exercise] automatically") on a 1-5 scale. The researchers also measured how effectively rewarding participants felt exercise was, how consistently they exercised, how comfortable they felt in their exercise environment, and how difficult they felt exercise was for them.

The results showed that frequency of exercise significantly predicted habit formation: at 12 weeks, 63.8% of participants who exercised 4 or more times per week formed an exercise habit (i.e., scored higher on the automaticity measure), compared to only 22.6% of participants who exercised fewer than 4 times per week. The most significant predictors of exercise habit at the end of the 12 weeks were (in order): exercising in a consistent manner, low perceived exercise difficulty, a sense of ease in one's exercise environment, and reward. Predictors of initial habit formation, however, were reward and consistency.

LALLY, CHIPPERFIELD AND WARDLE (2008) found that simply providing tips on how to adopt habits that promote weight loss resulted in significantly more weight loss compared to a control group that did not receive the tips. Participants in two

treatment conditions received a simple pamphlet, titled "Ten Top Tips for Weight Loss", that listed ten simple behaviors to adopt including eating meals at the same time each day and refraining from performing other activities while eating (e.g., no eating while watching TV). All participants, who were employees of local businesses that volunteered to test a new weight loss program, were weighed at the initial recruitment meeting (baseline weight) and then weighed by the authors during drop-in sessions on either a monthly or weekly basis. Control group participants were told that they had been placed on a waiting list for the program and merely participated in monthly weigh-in sessions. All treatment group participants received the treatment pamphlet and half participated in monthly weigh-in sessions while the other half participated in weekly weigh-in sessions. After eight weeks, participants weighing in monthly lost an average of 2.4 kg while those weighing in weekly lost an average of 1.6 kg. Both of these treatment groups lost significantly more weight than the control group which lost on average 0.4 kg. There was no significant difference in weight loss between the two treatment groups. The authors emphasized the fact that the intervention was cost effective and did not require any participation from health professionals. They suggested testing similar pamphlets leveraging principles of habit formation and extending the research to also include implementation intentions.



LALLY ET AL. (2009) show that it can take anywhere between 18 to 254 days for people to reach their automaticity limit in an eating, drinking or activity behavior of their choosing. Further, the authors show that an asymptotic curve models the relationship between repetition and automaticity.

For this study, 96 university students were recruited. Participants were asked to choose a healthy eating, drinking or exercise behavior they would like to make into a habit. The behavior of their choosing had to be something they didn't already do

and that could be performed in response to a cue which occurred once every day, e.g. running for 15 minutes before dinner. Participants were asked to carry out their chosen behavior once every day for 84 days. Each day, students had to log in to the study website to report whether they performed the behavior the previous day and to fill out the self-report habit index (SRHI), a questionnaire that measures habit strength on a 7-point Likert scale. The authors made use of 7 out of the 12 items on the questionnaire. In their analysis, the authors plotted each individual's daily automaticity scores over 12 weeks and showed that an asymptotic curve fitted for 62 of the 82 participants for whom enough data was available. Performing the chosen behavior more consistently was associated with a better fit model. It can take anywhere between ***18 to 254 days*** for people to reach a plateau of automaticity (asymptote) with a median time of 66 days. The median asymptote automaticity score did not differ between eating, drinking or exercise behaviors, whereas the drinking group showed higher overall compliance. The researchers also showed that missing one day did not affect habit formation.

Another study found that placing the cue before the intended action significantly improved the habit formation of the behavior over placing the cue after the behavior. **JUDAH, GARNER, AND AUNGER (2012)** measured participants at baseline for prior flossing frequency and had them report their evening flossing routines. Following which the researchers applied their motivational intervention; participants were instructed to floss daily and were given persuasive information about the benefits of flossing. Subjects were then instructed how and when to floss, randomly assigned to either before or after brushing their teeth. The researchers then helped each subject determine an appropriate cue for a flossing implementation intention, and then each participant signed pledge to brush their teeth every night at the appropriate time. During the first 28 days of the study, each participant received a text message asking whether or not they had flossed the previous night. 8 months following the baseline reading, each subject received a follow-up email asking to complete behavior and habit measures. At the 8 month follow-up, both conditions (before or after brushing teeth) had greater times flossing per month than at baseline (3.5 vs. 1.47 before, 10.5 vs. 1.24 after). The after teeth-brushing condition had significantly higher flossing habit score (16.9) than the before teeth-brushing condition.

Intentions and implementation intentions in flossing. ORBELL AND VERPLANKEN (2010) examined the utilization of cues and implementation intentions to create automatic behaviors, and they found that this type of intervention increased the automaticity of a desirable health behavior when the intention to complete the health behavior was moderate or strong, but not when it was weak.

The authors investigated how cues and implementation intentions affect the habit of flossing, using 274 students at a university in the UK. Participants were asked to complete a baseline questionnaire measuring habitual automaticity (using the Self-Report Habit Index), and then they were randomized into an intervention condition using cues/implementation intentions, or a control condition. The individuals in the cue/implementation intention condition were asked to complete an implementation intentions statement: "You are more likely to carry out your intention to perform dental flossing every day if you make a decision about when and where. Most people perform dental flossing in the bathroom immediately after they brush their teeth at night. Others prefer to do it in the morning after breakfast.

Write down where and when you intend to floss your teeth everyday for the next 4 weeks." These sentences were followed by a space where participants had to specify a location and time of day for flossing. All other aspects of the questionnaires and interventions were identical for both treatment and control groups. All participants were also given a special container of floss that had been precisely weighed. Participants were asked to complete additional questionnaires after 2 and 4 weeks, and the end of the fourth week, they returned their floss container, which was weighed to help verify self-reported flossing.

The authors found that goal intention interacted with the implementation intentions treatment - those with low goal intention did not develop a habit using the treatment, whereas those with moderate or high goal intentions were more likely to develop the flossing habit because of the treatment. This finding illustrates the fact that an effective habit intervention is still contingent on behavior intention, so determining behavior intentions is crucial. If the intention is not there, ways to create the intention should be investigated.

GERBER, GREEN, AND SHACHAR (2003) find that when eligible voters are encouraged to vote through direct-mail and face-to-face canvassing, they are not only more likely to vote in the upcoming election, but also in the following year's election, relative to a control group. The results suggest that, holding all other factors constant, the mere decision and act of casting a ballot in one election profoundly increases one's likelihood of voting in the next election.

The experiment targeted 28,380 respondents whose names appeared on voter rolls in Connecticut. Each respondent was randomly assigned to one of eight groups that varied based on whether they received personal canvassing or not, and how many direct mailers they were sent (0, 1, 2, or 3). A control group of 10,073 received no contact. The messages conveyed in treatment groups were non-partisan messages reminding the recipient to vote.

Both canvassing and direct mail were found to increase voter turnout in the upcoming election, compared to controls. Turnout increased from 48.1% to 51.5% from groups who received no-canvassing and those who did, and increased 48.5% to 50% from groups who received no-direct mail and who received three mailings. Thus, the treatment manipulation successfully increased voter turnout for the upcoming election.

The researchers then isolated the impact of voting in the first election on the propensity to vote in the following year's election. They found that the mere act of voting in the first election raised the probability of voting in the subsequent election by 46.7% while controlling for all unobserved factors affecting the likelihood to vote in each election. As a comparison, a leading factor for increasing turnout is level of education obtained, where those with a postgraduate education are 26% more likely to vote than someone with some high-school education. The researchers argue that these findings display the profound influence that current behavior can have on subsequent behavior for behaviors such as voting.

LABRECQUE AND WOOD (2018) shows that deliberation without sufficient practice can impede habit formation, employing a novel habit formation sushi-making task. 331 university students played a videogame guided by an avatar to practice

a 16-step sequence to make sushi, randomly assigned to four different experimental groups, either with or without additional instructions to deliberate (with deliberation augmented with "pay close attention" and "remember each step"), instead of simply repeating the steps, and either repeating the practice 2-3 times or 10 times. When practicing only 2-3 times, deliberations leads to less errors in the short run, but less strength in habit formation.

This impediment effect of deliberation did not hold, however, for those who repeat the practice 10 times. These findings highlight the beneficial role of repetition of practices and the detrimental role of deliberation in habit formation.

LABRECQUE, WOOD, NEAL, AND HARRINGTON (2017) found that people were less likely to use a new product and more likely to slip into old laundry habits when they thought relatively little about laundry and did not make an effort to integrate the product into their existing routine. The authors first conducted a survey of 150 Mturkers in which participants evaluated 2 products they had purchased in the past 6 months - one they used regularly, and one they didn't. Participants rated products they regularly used as more automatic than those they rarely used. When asked to discern why they did not use a product, they reported cognitive lock-in (i.e., finding the new product difficult to use or not learning how to use it) and habit slips (failing to use the new product because they fell back into an old habit) as the most common reasons for not doing so. The products they did use conflicted less with old habits, while those they did not often use did conflict with old habits.

In a second lab study, the researchers asked 69 college students to use a laundry product on a trial basis of 4 weeks. The product was a "laundry refresher" used to decrease the number of times one washes their clothing. Participants were either assigned to an implementation intention group (told that if an item of their clothing was smelly, then they should use the fabric refresher product they were given), a habit-cue use group (told to replace their existing habits with using the laundry refresher, and they wrote about how they would not fall into their typical laundry habits), or a control group. Participants came in for an initial lab session to receive and evaluate how likely they were to use and purchase the product, how easy they thought it would be to use, and to provide their existing laundry habits, including how much thought they typically put into doing laundry. They also responded to a weekly survey of product use and how autonomous they felt the decision to use the product was. At the end of the 4 weeks, participants explicitly evaluated the product in terms of convenience, time-saving, lifestyle fit, whether they would recommend it to a friend, etc. While the implementation intention group did not use the product significantly more than the control group, participants in the habit-cued group used the product significantly more often than both groups. Regardless of condition, people who put more thought into their laundry or integrated the product into their routine used the product more often. People who put relatively little thought into their laundry decisions were more likely to fall into a habit slip.

Long-term health habits. Past interventions were successful in changing people's behavior in the short-term, but once the intervention ended, people typically relapsed into their old routines and habits. **WOOD AND NEAL (2016)** show that an approach that breaks existing unhealthy habits while at the same time promoting and forming healthy habits is best in establishing long-term health habits.

Forming new habits consists of three main parts: repetition, associated stable context cues, and reward. Habits develop gradually as people repeat rewarded behaviors in daily life, where context, such as time of day or location, becomes cue for what behavior will be rewarded. Creating such stable context cues that trigger new health habits can be achieved with the help of implementation intention plans or by piggybacking on existing habits. While rewards effectively drive short-term behavior changes, uncertain rewards are most effective in promoting repetition and habit formation. Uncertain rewards occur at uncertain intervals and not for every behavior. Besides creating new habits, breaking unhealthy habits is central to a health behavior change. Breaking unhealthy habits requires neutralizing the cues that automatically trigger these unhealthy behaviors. Such cue disruptions are usually associated with life transitions, such as moving to a new home, beginning a new job, or having a child. Other habit-breaking interventions are environmental reengineering and vigilant monitoring. In addition to cue disruption, environmental reengineering either adds friction to unhealthy behaviors, such as smoking bans in public areas, or removes friction from healthy behaviors, such as freely available bike-share programs. Vigilant monitoring "increases awareness of the cues that trigger unhealthy habits". An example of such, are food labeling regulations.

DE MEL ET AL. (2013) found that regular face-to-face reminders over the course of six months created a savings habit; however the effect seemed to wear off after the reminders were replaced by a less salient treatment.

Roughly 800 inhabitants in semirural areas of Sri Lanka were divided into a treatment group and a control group. The treatment group was visited by a deposit collector once a week for half a year and given the chance to deposit savings into the bank through this person. Withdrawals were still only possible at the bank. The control group could only go to the bank should they wish to deposit, as had been the case before. As was to be expected, the treatment group, which received frequent, salient reminders and experienced lower friction to deposit, on average deposited significantly more than the control group (616 LKR vs. 2 LKR [1 USD ≈ 155 LKR]).

To examine low cost alternatives to the costly face-to-face deposit collection, the researchers designed a follow-up experiment that ran for seven months following the first part of the study. For this, the treatment group was subdivided into three groups: one continued to receive weekly home collection in person, one received such collection biweekly, and one was provided with a neighborhood savings lockbox for savers to deposit their money which was emptied once a week. The control group also was subdivided into three groups: one remained a pure control, one received a lockbox emptied weekly, and one received a lockbox emptied biweekly. Through these manipulations, the researchers hoped to unbundle the effects of frequency (weekly vs. biweekly), salience (in person home visit vs. shared lockbox), and habit (coming to a lockbox from regular deposit collection vs. from a control group without any stimulation to save).

The researchers found that the weekly collection led to ca. 142 LKR higher deposits per month than the biweekly collection. However, withdrawals rose by a similar amount for that group, leading to no significant difference in savings. Going from home collection to box deposits (salience) led to no significant difference in deposits. Habit formation played a significant role: the group that had moved to box deposit from weekly collection deposited on average 262 LKR more than the group that had started using the box without prior treatment. (Withdrawals were higher by 168 LKR, so not so high that they would have compensated for that effect.) The authors caution, however, that this habit effect diminishes with time.

These findings suggest that ~26 successive deposits induced by an external trigger (the deposit collector) may not be enough to create a lasting habit.

CARDEN ET AL. (2017) found that incentives impeded progress on tasks that are learned habitually, due to the belief that thought and effort were required. The first experiment required participants to perform a task they had completed hundreds of times before. When an incentive was offered participants preferred thoughtful and controlled strategies as opposed to relying on habit, despite the fact that relying on habit proves to be successful.

The second experiment involved students completing 100 trials of a weather prediction task based on habit (feedback provided) or rule (observational) learning. Following this, 50 trials were completed with no feedback and a further 50 were completed with a monetary bonus for each correct answer. When an incentive was offered observational learners did significantly better whereas habit-based learners did significantly worse. Further, observational learners improved with the incentive and habit-based learners declined.

In the third experiment students completed the 100 trials of the weather prediction task followed by scrambling sentences with words related to achievement or control words. Participants then completed a further 50 trials of the weather task. When implicit achievement priming was used, observational learners had improved results and vice versa for feedback-based learners.

NEAL, WOOD, WU, AND KURLANDER (2011) investigated factors that facilitate or disrupt habits, and found that mechanisms of automaticity affect how people perform (or don't perform) habits. Specifically, people will perform habits when presented with the corresponding habit cue, but the habit can be interrupted by disrupting part of the mechanism or process involved in executing the habit.

Eighty-nine participants were recruited for a study that measured the habit of eating popcorn at the movies. The participants were recruited and participated at a campus cinema before the showing of a movie. The authors used a between-subjects design with two factors: Hand Used to Eat (dominant vs nondominant) and Food Freshness (fresh vs stale). The authors used specially designed popcorn boxes to help enforce the eating hand requirements. The authors hypothesized that, if participants had a strong habit of eating popcorn at the movies and could use their dominant hand, they would eat the same amount of fresh versus stale popcorn, since it was a habit (and therefore not as influenced by taste/preferences). However, participants with a strong habit of eating popcorn at the movies who had to use their nondominant hand to eat would eat less stale popcorn, since their habit would

be disrupted by having to focus on using that particular hand. Participants' habits were measured with a 7-point Likert scale asking how frequently in the past they ate popcorn in movie theaters (always to never).

The authors' hypothesis was proven correct - using the dominant vs nondominant hand to eat popcorn enabled or disrupted habit execution. The same amount of fresh and stale popcorn was eaten by participants with moderate and strong habits when using their dominant hand, while those with weak habits ate more fresh popcorn and less stale popcorn when using their dominant hand. Those eating with their nondominant hand, however, had their habit mechanism disrupted - those with moderate and strong habits ate less stale popcorn versus fresh popcorn. The authors also explored whether hunger or popcorn liking affected the interaction between habit, cue, and habit mechanism, and they found that neither of these factors when taken into account eliminated the interaction.

LIN, WOOD, AND MONTEROSSO (2016) found that unhealthy habits cause people to make more unhealthy decisions when depleted than healthy habits. In this task, participants repeatedly either pulled or pushed a joystick toward or away from themselves in response to cues related to chocolate consumption. The theory behind this is that pulling the joystick closer when presented with a chocolate consumption cue is a metaphorical acception of the chocolate, and pushing the joystick away is a rejection of the chocolate. All participants were repeatedly shown 6 images, 3 of people playing string instruments, and 3 of people eating chocolate. Some were told to push away when presented with the chocolate, and some were told to pull inward. Afterward, all subjects watched a 7-minute long comic video and were told either to inhibit their facial expressions (to induce energy depletion) or to watch the video normally. Following the video, there was a chocolate consumption task where participants tested 3 kinds of sugar-free chocolates, and evaluated them on several 7-point scales. The number of chocolates consumed was counted after the subjects left the lab. There was a significant effect of habit training and depletion on the number of chocolates consumed, meaning that the unhealthy, consumption habit group (pulling the joystick toward themselves) ate more chocolates when depleted than when not depleted. Depletion did not having any effect on people who pushed the joystick away from themselves.

Training parents to develop a habit for feeding their family healthy foods and drinks can lead to increased habit strength, as well as to an increase in children's intake of vegetables, healthy snacks, and water. **McGOWAN ET. AL. (2013)** used a clustered-RCT among 90-parents in London to study the effect of explicitly training respondents to develop healthy habits. Children's Centers were randomly assigned to either a treatment group or a control group. Parents who attended Centers in the treatment group received 4-in home visits from the researchers who conducted the habit training. Parents who attended Centers in the control group only completed baseline and follow-up questionnaires. In each of the four habit training sessions, parents were given a booklet that introduced the concept of habit formation ("actions becoming easier with repetition") along with tips for habit formation (e.g. having a specific plan, identifying feasible triggers or prompts to habits, sticking to a routine, consistency, and persistence). Booklets had detachable self-monitoring sheets (see below). Parents also discussed with the researchers why they thought it important to have healthy feeding habits, and together they formulated a specific, healthy feeding goal. Each visit focused on one target feeding domain: serving fruits

and vegetables, healthy snacks, or healthy drinks. In subsequent visits, parents were encouraged to continue with the previous habit as well as develop a new one. The study period lasted 8 weeks.

The primary outcome measure was the parental habit strength at the end of the 8-weeks. Habit strength was measured using a 4-item version of the Self-Report Habit Index, which quantifies the automaticity of behaviors. For instance, one item asked, "Giving my child only water or milk is something I do automatically," and asked for level of agreement (e.g. "strongly agree") on a 7-pt scale. The second outcome measure was reported child intake of targeted foods.

Results showed that automaticity scores among the treatment group increased from baseline by an average of 1.0 points on the 7.0 scale for fruit and vegetable feeding habit, 1.8 points for the healthy snacks feeding habit, and 1.4 points for healthy drinking habit. No significant change was found for the control group. Similarly, positive effects were found in children's healthy food intake. Children in the intervention group increased their fruit intake by 0.5 servings per day and vegetable intake by 0.8 servings per day. Unhealthy snack intake decreased by 0.4 servings per day and healthy snack increased by 1.0 servings per day. No significant changes in food or drink intake were found among the control group. In summary, the study shows the powerful effect that explicitly teaching habit forming behavior can have on dietary choices.

ABANDONING BAD HABITS

THORGERSEN AND MOLLER (2008) found that giving people who regularly commute with their own vehicles a free public transportation travel card significantly increased the number of people using public transportation in the short run, but had no effect on public transportation in the long run. Data was collected through phone interviews before, during, and after the intervention period. Participants self reported how many of the last 10 commuting trips they had used public transportation, how many of their next 10 trips they had used public transportation, and how often over the next month they thought they would use public transportation. During the promotion period with the free travel card, participants with the travel card used public transportation significantly more (1.05 out of 10 times) than those without it (0.5 out of 10 times). 5 months after the promotion there was no significant difference between people who had received travel cards or not. It appears that the habit of taking your own personal vehicle to commute was only reduced while there was less of a barrier to using public transportation, namely cost. Therefore, the habit wasn't really reduced.

VERPLANKEN ET AL. (2008) found that people who have recently moved and are concerned about the environment are more likely to use public transportation relative to people who have not moved recently and are less concerned about the environment. The authors recruited 433 subjects employed by a small English

university. Subjects reported how often they traveled to campus (76% said 5 days per week), whether they had moved in the past year (15.9% had recently moved), and how they typically traveled to campus (by car, bus, on foot, etc.). In addition, subjects reported their levels of environmental concern, and the researchers later split subjects into high or low environmental concern through a median split. Subjects who had recently moved were younger, on average, compared to subjects who had not (33.74 vs. 42.74). However, recent movers were not any more concerned about the environment than non-movers. Unsurprisingly, subjects who reported low environmental concern also reported driving to campus more often than subjects high in environmental concern. Subjects who had recently moved were more likely to use eco-friendly transportation (like the bus or their own two feet), but only if they also reported high environmental concern.

QUINN, PASCOE, WOOD, AND NEAL (2010) found that vigilant monitoring is an effective and commonly used strategy to break unwanted habits. The authors first conducted two diary studies in which students from Duke and the University of North Carolina reported every attempt at self-control for a behavior they wished to stop (study 1a) or a behavior they wished to start and/or stop (study 1b). In phase 1, they were given instructions on how to report their behavior, writing down all instances in which they wished to stop or change a behavior, and which strategy they used. Students were instructed to pick from a list of strategies they might have used to stop themselves from doing the unwanted behavior: ***vigilant monitoring (thinking "don't do it," and watching closely for mistakes (1a); monitoring my behavior carefully (1b)), distracting oneself, stimulus control (removing oneself from the situation entirely),*** or nothing - didn't try to stop. They were instructed to record their self-control (or lack thereof) within 15 minutes. Students in both studies first listed behaviors that fell into these categories in order to monitor their self-control. Students in the first study reported their self-control behaviors for 7 days, while those in the second reported their behavior for 14 days. In phase 2, participants reported their behaviors as described above, and also came into the lab every 2-3 days in order to report their success in behavior change on a scale from 1 (unsuccessful) to 7 (successful). Participants also reported how often they performed each behavior prior to the experiment on a scale from monthly or less to several times per day, and the extent to which they performed the behavior under similar circumstances every time. They were also asked to report how tempting each behavior was on a 7-point Likert scale. Participants rated relatively low success overall - the average was a 3.57 in study a and 3.85 in study b on a 7-point scale. Unsurprisingly, doing nothing was the least effective strategy, as its effectiveness was rated only 1.95, while all other conditions averaged 3.98 effectiveness. Vigilant monitoring was the most commonly reported strategy, and was more successful in inhibiting bad habits (3.83) compared to stimulus control (2.81). However, stimulus control was more successful in inhibiting strong temptations (5) compared to vigilant monitoring (3.86).

In study 2, **QUINN ET AL. (2010)** asked 65 Duke undergraduates to form a habit in the lab in order to further test the effectiveness of vigilant monitoring on habit inhibition. To form this habit, participants were tasked with correctly completing word pairs (e.g., the pair knee-b_n_ was correctly completed as "knee-bend"). Participants would see each word pair individually, and silently guess how the pair would be completed. The correct pairing would be displayed immediately following this. Words could be paired with multiple other words, varying in frequency. For

example, the correct completion of the word pair "knee-b_n_" could be "knee-bend" in some instances and "knee-bone" in others. Participants were randomly assigned to see one of these word pairs 75% of the time and the other 25% of the time in the high frequency (strong habit) condition, or to see each 50% of the time in the moderate frequency (weak habit) condition. They completed 5 blocks of 80 word pairs, including 20 different cue words which appeared 4 times per block. Participants were also given one of three strategies for the second phase of the experiment: a) vigilant monitoring (avoid making mistakes in this round), b) focus on success (do your best), or c) no strategy. In phase two, participants were first shown a list of 8 word pairs from the previous phase (not the pairs they were trained to habitually respond to). Then, they had to count backwards from a randomly generated 3-digit number for 30 seconds in order to prevent rehearsal of the word pairs. Following this, participants completed test trials in which they had to recall strong or weak habits of completing the missing letters from phase one (habit performance) and respond using the words from phase two (habit inhibition). This cycle of trials was repeated 20 times. Participants were less able to inhibit strong habits (62%) compared to weak habits (68%). In addition, participants given the strategy of vigilant monitoring were more successful at habit inhibition (71%) than either the success (60%) or control (64%) conditions. Taken together, these studies suggest that vigilant monitoring may be a good strategy to help individuals to stop doing strongly habitual (but not strongly tempting) behaviors.

VERPLANKEN AND WOOD (2006) propose that successful habit change interventions involve disrupting the environmental cues that automatically trigger habit performance. The authors propose two such habit change interventions: downstream-plus-context-change and upstream.

Unlike downstream interventions, such as informational campaigns and self-help programs that focus on changing individuals' behavior to an existing problem, downstream-plus-context-change interventions in addition focus on disruptions to the environment that trigger and maintain those undesirable habits. Downstream interventions often successfully change people's intentions and weak habits, whereas downstream-plus-context-change interventions make people act on those intentions even when strong habits exist. According to the authors, an intervention to effectively change existing habits is most successful when a downstream intervention (e.g. an information campaign) is launched during a time of environmental change, such as a relocation or change of job. Naturally occurring lifestyle changes make people vulnerable to new information and thus make it possible for downstream interventions to take effect. Context changes do not only refer to changes in the physical environment, but also encompass changes to one's social environment (e.g. a new group of friends). Upstream interventions are designed to prevent undesired habits from forming instead of trying to change already existing bad habits. These type of interventions target social norms for desired actions by the means of economic incentives (e.g. taxes, subsidies), legislation changes, environmental designs (e.g. smart city planning), technological development (e.g. monitoring devices for healthy lifestyles) or interventions, such as putting standard portion sizes on food packaging or improving the availability of bus networks. Also, implementation intentions are useful in creating new habits, but do not appear to be strong enough to override existing habits.

To conclude, the authors name two critical ingredients in abandoning old habits and adopting new ones:

1. Changing the environment that triggers the old habit
2. Introducing opportunities that encourage the new habit

Table 1. Effective Policy Interventions to Change Weak Versus Strong Habits

Behavior to Be Changed	Interventions Downstream of the Behavior	Interventions Upstream of the Behavior
Weakly or not habitual	**Information/education to** •increase self-efficacy •change beliefs/intentions •motivate self-control •form implementation intentions	**Education** Economic incentives Legislation and regulation Environmental design Technology development Normative approaches
Strongly habitual	Downstream-plus-context-change	**Economic incentives** Legislation and regulation Environmental design Technology development Normative approaches

Notes: Our distinction between interventions that are downstream and those that are upstream of the to-be-changed behavior is based on McKinlay (1975).

Just having a better awareness of the cue that leads to a negative habit may also lead to better outcomes in reducing said habit, suggest **ADRIAANSE ET AL. (2010)**. In a study on unhealthy snacking, they had a treatment group visualize the positive outcome of reducing their snack intake, visualize an obstacle that prevents them from this reduction, and then come up with and visualize an implementation intention targeting that obstacle ("If I [obstacle] and I feel like having a snack, then I will eat a(n) [choice of fruit].". A control group was asked to think about healthy snacks that they could consume when they felt like having a snack. According to the food diaries that participants kept for the week following the exercise, the treatment group consumed significantly less calories (1745 vs. 2870 kcal) from unhealthy snacks than the control group. Intake of fruit, notably, did not differ significantly between the two conditions.

In a follow-up study, the experimenters tested the mental contrasting and implementation intention condition against only mental contrasting (visualizing the positive outcome and the obstacle) and only implementation intentions. They also let participants choose their own behavioral response for the two conditions involving implementation intentions ("If (your personal critical obstacle), then I will (your behavior to overcome the obstacle)."), and measured the success not through food diaries but through a questionnaire using 7-point Likert scales administered one week after the initial exercise. The condition combining mental contrasting and implementation intentions (M=5.37) significantly outperformed mental contrasting on its own (M=4.47) and implementation intentions on their own (M=4.08).

After evaluating additional questions from the questionnaire, the authors hypothesize that mental contrasting affords participants additional clarity about the cues for their bad habit, and that could be the deciding factor that makes mental contrasting an effective complement for implementation intentions.

Past research on addiction has shown that disconnecting the cue from the reward in people's memories is an effective way to disrupt the habit. **GERMEROTH ET AL. (2017)** found that extinction training preceded by memory retrieval of smoking cues resulted in a significantly greater reduction in cigarette cravings and in the number of cigarettes smoked as compared to extinction training preceded by memory retrieval of neutral or nonsmoking cues. Participants (n=88) had been smoking 10 or more cigarettes per day for 3 years or more. Participants watched a 5-minute video of either smoking (retrieval extinction treatment group) or neutral material (non-retrieval extinction control group) followed by 10 minutes of no exposure and then both groups received 1 hour of extinction training which consisted of repeated exposure to smoking-related photos without access to smoking. At no point were participants allowed to smoke. Participants received the same exposure and training at the 2-week and 1-month follow-up sessions. In the follow-up sessions, participants in the treatment group showed significantly greater decreases in pre-cue and post-cue cravings as measured using the self-report Craving Questionnaire. Participants in the treatment group also reported smoking significantly fewer cigarettes per day as compared to the control group (a mean of ~7 compared to a mean of ~9). The authors hypothesize that cue-retrieval creates a window of opportunity to overwrite old memories and that when cue-retrieval is followed by extinction training, it results in reduced craving and cue-reactivity.

ROYER ET. AL (2015) found that an incentive programme for use of a company gym paired with a commitment contract resulted in long-term increases in physical activity. 1000 participants were offered free gym membership and a $10 per session incentive (for up to 3 sessions per week). After this 4-week period, half the participants were randomly selected and offered a commitment contract - participants put their own money at stake for a commitment that they would continue to use the gym once every 14 days for a 2 month period. Each participant decided how much to put at stake - the average amount people chose was $58. If the employee kept the commitment they got the money back, if not it was donated to charity.

Over the 2 months, the 12% of people who agreed to a commitment contract had 25% higher gym attendance than those in the incentive-only group and 50% higher than the control group. The incentive programme motivated 18.2% of employees who weren't gym members to attend the gym and 6 months after the incentive ended attendance rates were a few percentage points higher than the control group. However, the incentive+commitment group had even higher attendance relative to the control and showed increased attendance even 2-3 years after the programme ended.

Of interest, women, overweight people and people who already exercised regularly were more likely to sign the commitment contract.

Though the study of habits is still considered to be in its infancy, combating bad habits has been a topic of interest for decades. In one early paper, **STRELTZER AND KOCH (1968)**, found that participants who performed in a frightening role-play scenario involving being exposed to the consequences of smoking reported smoking fewer cigarettes daily compared to a control group in a 3-4 week follow-up. The researchers interpret these findings as evidence of habit change.

The study included a total of 30 female university students - all self-reported smokers. All participants first read a factual article relating smoking to cancer and other disease. Then, 20 participants individually took part in the role-play scenario (treatment group) while 10 did not (control group). In the scenario, each participant was asked to imagine that she was a patient visiting a doctor who was treating her for a bad cough. The researcher, playing the role of doctor, followed a memorized script informing the participant, ostensibly, that she has lung cancer, that she might need to undergo a serious operation, and that it is essential that she ceases smoking immediately. All participants completed a pretest, posttest, and a delayed posttest 3-4 weeks later.

Role-playing effectively changed participants attitudes for smoking (presumably in the expected direction, but not reported), and resulted in reduced daily consumption of cigarettes compared to the control group. Participants in the treatment group reported smoking fewer cigarettes per day on average in the delayed posttest (1.6) compared to at prettest (2.1) while participants in the control group reported increased consumption (3.0 and 2.4, respectively).

It is worth commenting on how the interpretation of these results might be different to habit researchers in 2018, compared to the interpretation offered by researchers in 1968. A key question is whether a change in smoking behavior necessarily equates to habit change? While the authors of the paper presume so, a contemporary perspective would likely argue that it does not. A change in smoking behavior that is related to a change in one's attitude toward smoking and intent to smoke is different than a change in one's automatic, habitual responses related to smoking. In other words, role-playing could very well have reduced smoking behavior, but it may have succeeded through a different process than through changing a habit. To comment on any habit-change, modern habit researchers would require measurement of a conceptually valid measure, such as the SRHI.

APPROACH-AVOIDANCE TRAINING

One promising paradigm for adopting good habits and abandoning bad ones is approach-avoidance training, which makes use of repeated approaching and avoiding movements to create respectively positive and negative associations with certain choices.

The effect of combined avoidance and control training on implicit food evaluation and choice. **BECKER ET AL. (2015)** conducted 3 studies to determine the effect of approach avoidance training (AAT) on eating and found no conclusive evidence that the approach changed implicit and explicit food preferences or eating behaviour. Throughout their studies, female students of a healthy weight were used.

In study 1, 51 students were assigned to the experiment or "sham" condition. Button presses with each hand either made the participant approach (zoom in) or avoid (zoom out) images, based on whether the images were presented horizontally or

square shaped. Pre-assessment and sham consisted of equal numbers of healthy and unhealthy images, the experiment contained avoidance of 90% of unhealthy stimulus. Participants were given a survey after the experiment and asked to pick between 3 snacks (tangerine, granola bar, chocolate) as a reward. Women in the experimental group made healthier choices in the survey and made a healthier snack choice post-experiment.

Study 2 involved 104 participants completing a similar task to study 1. Notable differences include measurements of impulse strength and dieting goal strength before the experiment. The survey given after the experiment contained more healthy and unhealthy options (3 of each as opposed to 1) and participants were asked how much they liked and wanted each of the options presented during the experiment. Differences in self-control, impulse strength and dieting goal strength did not significantly influence the training in AAT.

Study 3 used only images of chocolate (stimulus) and stationery (neutral) during training. The 103 participants recruited had a strong desire for chocolate and intention to reduce chocolate intake. Participants completed the same pre-study surveys as study 2, then chocolate craving was induced before the AAT training. A joystick was used to zoom in and out as opposed to keyboard presses. A bogus 5 minute taste test using M&Ms was used, with the amount of chocolate eaten measured by an experimenter. Participants in the experimental condition consumed more chocolate than those in the sham condition, which could be explained by participants in the sham condition having higher self-control scores. In conclusion, AAT does not have a proven, reliable effect on eating the same way it does with alcohol. Further research is needed to determine if overweight populations and multiple AAT training sessions will have an effect on healthy eating behaviour.

In a similar study design, **DICKSON ET AL. (2016)** examined the effects of a computerized approach-avoidance task (AAT) on approach bias and consumption of chocolate in undergraduate students.

Approach-avoidance tasks have been shown to be successful in reducing alcohol consumption. Applying the same concept to food is rather new. The researchers recruited 90 students. Each student completed the 11-item Strength form of the Craving Experience Questionnaire and next was randomly assigned them to either “approach” landscape-format pictures and to “avoid” portrait-format pictures or to “approach” portrait-format pictures and to “avoid” landscape-format pictures during the AAT. Pulling the joystick made the picture larger (simulating approach), whereas pushing it away made it smaller (simulating avoidance). For approximately 30 minutes, each student was shown a series of pictures either depicting chocolate or other snack images (watermelon, pineapple, apple pieces, almonds, carrots or muesli bars). For students in the Approach-Chocolate condition, 90% of the chocolate images were presented in pull-format, and 90% of alternative images were presented in push-format. For students in the Avoid-Chocolate condition these percentages were reversed. After completion of the AAT, students were asked to taste and rate chocolates from four different bowls. Each bowl contained 50g of chocolate. After the taste test, students completed a second 11-item Strength form of the Craving Experience Questionnaire.

Training to avoid chocolates resulted in faster avoidance responses to chocolate images, compared with training to approach it. Similar to the study by **BECKER ET AL. (2015)**, the researchers did not find a significant effect of the AAT on the amount of chocolate consumed nor on chocolate craving.

In two 2003 experiments, Jens Förster[1] examined the effect of arm position on food intake. In the first of these experiments, 20 participants were asked to watch a video of a political program for 25 minutes. They were told that their muscle activity would also be recorded, and to that effect were randomly assigned into two groups: one had to press the palm of their left hand against the bottom side of the table (mimicking arm flexion, i.e. an approach gesture), the other had to press down with the palm of their hand onto the surface of the table (mimicking arm extension, an avoidance gesture). A bowl of chocolate cookies was placed on the table next to them without further explanation and the experimenter left the room for the duration of the video. Participants in the arm flexion condition on average consumed significantly more cookies than those in the extension condition (2.60 vs. 0.90).

In a second study, the effect of the attractiveness of the targeted food/drink was examined. To that effect, Förster divided the 96 participants first into two groups, one of which was given a glass of orange juice instead of the chocolate cookies, the other a glass of lukewarm tap water. Each of these two groups was then further divided into three groups each: one was told to press upward (arm flexion), one to press downward (arm extension), and one was not given specific instructions. For participants in the orange juice condition, the results mimicked those of the first experiment: the arm flexion group drank significantly more (381 g) than the control group without instructions (298 g) or the arm extension group (187 g). The same was not true for the water condition: here, the extension group actually drank more (228 g) than the flexion group (206 g), although this difference was not significant.

To explain this difference, Förster invokes the creative tuning account he developed with Ronald S. Friedman. According to this theory, there are two kinds of motivational orientations: a promotion focus, which motivates an individual to seek nurturance (that is, food), and a preservation focus, which motivates the individual to seek security. Förster posits that a fit between the motivational orientation and the food in question (e. g., promotion focus, which encourages trying out new alternatives, and the luxurious orange juice) would lead to additional consumption, whereas a misfit between the two (such as a preservation focus and a luxurious drink, or a merely nurturing drink while in promotion focus) would inhibit intake.

While this study is interesting for examining the effects of direct body movement (rather than using an intermediary like a joystick), it did not examine whether this effect was only present during the movement or could be trained for the long-term.

VELING, FOLKVORD, AND HOEKEN (2016) found that children exposed to snack food images that were consistently paired with no-go cues consumed significantly less snack food as compared to children exposed to neutral images (colored circles) paired with no-go cues. Participants were 133 children between ages 7 and 10 that

1. Some caution is warranted in citing Forster's work. He is under investigation for fraud by the University of Amsterdam though he has denied the charges. Some papers have been retracted.

were instructed to press the computer space bar whenever they saw an image with a blue border (go trials) and to refrain from pressing the spacebar whenever they saw an image with a gray border (no-go trials). All participants were exposed to images of cute animals that had blue borders (go trials). Participants in the food condition were exposed to images of jelly candy with that had gray borders while participants in the control condition were exposed to images of colored circles that had gray borders (no-go trials). After the task, participants were moved to a table containing a bowl of jelly candy and a bowl of milk chocolate and were told they would have a 5 minute break and could eat as much as they wanted. After the break, participants took a survey about their candy preferences. The bowls were weighed after each individual session and then refilled. Children in the food condition consumed on average 169.6 kilocalories of snack food while those in the control condition consumed on average 226.0 kilocalories of snack food. The authors pointed out that their study only analyzed immediate effects of the go/no-go task and that future studies should examine how long the effect continues.

KAKOSCHKE, KEMPS, AND TIGGEMANN (2015) show that participants with both an approach-avoidance bias towards unhealthy foods and relatively lower inhibitory control consume more snack food than participants with without these two characteristics. While the study does not examine approach-avoidance training directly, it supports the suggestion that snacking behavior is guided by both controlled and automatic processing systems - with the latter, in this case, being measured with approach-avoidance tendency towards food. Hence, this evidence would suggest that effective training in approach-avoidance tendencies might be able to lead to behavior change, and suggests who might benefit most from the training.

In their test of 146 undergraduate women, all participants completed three exercises before a "taste test" exercise which measured the quantity of their voluntary consumption of unhealthy snacks (the primary outcome measure, measured in calories). The first exercise measured participant's attentional bias by a dot probe task. In this task, participants are exposed to two pictures side-by-side, one of which is a picture of unhealthy food and one is a control (animal). The two pictures then disappear, with one picture being replaced with a dot matrix. The participant must select, as quickly as possible, which picture (left or right) the dot probe replaced. Attentional bias as calculated by the difference in reaction time to when the dot probe replaced a picture of food and when it replaced the control image. A positive score indicates an attentional bias towards unhealthy food.

The second exercise measured participant's approach bias (automatic behavioral tendency to move towards rather than avoid food cues). In this task, participants were exposed to either a picture of unhealthy food or a control (an animal). Participants were instructed to pull (approach) or push (avoid) a joystick according to whether the picture was presented in portrait or landscape format. Approach bias was calculated as the difference between median pushing and pulling reaction times for food pictures. Positive scores indicate an approach bias for food whereas negative scores indicate an avoidance bias for food.

The third exercise measured controlled processing. Specifically, the exercise gauged inhibitory control (the ability to inhibit a behavioral impulse in order to attain higher-order goals). All participants were instructed to eat 2-hours before the

session, and their levels of hunger were measured to ensure it did not confound the results.

The results showed a significant interaction effect between approach bias and inhibitory control. Specifically, participants who showed relatively high approach bias (a tendency to "pull" snacks more than "push" them away) consumed more snacks when they displayed lower inhibitory control (~205 calories), but not when they displayed high inhibitory control (~145 calories). In contrast, participants with relatively lower approach bias consumed the same amount of snacks regardless of their inhibitory control (~173 calories). In other words, participants with poorer inhibitory control (controlled processing) ate more unhealthy snacks only if they showed a relatively greater approach bias (automatic processing). No other main effect or interaction effect was found to predict unhealthy food intake.

The researchers argue that this finding suggests that consumption of unhealthy food is determined by a combination of controlled and automatic processing. Further, it suggests that people with low inhibitory control in combination with high approach bias are most susceptible to increased unhealthy food intake. This particular group of people might be most benefited by an approach-avoidance training.

The same group of researchers conducted a literature review two years later **(KAKOSCHKE ET AL., 2017)** that summarized the findings of 18 approach avoidance studies – 7 for eating behavior, 8 for alcohol consumption and 3 for cigarette smoking. Besides the targeted behavior, they also classified these studies by the method used (besides approach avoidance training, which the majority used, one study also used joystick category judgement, where the participants move the joystick to categorize healthy and unhealthy foods explicitly, and one used an implicit association task, where participants were asked to classify stimuli into chocolate vs. non-chocolate and approach vs. avoid) and the type of control group used (mostly sham training, approaching the undesirable stimulus, or no training). They highlight positive effects, both for approach bias and consumption behavior in 5 out of 8 alcohol studies and in 2 out of 3 smoking studies, as well as in 5 out of 7 eating studies for approach bias, 4 out of 7 for consumption behavior. Overall, the authors conclude, this shows that AAT is a useful behavior change technique.

However, in a commentary on the paper, **BECKER ET AL. (2018)**, who contributed to three out of the seven experiments in the eating domain (see above), question that interpretation. They highlight that only four out of seven studies, so barely more than half, actually led to behavior change, and find methodological weaknesses in the successful studies. They particularly take issue with the selection of control groups – one experiment did not have a control group at all, making it impossible to verify whether it was the AAT that led to the behavior change, and the three others had the control group approach the undesired stimulus, which inflates the difference of treatment and control group. The studies that used a sham training group (in which participants approached, and avoided, an equal number of healthy and unhealthy stimuli) all did not find significant effects. In summary, the authors agree that AAT holds promise as a behavior change technique, but find it too early to draw conclusions in the eating domain as in the current studies, success seems merely dependent on the choice of control group.

CHAJUT, MAMA, LEVY, AND ALGOM (2010) find that when people are instructed to approach negative stimuli, they are slowed down by their vigilance toward those stimuli. 35 undergraduates participated in a version of the emotional Stroop task conducted on a Dance-Dance Revolution mat (see image below). In the original Stroop task, participants are presented with color words written in varying ink colors and asked to say the color of the word (e.g., if the word "red" is written in green ink, then the correct response would be "green"). This task forces people to override their automatic response of simply reading the color word. As such, people are generally much quicker at this task when, for example, "red" is written in red, compared to when it is written in any other color. In the emotional Stroop task, emotion-laden words (in this case, negative Hebrew words like "suicide" and "poison," and neutral words like "sweater" and "overall") are written in different colors. In this specific task, the words were presented twice in each of 4 colors. Participants were assigned to approach (i.e., step forward on the mat) 2 of the colors, and to avoid (step backward) the other 2 colors, regardless of what the words were. Participant reaction time was the main dependent variable. Participants took longer to approach negative words than neutral words, and the reverse pattern emerged for avoidance. The authors ran a similar second experiment, this time with a joystick as the approach-avoidance apparatus, and found similar results.

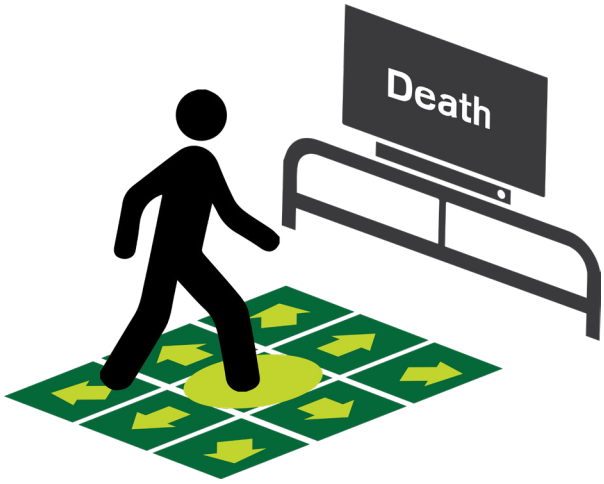


FIGURE 1: The setup of Experiment 1: The participant stepped forward or backward in response to the ink color of emotion or neutral words

RINCK ET AL (2013) found evidence that using approach-avoidance training is effective in helping those with social anxiety deal with their anxiety and positively approach social situations.

The authors enlisted 40 undergraduate students at Radboud University Nijmegen who scored high on a social anxiety questionnaire to participate in the study; the participants were compensated with course credits. Eight of the participants were excluded from the final analysis because their scores on the Social Interaction Anxiety Scale **(SIAS; MATTICK AND CLARKE, 1998**) were not high enough, though the authors completed additional analyses including these individuals and found similar results. The participants were randomly assigned to one of two conditions (16 per condition) - an approach smiling faces/avoid checkerboards condition, or an approach checkerboards/avoid smiling faces condition. Approach-avoidance training (AAT) reaction times, face-turn (FT-AAT) reaction times, and mood ratings were measured before and after the intervention. The intervention consisted of a pull-push approach-avoidance task where participants were asked to distinguish and categorize pictures according to their color (gray vs. sepia) as quickly as possible using a joystick - participants were instructed to pull the joysticked towards themselves for gray pictures, or push the joystick away from themselves with sepia pictures. The pictures were smiling male/females faces taken from the Karolinska Directed Emotional Faces **(KDEF; LUNDQVIST ET AL., 1998)** inventory, or neutral

checkerboards. When participants pulled on the joystick, the pictures zoomed in, whereas when they pushed on the joystick, the pictures zoomed out.

The authors did not find the hypothesized interaction between training type and movement type (approach vs avoid) overall, but they did discover an interaction when focusing only on female faces - participants who had been trained to approach smiling faces approached female faces more quickly than participants who had been trained to avoid those faces. They also found that participants' in the approach-faces training condition had improved mood and anxiety measures. The authors hypothesized that female faces were perceived as less threatening by the mostly female participants in the study.

KRIEGLMEYER AND DEUTSCH (2010) compared the manikin task to two versions of the joystick task over three experiments. The manikin task is an approach-avoidance task that involves a computer screen where the stimulus is presented in the center of the screen and a manikin figure is placed either above or below the stimulus. Before each trial, the participant centers their middle finger onto the "5" key of their keyboard (they do not specify, but I believe that all numbered keys mentioned here are based on a desktop PC keyboard). After the manikin appears, and depending on whether they were supposed to approach or avoid the stimulus, the participant must press the "8" key three times with their middle finger to go up the screen, and the "2" key to move the manikin down. The key presses made by the participants caused the manikin to move with an animation of walking toward or away from the stimulus. The joystick task, as described above, involved the presentation of a stimulus on a computer screen while the participant held onto a joystick controller. If the stimulus was positive, they were instructed to pull the joystick toward themselves, and if the stimulus was negative, they were instructed to push the joystick away. The feedback-joystick task, as also described above, was much the same as the joystick task except that when the participant pulled the joystick the stimulus became larger on the screen, simulating approach, and when they pushed the joystick the stimulus became smaller, simulating avoidance.

The researcher's first experiment compared the manikin task and the joystick task under conditions where the participants were instructed to evaluate the valence of the stimulus. People were presented with positive or negative words, and either told to approach or avoid positive words and vice versa for negative words (compatibility vs. incompatibility). The researchers found that reaction times differed significantly in the manikin task between compatible and incompatible conditions, but only marginally so in the joystick task. The second experiment compared the mankin task to both the joystick task and the feedback-joystick task under conditions where the valence of the stimulus was task-irrelevant. For this experiment, the researchers found positive and negative nouns and adjectives, and asked participants to either approach or avoid the word based on its grammatical content rather than its valence. For instance, if they were asked to approach nouns, they would both approach the words "poison" and "bunny". In this experiment, the incompatible trials were the trials in which the participant was to approach negative words or vice versa, whether or not they were nouns or adjectives. The researchers found that the joystick task was not significantly different in terms of response time between compatible and incompatible trials, but both the manikin task and joystick-feedback task were, suggesting feedback may be necessary when valence is task-irrelevant.

To validate the manikin and joystick-feedback measures, the third experiment compared both the manikin and joystick-feedback tasks with data about arachnophobia. All participants completed one of the two approach-avoidance tasks, where the stimuli were either pictures of spiders or butterflies. After which, they evaluated each of the pictures on a scale from 1 (very negative) to 9 (very positive), and then completed the Fear of Spiders Questionnaire and the Fear of Spiders Screening. Again, the manikin task conferred significant differences in response time between compatible and incompatible trials, while the feedback-joystick task had a marginally significant difference. Also, the arachnophobia measures were significantly correlated with avoidance of spider pictures, but not with approach of butterfly pictures, validating the manikin task as a valid measure of approach-avoidance.

Inspired by exposure treatment of anxiety disorders, **VAN DEN AKKER ET AL. (2016)** developed a cue exposure therapy for the treatment of overeating and obesity. During therapy, individuals are repeatedly exposed to their personal food cues, such as sight, smell and taste without eating. The authors were primarily interested in the effect of cue exposure on long-term weight loss, eating psychopathology, food cue reactivity and snacking behavior.

For this study, the authors recruited overweight, female adults in Maastricht, the Netherlands who reported high motivation to lose weight and prior difficulties in refraining from snack food. The 45 recruited women were randomly assigned to either an 8-session cue exposure intervention or an 8-session lifestyle intervention of which 39 completed the study. 4 participants dropped out in the cue-exposure intervention, and 2 dropped out of the lifestyle intervention. All participants took part in pre-measurements, their respective intervention, post-measurements and 3-month follow-up measurements. Each of the 8 intervention sessions were individual session with a therapist and took place within a month. The treatment was personalized for each participant. Exposure exercises used the participant's favorite high-calorie foods and their conditional stimuli, such as physical context, times of day, mood, satiation states as well as presence or absence of family members. Participants assigned to the lifestyle intervention received healthy lifestyle advice, mindfulness training, power-posing exercises and psycho-education on body image.

At the beginning of each therapy session, participants completed a hunger and a desire to eat visual analog scale (VAS). Additionally, participants in the cue exposure intervention completed desire to eat VASs during each minute of an exposure exercise. Eating psychopathology was measured by means of the Eating Disorder Examination Questionnaire, a 28-question self-report questionnaire. Food cue reactivity was measured by a participant's desire to eat, salivation and prospective portion size before and after exposure to one's favorite snack from a list of ten popular snack foods. **VAN DEN AKKER ET AL. (2016)** do not provide any study results, but merely mention which analysis should be done to obtain results.

NEIMEJER ET AL. (2015) conducted a longitudinal study that determined automatic approach tendencies (AAT) toward food increased one year after treatment for anorexia, but was not indicative of weight gain or reduction of eating disorder symptoms. Participants included 152 adolescents who had been diagnosed by the eating disorder examination (EDE) interview, which determined the severity of the

eating disorder. An Affective Simon Task Manikin (AST-Manikin) test was conducted to measure automatic approach-avoidance tendencies to food. High fat food, low fat food and neutral pictures were presented, and participants approached or avoided based on the perspective of the picture (top-view or side-view). Craving, liking and frequency of eating all the foods displayed was determined by a survey and height and weight measurements were recorded. One year later the same tests were carried out, with only 76 people participating (there was no difference between drop-outs and completers). The results showed that at baseline, participants had an approach bias for low calorie food but after a year participants had an approach bias for low and high calorie food. However, there was no significant difference between change in body-weight, symptoms and positive approach bias towards high calorie food. One limitation was that participants were in different stages of treatment at the one year mark, another follow up at a later period is needed.

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