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What Does it Take for Sour Grapes to Remain Sour? Persistent Effects of Behavioral Inhibition in Go/No-Go Tasks on the Evaluation of Appetitive Stimuli

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Abstract

Recent studies have provided contradictory results on whether the pairing of appetitive stimuli with no-go responses in go/no-go tasks leads to a devaluation of these stimuli. The authors of the present studies argue that devaluation effects after pairings of appetitive stimuli (e.g., unhealthy snacks or fruit) with no-go responses are usually short-lived but can become persistent if the stimuli form a meaningful category of appetitive stimuli that one should usually avoid (e.g., unhealthy snacks). In three studies, the authors found no persistent devaluation effects for appetitive stimuli that were paired with no-go responses when the pairings conveyed no meaning beyond the completion of the go/no-go task (e.g., pairing of no-go responses with fruit or pairing of no-go responses with a mixture of healthy and unhealthy stimuli). However, persistent devaluation effects after a delay of 10 min were found when no-go responses were consistently paired with unhealthy snacks contrasted against fruit.

Keywords: stimulus devaluation, go/no-go task, response inhibition, self-regulation, inhibitory control training

What Does it Take for Sour Grapes to Remain Sour? Persistent Effects of Behavioral Inhibition in Go/No-Go Tasks on the Evaluation of Appetitive Stimuli

In Aesop's fable "The fox and the grapes," when a fox realizes that he cannot reach some initially very tempting grapes, he decides to re-evaluate the grapes as being sour rather than sweet. This change in the fox's evaluation of the grapes is an example of stimulus devaluation. The extant literature in psychology has described this phenomenon in various forms. Studies found stimulus devaluation, for example, for inaccessible or distracting items, and after the choice of alternative options (Brehm, 1956; Martiny-Huenger, Gollwitzer, & Oettingen, 2014; Raymond, Fenske, & Tavassoli, 2003). Researchers have regarded stimulus devaluation as a highly adaptive mechanism that can be applied to help people save resources and focus on feasible goals (Brendl, Markman, & Messner, 2003; Elster, 1983). It is interesting, however, that research has demonstrated not only that situational constraints evoke stimulus devaluation but also that the "act" of not selecting stimuli or not responding to stimuli in simple response tasks might lead to stimulus devaluation. For example, Janiszewski, Kuo, and Tavassoli (2013) applied a design in which participants had to neglect products in a simple selection task and found a reduced preference for the neglected products in a subsequent choice task. Veling, Holland, and van Knippenberg (2008, Experiment 1) applied a go/no-go task and found similar effects. They instructed participants to respond to the presentation of a picture when a specific letter was displayed but not to respond when another specific letter was displayed. After the task, participants provided less positive evaluations of the stimuli used in no-go trials than of the stimuli used in the go trials or of stimuli that were not used in the go/no-go task.

Because go/no-go tasks are easy to apply and require very little time, researchers developed the idea of including go/no-go tasks in self-control trainings with the goal of reducing undesired behavior such as alcohol (Houben, Havermans, Nederkoorn, & Jansen,

2012) or unhealthy food consumption (van Koningsbruggen, Veling, Stroebe, & Aarts, 2014). Recent meta-analyses have revealed that go/no-go tasks are an effective tool for changing consumption behavior (Allom, Mullan, & Hagger, 2016; Jones et al., 2016). In their analysis, Jones et al. (2016) included 11 studies of 562 participants involving a go/no-go intervention and found a significant standardized mean difference between the intervention and control conditions of 0.47 (95% CI [0.39, 0.56]). An impressive aspect of the effects of go/no-go interventions is that they can obviously affect behavior over a longer time period. Houben, Nederkoorn, Wiers, and Jansen (2011) asked participants in one condition (beer/no-go condition) to complete a go/no-go task that consistently linked pictures of glasses of beer with a “no-go” response and asked all participants to report their alcohol consumption during the following week. They found that alcohol consumption was significantly reduced for the beer/no-go condition compared with a condition in which the pictures of glasses of beer were linked to go responses in the go/no-go task.

Although the results on long-term behavioral effects are consistent, it is not clear whether the effects on evaluation are more than short-lived (Jones et al., 2016). Previous studies have usually examined evaluations directly after the go/no-go task was implemented. At first glance, it might appear intuitive that go/no-go training effects on evaluations persist over time because the training has long-term effects on behavior. However, a number of alternative explanations can also explain why pairing certain products such as sweets or beer with no-go responses leads to a reduction in consumption – independent from persistent effects on evaluation. For instance, combining no-go responses with unhealthy food might remind participants of their goal to consume food in a more responsible way and make this goal highly accessible in memory (Fishbach, Friedman, & Kruglanski, 2003). However, increasing the salience of the goal to consume food in a healthy manner does not necessarily mean that the relevant stimuli will be rendered less attractive.

The mentioned meta-analysis by Jones et al. (2016) revealed the difference in effects of no-go stimulus-response pairings on evaluations and behavior. Although the observed effects on consumption behavior were impressive, this meta-analysis did not find devaluation effects for no-go stimulus-response pairings across the studies. The authors of this meta-analysis concluded that “repeated inhibition of behavior in response to appetitive stimuli does not appear to lead to devaluation of those stimuli” (Jones et al., 2016, p. 24). However, the authors also acknowledged that “the majority of studies included in the analysis used the implicit association test (IAT) to measure stimulus devaluation” (Jones et al., 2016, p. 24). This is a notable constraint because the implicit attitudes measured by the IAT are less malleable when already formed compared with explicit attitudes (Gregg, Seibt, & Banaji, 2006). Indeed, promising evidence that devaluation might occur on explicit evaluations also after a longer period of time comes from a study by Lawrence, Verbruggen, Morrison, Adams, and Chambers (2015). In this study, participants repeated a go/no-go training over couple of days in which healthy food was paired with a go and unhealthy food with no-go cues. In a subsequent evaluation, they observed a decrease in liking for the unhealthy food compared to a control condition without the described go/no-go task. However, a limitation is that the effect was not strong enough to yield a significant interaction between the training (go/no-go vs. control) and the food category (healthy vs. unhealthy vs. novel food) on the evaluations. Taken the analysis of the meta-analysis by (Jones et al., 2016) into account, the evidence is promising, but needs further support.

Hence, further research is necessary to clarify the conditions under which no-go stimulus-response pairings lead to devaluation effects. Specifically, we identified two important gaps in the literature. First, it is not clear whether the effects on evaluation fade away directly after the task or persist for a longer time. Second, the inconsistent findings on go/no-go effects on evaluation suggest the existence of important moderators. In line with the latter gap, Veling et al. (2008) pointed out that the endurance of the effect might depend on situational constraints, but they did not test this. We argue that the meaningfulness of the pairing of categories with the go and no-go responses might be another moderator. Meaningfulness is determined by how the stimulus-response combination is related to an individual's situations, goals, or experiences (Lehnert, Till, & Ospina, 2014). In particular, we suggest that an association between a (no-)go response with stimuli from a category will be meaningful when this combination is desired or socially approved and when it helps to oppose an undesired evaluation (e.g., a positive evaluation of unhealthy food or a less positive evaluation of healthy food).

Associations of no-go responses with specific healthy and unhealthy stimuli and the resulting devaluations might make it easier for individuals to complete the go/no-go task. However, it is not adaptive for individuals to hold on to such devaluations for a longer period of time when the devaluations are no longer needed. The same is true for a devaluation that is undesired outside the lab. For example, the association of no-go responses with a general category of healthy food and a possible subsequent devaluation of healthy food is not desired and not meaningful. By contrast, palatable but unhealthy food such as ice cream, chocolate, or chips provides a very good example of when devaluation might be meaningful and helpful for individuals. Such food is often tempting and positively evaluated. A devaluation of this food would be meaningful for participants because the reduction of unhealthy food intake is desired and socially approved and can help people overcome the temptation to consume such food.

Meaningfulness as a general concept is regarded as a factor that increases elaboration (Klein & Kihlstrom, 1986) and facilitates the integration of information in memory (Craik, 2002; Craik & Lockhart, 1972; Seamon & Murray, 1976). Therefore, we expect effects of go/no-go tasks on evaluations to be more persistent when the pairings between stimuli and go versus no-go responses are meaningful to participants.

Regarding the first gap, to understand why effects on evaluation might fade away after the completion of a go/no-go task, one ought to consider the behavior stimulus interaction (BSI) theory (Veling et al., 2008). The BSI theory is a prominent approach that is used to explain stimulus devaluation after inhibiting a go response. Usually, tempting stimuli such as sweets or alcohol evoke approach responses. However, when the approach response is unwanted, as is the case in no-go stimulus-response pairings, a response conflict occurs. The BSI theory would then predict that a devaluation of the stimuli can help to resolve the conflict. Indeed, it seems reasonable that the model applies to response conflicts outside the lab as well as to response conflicts while completing a go/no-go task. In other words, a devaluation of stimuli helps to verify the correct response in no-go stimulus-response pairings. A different question is whether this model can predict persistent effects. Even though the BSI theory predicts that stimuli that were paired with no-go responses will be evaluated as less positive in encounters that occur after the go/no-go task, it makes no explicit predictions about the temporal stability of the effects. However, from the point of view that devaluation is adaptive, it should be likely that the effects will be limited to the task and will not be durable. After all, a generalization of the devaluation effect across situations might be dysfunctional (Veling et al., 2008). Our first prediction is therefore that devaluation effects after a go/no-task will show a quick decay. Indeed, researchers have observed such flexible devaluation effects. Brendl et al. (2003) found that the devaluation of stimuli depends on current needs. For example, individuals devaluate nonfood stimuli when the need to eat is high but not when it is low. Hence, devaluation varies in accordance with the satisfaction of a need. Similarly, we expected effects of go/no-go tasks to decrease after a brief delay because the devaluation is foremost adaptive for the completion of the go/no-go task.

We further argue that the endurance of the devaluation effects of no-go stimulus-response pairings should be more likely to occur if the pairings are meaningful beyond the simple completion of the go/no-go task. For example, if participants complete a go/no-go task in which some healthy and some unhealthy food stimuli are paired with no-go responses, no persistent devaluation effects for these stimuli that go beyond the task should occur. But if the stimuli are paired with no-go cues in such a way that the unhealthy food stimuli are consistently paired with no-go responses and healthy food stimuli are consistently paired with go responses, participants might perceive a meaning that goes beyond the completion of the task (i.e., it is undesirable to approach unhealthy food). In this case, the response conflict—tempting but undesirable—and consequently the devaluation effect, might still occur when participants have to evaluate the stimuli after a delay following the completion of the task. It is important to note that we are not speculating about long-term effects that occur across a couple of days because, across such a long time period, other experiences might attenuate the effects. Our reasoning applies to immediate effects and those that occur after a brief delay of a couple of minutes.

The Present Research

Because we were not aware of any study that had systematically studied effects of no-go stimulus-response pairings on immediate explicit evaluations as well as after a delay, we conducted three studies that tracked explicit evaluations of stimuli immediately after the go/no-go task and after a short time delay. We argue that stimulus devaluation is based on a mechanism that is highly adaptive for regulating behavior and for increasing the efficiency of behavior. We expected that stimulus devaluation would take place during go/no-go tasks and immediately after the task because stimulus devaluation supports the effective completion of the task. Moreover, we expected that if the stimulus devaluation had no meaning beyond the task, it would exhibit a quick decay. By contrast, we expected a longer endurance of the devaluation effect for "meaningful" no-go pairings such as the consistent combination of unhealthy food with no-go responses, which would be contrasted by a consistent combination of healthy food and go responses. To analyze the persistence of devaluation effects, we asked participants in the present studies to evaluate stimuli before (Time 1) and immediately after a go/no-go task (Time 2) and, in addition, after a delay of approximately 10 min (Time 3). We analyzed the decrease in evaluation (short-term devaluation between Time 1 and Time 2; persistent devaluation between Time 1 and Time 3). To implement this comparison, we decided to report mean change scores for evaluation throughout the paper. This procedure reduces the complexity of the analyses and facilitates reading and understanding. In particular, change scores reduce the order of interactions by one degree. Hence, we did not need to break down each interaction that included time. It is important to mention that other researchers have used change scores in this area in the same way (Chen, Veling, Dijksterhuis, & Holland, 2016; Lawrence, O'Sullivan, et al., 2015).

The objective of Study 1 was to replicate previous research (Veling et al., 2008) and test potential devaluation effects after a delay. The objective of Study 2 was to provide initial evidence that the meaningfulness of no-go stimulus-response pairings in the go/no-go task would increase the likelihood of detecting a devaluation effect after a delay. Study 3 pursued the same goal as Study 2, while simultaneously ruling out the possibility that mere consistency in (no-)go category pairings is sufficient to produce persistent devaluation effects.

Study 1

In Study 1, participants completed a go/no-go task in which no clear category was associated with the no-go responses. In this task, products were paired with either go or no-go responses. We measured participants' evaluations of the products that were used in the go/no-go task and also their evaluations of products that were not used in the go/no-go task (untrained stimuli). We expected an immediate devaluation effect for the stimuli that were paired with the no-go responses compared with the other stimuli. However, because there was no meaningful category-response combination, we expected a decay of the devaluation effect.

Method

Participants and design. We recruited 53 participants on the campus of the university and through word of mouth. Participants did not receive any compensation. We excluded two participants because of missing data on the main dependent variable. Another two participants had missing values on only the age variable and were not excluded. The final sample consisted of 51 participants (M_{age} = 26.65, SD_{age} = 4.34; 24 women). The study used a 3 (stimulus status: go vs. no-go vs. untrained) by 3 (evaluation: Time 1 vs. Time 2 vs. Time 3) within-subjects design.

Apparatus and stimuli. The stimulus monitor was a 13.3-inch notebook screen with a resolution of 1440 x 900 pixels and a refresh rate of 60 Hz. The pictures of products were presented in the middle of the screen at an approximate size of 620 x 450 pixels.

We used 24 pictures of attractive food items from different product categories (beverages, candy, chewing gum, chips, fruit, ice cream). These products were organized according to stimulus status (go vs. no-go vs. untrained) in three sets, each with eight products from different categories. Participants evaluated all products in all three sets, but only Set 1 and Set 2 were used in the go/no-go task. Set 3 was not used in the go/no-go task and participants saw the pictures only during evaluation.

Procedure and measurement. After the participants arrived in the lab, they answered a demographic questionnaire. We asked participants to imagine themselves in a shopping environment. Subsequently (*evaluation: Time 1*), participants evaluated all products (9-point Likert scale; 1 = *not at all appealing*, 9 = *extremely appealing*). Then, participants were randomly assigned to work on one of two versions of the go/no-go task. In one version, the products in Set 1 were consistently paired with go cues, and the products in Set 2 were consistently paired with no-go cues. In the second version, the pairings were reversed (i.e., Set 1 with no-go cues, Set 2 with go cues). None of the versions paired the products in Set 3 with either go cues or no-go cues. The instructions and the procedure were exactly the same for the two versions. The instructions informed participants that they would see pictures of several products that are paired with either a “P” or a “F”. They were told that they should respond by pressing the spacebar when a “P” is presented, whereas they should not respond when an “F” is presented. They were encouraged to react as fast and accurate as possible. The task instruction further explained the temporal procedure of the go/no-go task.

The go/no-go task consisted of 15 practice trials and 80 main trials (Figure 1). Each trial began with the presentation of a product for 1,500 ms followed by a go cue (capital letter “P” in black) or no-go cue (capital letter “F” in black), respectively. The cues were presented for 1,500 ms and indicated whether participants should respond (go cue) by pressing the space bar or by withholding the response (no-go cue). Participants were allowed to respond as soon as a question mark appeared after the presentation of the cue. The blue question mark was presented for 1,000 ms or until the space bar was pressed. The trial ended with feedback on the participants’ correct (capital letter “O” in green) or incorrect (capital letter “X” in red) (non)responses. The inter-trial interval was 800 ms. The cues, the feedback, and the question mark were displayed in the middle of the screen in a standard Arial font with a size of 81 pixels.

Immediately after the go/no-go task, participants evaluated the products again (*evaluation: Time 2*). Participants then worked on a distractor task for 10 min. The distractor task consisted of two parts. In the first part, participants watched a documentary for 8 min 14 s. In the second part, participants answered questions about the content of the documentary for the remaining 1 min 46 s. Finally, participants evaluated the products again (*evaluation: Time 3*).

The product evaluations were the main dependent variables. We averaged the evaluations of the products according to the applied 3 (stimulus status: go vs. no-go vs. untrained) by 3 (evaluation: Time 1 vs. Time 2 vs. Time 3) design, resulting in mean product evaluations for products with no-go stimulus-response pairings, products with go stimulus-response pairings, and untrained products for each of the three times of measurement.

Results

Short-term devaluation. To test for short-term devaluation, we subtracted the mean product evaluations at Time 2 from those at Time 1. Short-term devaluation, or more precisely a decrease in evaluations from Time 1 to Time 2, was indicated by a negative value. To test whether devaluation was stronger after no-go stimulus-response pairings compared with go stimulus-response pairings or compared with the devaluation of untrained products, we conducted a within-subjects analysis of variance with one factor (stimulus status: go vs. no-go vs. untrained). The main effect was significant, $F(2, 49) = 7.03$, $p = .001$, $\eta_p^2 = .12$. As expected, contrast tests revealed that participants devaluated the no-go stimuli ($M = -0.25$, $SD = 0.39$) more strongly than both the go stimuli ($M = -0.04$, $SD = 0.34$), $F(1, 50) = 11.16$, $p = .002$, $\eta_p^2 = .18$, and the untrained stimuli ($M = -0.09$, $SD = 0.28$), $F(1, 50) = 5.99$, $p = .02$, $\eta_p^2 = .11$. The strength of devaluation did not differ between the go stimuli and the untrained stimuli, $F(1, 50) = 1.31$, $p = .26$, $\eta_p^2 = .03$.

Persistent devaluation. To test for persistent devaluation, we subtracted the mean product evaluations at Time 3 from those at Time 1. A more negative value indicated a stronger devaluation. To test whether devaluation was stronger after no-go stimulus-response pairings compared with go stimulus-response pairings and untrained stimuli, we conducted a within-subjects analysis of variance with one factor (stimulus status: go vs. no-go vs.

untrained). The main effect was not significant, $F(2, 49) = 2.2$, $p = .11$, $\eta_p^2 = .04$. A contrast test confirmed that there was no difference in devaluation between no-go stimuli ($M = -0.15$, $SD = 0.39$) and untrained stimuli ($M = -0.11$, $SD = 0.40$), $F(1, 50) = 0.39$, $p = .53$, $\eta_p^2 = .008$, and only a marginally significant difference between no-go stimuli and go stimuli ($M = -0.04$, $SD = 0.47$), $F(1, 50) = 3.34$, $p = .07$, $\eta_p^2 = .06$. Further, the strength of devaluation did not differ between the go stimuli and the untrained stimuli, $F(1, 50) = 3.15$, $p = .08$, $\eta_p^2 = .06$ (Figure 2).

Because of the challenge to support a non-effect with conventional analyses, we applied Bayesian analysis to the non-significant persistent devaluation effect using JASP (Version 0.8.0.1, JASP Team, 2016; Love et al., 2015). A paired sample t-test (Cauchy prior = 0.707) substantially supports the null hypothesis that persistent devaluation did not differ for no-go stimuli and untrained stimuli, $BF_{10} = 0.18$. The evidence was inconclusive for differences between go stimuli and untrained stimuli, $BF_{10} = 0.71$, as well as between no-go stimuli and go stimuli, $BF_{10} = 0.65$.

To underscore the finding that no-go response pairings lead to short-term devaluation but not to persistent devaluation, we included time (short-term devaluation vs. persistent devaluation) as additional factor in the within-subject analysis of variances. We conducted a 3 (stimulus status: go vs. no-go vs. untrained) by 2 (time: short-term devaluation vs. persistent devaluation) within-subject analysis of variances. In line with the analyses reported above, the Stimulus Status x Time interaction was significant, $F(2,100) = 4.90$, $p = 0.009$., $\eta_p^2 = 0.09$. This interaction qualified the main effect of stimulus status, $F(2,100) = 4.83$, $p = .01$, $\eta_p^2 = .09$. Participants devaluated the no-go stimuli ($M = -0.20$, $SD = 0.37$) more strongly than the go stimuli ($M = -0.04$, $SD = 0.38$), $F(1, 50) = 7.88$, $p = .007$, $\eta_p^2 = .14$. The strength of devaluation did not differ between the untrained stimuli ($M = -0.10$, $SE = 0.33$) and both the go and no-go stimuli, *F*s < 2.84, *p*s > .10. The main effect of time was not significant, $F(1,50) = 0.68$, $p = .41$, $\eta_p^2 = .05$.

Task performance. The mean accuracy (percentage of correct responses) was 96.4% (*SD* = 3.9%) and the mean go-latency was 396.8 ms (*SD* = 97.6 ms). Accuracy after no-go stimulus-response pairings (*M* = 98.9%, *SD* = 2.0%) was higher than accuracy after go stimulus-response pairings (*M* = 94.0%, *SD* = 7.2%), $t(50) = -5.08$, $p < .001$, $d_z = 0.71$.

Discussion

In Study 1, we measured devaluation with explicit evaluation items and found a devaluation effect immediately after the go/no-go task. The results are in line with previous research (Chen et al., 2016; Lawrence, O'Sullivan, et al., 2015; Veling, Aarts, & Stroebe, 2013b; Veling et al., 2008). The meta-analysis by Jones et al. (2016) did not find a reliable effect of no-go stimulus-response pairings on devaluation. However, their analysis was mainly based on implicit measures, which are usually less malleable when already formed compared with explicit measures (Gregg et al., 2006).

Extending previous research, we also assessed devaluation effects after a delay. It is interesting that we did not find a persistent devaluation effect after a delay of 10 min. This finding is in line with our view that the devaluation effect is based on a highly adaptive process that helps participants complete the go/no-go task. We further argued that delayed devaluation effects would be more likely to occur if no-go stimulus-response pairings were imbued with meaning beyond the simple completion of the task. Consequently, we addressed this point in Study 2.

Study 2

In Study 2, we used unhealthy snacks and fruit as stimuli. It is important to mention that we included a condition in which no-go responses were consistently paired with unhealthy snacks and go responses with fruit. Because fruit is usually regarded as superior and healthier than unhealthy snacks, the no-go response should hence become meaningful beyond the go/no-go task. Therefore, we expected an immediate and persistent devaluation effect in this condition. By contrast, we expected no persistent devaluation effect in a condition with mixed pairings. The condition with mixed pairings used the same stimuli as the condition with the meaningful category, but half of the unhealthy snacks and half of the fruit were paired with go responses and the respective other half with no-go responses. In an additional control condition, participants completed a go/no-go task on unrelated stimuli.

Method

Participants and design. We recruited 119 first-year undergraduate psychology students from the local subject pool at the university. Participants received course credit as compensation. To avoid computing analyses with missing values, we included only participants who completed the study. Overall, 114 participants completed the study. We excluded four vegan participants because they would not consume many of the food products we used as stimuli. Furthermore, we had to exclude one participant for technical reasons that resulted in missing values on the main dependent variable. The final sample consisted of 109 participants (M_{age} = 22.37, SD_{age} = 4.46; 78 women).

This study used a 2 (stimulus status: go vs. no-go) by 3 (evaluation: Time 1 vs. Time 2 vs. Time 3) by 3 (category-response combination: consistent vs. mixed vs. control) mixed design. Stimulus status and evaluation time were within-subjects factors. Category-response combination was a between-subjects factor.

Apparatus and stimuli. The stimulus monitor was a 21.5-inch screen with a resolution of 1920 x 1080 pixels and a refresh rate of 60 Hz. The pictures of products were presented in the middle of the screen and had an approximate size of 620 x 450 pixels.

As stimulus material, Study 2 used two geometrical figures, 20 pictures of food products, and two pictures of beverages. The stimulus material was adopted from Study 1 and slightly adapted. In the practice trials, we used the geometrical figures (i.e., a rectangle and a triangle). The 20 pictures of food products, which were evaluated in all conditions, were 10 pictures of fruit (apple, banana, blueberries, cherries, grapes, kiwi, orange, pineapple, raspberries, and strawberries) and 10 pictures of unhealthy snacks (Häagen-Dasz ice cream, Magnum Classic ice cream, Bahlsen Selection, Leibniz butter biscuits, Haribo Tropifrutti, Daim bar, Nestlé Lion, Nestlé Smarties, Nestlé Yes Torty cacao, Pringles Original). The go/no-go task in the consistent and mixed response combination conditions used these stimuli. The go/no-go task in the control condition used two beverages (Fanta and Sprite). The picture of one beverage was consistently paired with go responses and the picture of the other beverage with no-go responses.

Procedure and measurement. After receiving brief instructions, participants evaluated the 20 food products (9-point Likert scale; 1 = *not at all appealing*, 9 = *extremely appealing*) in all conditions (*evaluation: Time 1*). Subsequently, participants were randomly assigned to one of three conditions: the consistent condition ($N = 36$), the mixed condition ($N = 39$), or the control condition ($N = 34$). As mentioned above, the conditions differed in the stimulus materials that were used in the go/no-go task. In the consistent condition, fruit pictures were consistently paired with go cues, whereas pictures of unhealthy snacks were consistently paired with no-go cues. In the mixed condition, we used the same material as in the consistent condition. However, half of the fruit pictures and half of the pictures of unhealthy snacks were consistently paired with go cues. The remaining half of the food pictures were consistently paired with no-go cues. The assignment of the specific food pictures to go or no-go stimulus-response pairings was randomized, but the number of unhealthy snacks or fruit was fixed for the go and no-goal trials in the mixed condition. In the control condition, one beverage was consistently paired with go cues, and one beverage was paired with no-go cues. Participants in the control condition also rated the 20 food products but not the beverages.

Besides the different products that were used in the go/no-go task, the instructions and the procedure in each condition were exactly the same and similar to Study 1. The go/no-go task consisted of 15 practice trials and 100 main trials (Figure 1). Each trial began with the presentation of a product for 1,500 ms followed by a go cue (capital letter “P” in black) or no-go cue (capital letter “F” in black), respectively. The cues were presented for 1,500 ms and indicated whether participants should respond (go cue) by pressing the space bar or by withholding the response (no-go cue). Participants were allowed to react as soon as a question mark appeared after the presentation of the cue. The blue question mark was presented for 1,000 ms or until the space bar was pressed. The trial ended with feedback on the participants’ correct (capital letter “O” in green) or incorrect (red capital letter “X”) (non)responses. The inter-trial interval was 800 ms. The cues, the feedback, and the question mark were displayed in the middle of the screen in a standard Arial font with a size of 81 pixels.

Immediately after the go/no-go task, participants evaluated the products again (*evaluation: Time 2*). Participants then worked on a distractor task for 10 min. The distractor task was the same as in Study 1. Finally, participants evaluated the food products again (*evaluation: Time 3*).

The product evaluations were the main dependent variables. To account for potential changes in evaluation over time that were independent of the (no-)go stimulus-response pairings, we used evaluations at the three time points in the control condition as baseline measures. Specifically, in the control condition, we averaged the evaluations of each specific product across participants for the three evaluation times separately. This resulted in three mean evaluations (Time 1 vs. Time 2 vs. Time 3) for each of the 20 food products.

Subsequently, we mean centered evaluations of participants in the consistent and mixed combination conditions on the respective mean evaluation of the food products in the control condition. For example, ratings of the apple in the consistent and mixed conditions at evaluation Time 1 were mean centered at the mean evaluation of the apple in the control condition at Time 1. The same procedure was applied for evaluations of the apple at Time 2 and Time 3. Afterwards, we averaged the mean-centered evaluations of food products according to stimulus status (go vs. no-go) and evaluation time (Time 1 vs. Time 2 vs. Time 3). This operation resulted in the main dependent variable that was used in all further analyses: product evaluations for go stimulus-response pairings and no-go stimulus-response pairings at the three evaluation times.

Results

Short-term devaluation. To test for short-term devaluation, we again subtracted the product evaluations at Time 2 from those at Time 1. Short-term devaluation, or more precisely a decrease in evaluations from Time 1 to Time 2, was indicated by a negative value. We hypothesized that there would be a stronger devaluation after no-go stimulus-response pairings compared with go stimulus-response pairings. To test this hypothesis, we conducted a 2 (stimulus status: go vs. no-go) by 2 (category-response combination: consistent vs. mixed) mixed-design analysis of variance. Stimulus status was a within-subjects factor, and category-response combination was a between-subjects factor. In line with our hypothesis, participants devaluated food products after no-go stimulus-response pairings (M = -0.13, SD = 0.57) more strongly than they devaluated food products after go stimulus-response pairings (M = 0.14, SD = 0.56), $F(1, 73) = 5.93$, $p = .02$, $\eta_p^2 = .08$. Neither the category-response combination nor the interaction between stimulus status and category-response combination was significant, Fs < 1.45, ps > .23. Thus, the short-term devaluation effect was independent of the category-response combination.

Persistent devaluation. To test for the persistent devaluation effect, we again subtracted the product evaluations at Time 3 from those at Time 1. We hypothesized that there would be a stronger devaluation after no-go stimulus-response pairings compared with go stimulus-response pairings, which would be moderated by the category-response combination. In particular, we expected persistent devaluation effects in the consistent condition but not in the mixed category-response combination condition. To test our hypothesis, we conducted a 2 (stimulus status: go vs. no-go) by 2 (category-response combination: consistent vs. mixed) mixed-design analysis of variance. Stimulus status was a within-subjects factor, and category-response combination was a between-subjects factor. The analyses revealed a main effect of stimulus status, $F(1, 73) = 9.29$, $p = .003$, $\eta_p^2 = .11$. The main effect of category-response combination was not significant, $F(1, 73) = 0.53$, $p = .47$. In support of our hypothesis, the main effect of stimulus status on the persistent devaluation effect was qualified by a significant Stimulus Status x Category-response Combination interaction, $F(1, 73) = 4.08$, $p = .05$, $\eta_p^2 = .05$ (Figure 3).

We analyzed the nature of the interaction by computing paired *t* tests separately for the consistent and mixed conditions. We tested the effects of stimulus status on the devaluation. In the consistent condition, stimuli were devaluated more after no-go stimulus-response pairings ($M = -0.27$, $SD = 0.53$) than after go stimulus-response pairings ($M = 0.28$, $SD = 0.53$), $t(35) = 4.21$, $p < .001$, $d_z = 0.70$. This difference in devaluation after no-go stimulus-response pairings ($M = 0.01$, $SD = 0.62$) compared with go stimulus-response pairings ($M = 0.12$, $SD = 0.64$) was not present in the mixed condition, $t(38) = 0.66$, $p = .52$, $d_z = 0.10$.

Task performance. The mean accuracy (percentage of correct responses) was 98.4% ($SD = 6.5\%$) and the mean go-latency was 334.1 ms ($SD = 169.3$ ms). Accuracy did not differ between no-go stimulus-response pairings ($M = 99.3\%$, $SD = 1.6\%$) and go stimulus-response pairings (*M* = 97.6%, *SD* = 12.4%), $t(108) = -1.50$, $p = .14$, $d_z = 0.14$. Category-response combination (consistent vs. mixed vs. control) did neither influence accuracy, $F(2, 106) = 1.34$, $p = .27$, $\eta_p^2 = .02$, nor go-latency, $F(2, 106) = 0.56$, $p = .57$, $\eta_p^2 = .01$ (Table 2).

Discussion

As in Study 1, we again observed immediate devaluation effects for stimuli after no-go stimulus-response pairings. This result is congruent with our proposal that the stimulus devaluation effect is evoked in the go/no-go task to allow for more efficient responding in the task. It is important to mention that the pattern of results changed after a delay of 10 min. After 10 min, the stronger devaluation after no-go stimulus-response pairings compared with go stimulus-response pairings was significant only when the unhealthy snack pictures were paired with no-go cues and the fruit pictures were paired with go cues. This result is in line with our reasoning that devaluation effects become more persistent when they carry meaning that goes beyond the completion of the go/no-go task. An alternative explanation for the observed persistent devaluation effect is that using a clear category might facilitate associative learning in and of itself. When a category is applicable, participants do not have to learn evaluations of every single stimulus but rather just for the general category. We addressed this point in Study 3 by combining no-go cues with the category of fruit. Because fruit consumption is usually regarded as desirable (Stok et al., 2014), the devaluation of fruit should have no meaning for participants beyond the completion of the go/no-go task.

Study 3

We argue that consistently pairing unhealthy snacks with no-go responses and fruit with go responses should evoke a health goal that is meaningful beyond the simple completion of the task. However, associative learning might also be facilitated in the condition with consistent category-response pairings compared with the condition with mixed pairings. To address this point, Study 3 included a condition with consistent but nonmeaningful stimulus-response pairings. In this reversed condition, fruit was consistently paired with no-go cues and unhealthy snacks with go cues. Even though the pairings were consistent, we expected no persistent devaluation in this condition because the stimulus-response pairings were not meaningful. By contrast, we expected to replicate the persistent devaluation effect from Study 2 in a condition with consistent and meaningful stimulus-response pairings (fruit with go and unhealthy snacks with no-go).

Method

Participants and design. We recruited 178 first-year undergraduate psychology students from the local subject pool at the university. Participants received course credit as compensation. All participants completed the study. We excluded seven vegan participants because they would not consume many of the food products we used as stimuli. The final sample consisted of 170 participants (M_{age} = 21.71, SD_{age} = 3.78; 139 women).

This study used a 2 (stimulus status: go vs. no-go) by 3 (evaluation: Time 1 vs. Time 2 vs. Time 3) by 3 (category-response combination: consistent vs. reversed vs. control) mixed design. Stimulus status and evaluation time were within-subjects factors. Category-response combination was a between-subjects factor.

Apparatus and stimuli. Study 3 used the same apparatus and stimuli as Study 2. The stimulus monitor was a 21.5-inch screen with a resolution of 1920 x 1080 pixels and a refresh rate of 60 Hz. The pictures of products were presented in the middle of the screen and had an approximate size of 620 x 450 pixels.

In the practice trials, we again used the geometrical figures (i.e., a rectangle and a triangle). The go/no-go task in the consistent condition and the reversed condition used the 20 food pictures (fruit and unhealthy snacks). The go/no-go task in the control condition used two beverages (Fanta and Sprite). The picture of one beverage was consistently paired with go responses and the picture of the other beverage with no-go responses.

Procedure and measurement. Study 3 used the same procedure and measurement as Study 2 with the only change regarding the conditions. After receiving brief instructions, participants evaluated the 20 food products (9-point Likert scale; 1 = *not at all appealing*, 9 = *extremely appealing*) in all conditions (*evaluation: Time 1*). Subsequently, participants were randomly assigned to one of three conditions: the consistent condition with meaningful stimulus-response pairings ($N = 55$), the reversed condition with consistent but not meaningful stimulus-response pairings ($N = 56$), or the control condition ($N = 60$). In the consistent condition, fruit pictures were consistently paired with go cues, whereas pictures of unhealthy snacks were consistently paired with no-go cues. In the reversed condition, fruit pictures were consistently paired with no-go cues, whereas pictures of unhealthy snacks were consistently paired with go cues. In the control condition, one beverage was consistently paired with go cues, and one beverage was paired with no-go cues. Participants in the control condition also rated the 20 food products but not the beverages.

The instructions and the procedure in each condition were exactly the same. They were adapted from Study 1 and 2. The go/no-go task consisted of 15 practice trials and 100 main trials (Figure 1). Each trial began with the presentation of a product for 1,500 ms followed by a go cue (capital letter “P” in black) or no-go cue (capital letter “F” in black), respectively. The cues were presented for 1,500 ms and indicated whether participants should respond (go cue) by pressing the space bar or by withholding the response (no-go cue). Participants were allowed to react as soon as a question mark appeared after the presentation of the cue. The blue question mark was presented for 1,000 ms or until the space bar was pressed. The trial ended with feedback on the participants’ correct (capital letter “O” in green) or incorrect (red capital letter “X”) (non)responses. The inter-trial interval was 800 ms. The cues, the feedback, and the question mark were displayed in the middle of the screen in a standard Arial font with a size of 81 pixels.

Immediately after the go/no-go task, participants evaluated the products again (*evaluation: Time 2*). Participants then worked on a distractor task for 10 min. The distractor task was the same as in Study 1 and 2. Finally, participants evaluated the food products again (*evaluation: Time 3*).

The product evaluations were the main dependent variables. We used the same procedure of mean-centering on the evaluations in the control condition as described in Study 2 to account for potential changes in evaluation over time that were independent of the (no-)go stimulus-response pairings.

Results

Short-term devaluation. To test for short-term devaluation, we again subtracted the product evaluations at Time 2 from those at Time 1. Short-term devaluation, or more precisely a decrease in evaluations from Time 1 to Time 2, was indicated by a negative value. We hypothesized that there would be a stronger devaluation after no-go stimulus-response pairings compared with go stimulus-response pairings. To test this hypothesis, we conducted a 2 (stimulus status: go vs. no-go) by 2 (category-response combination: consistent vs. reversed) mixed-design analysis of variance. Stimulus status was a within-subjects factor, and category-response combination was a between-subjects factor. In line with the expected main effect of stimulus status, participants devaluated food products after no-go stimulus-response pairings (M = -0.15, SD = 0.65) more strongly than they devaluated food products after go stimulus-response pairings (M = 0.06, SD = 0.59), $F(1, 109) = 6.49$, $p = .01$, $\eta_p^2 = .06$. The main effect of category-response combination was not significant, $F(1, 109) = 1.96$, $p = .16$, but the Stimulus Status x Category-response Combination interaction was, $F(1, 109) = 8.72$, $p = .004$, $\eta_p^2 = .07$. We analyzed the nature of the interaction by computing paired t tests separately for short-term devaluation in the consistent and reversed conditions. In the consistent condition, stimuli were devaluated more after no-go stimulus-response pairings (M

= -0.34, *SD* = 0.80) than after go stimulus-response pairings (*M* = 0.13, *SD* = 0.49), *t*(54) = 3.38, *p* = .001, d_z = .46. This difference in devaluation after no-go stimulus-response pairings (*M* = 0.02, *SD* = 0.39) compared with go stimulus-response pairings (*M* = -0.01, *SD* = 0.67) was not present in the reversed condition, *t*(55) = -0.35, *p* = .73, d_z = -0.05.

Persistent devaluation. To test for the persistent devaluation effect, we again subtracted the product evaluations at Time 3 from those at Time 1. We hypothesized that there would be a stronger devaluation after no-go stimulus-response pairings compared with go stimulus-response pairings, which would be moderated by the category-response combination. In particular, we expected persistent devaluation effects in the consistent condition but not in the mixed category-response combination condition. To test our hypothesis, we conducted a 2 (stimulus status: go vs. no-go) by 2 (category-response combination: consistent vs. reversed) mixed-design analysis of variance. Stimulus status was a within-subjects factor, and category-response combination was a between-subjects factor. The analyses revealed a main effect of stimulus status, *F*(1, 109) = 7.29, *p* = .008, η_p^2 = .06. In support of our hypothesis, this effect was qualified by a significant Stimulus Status x Category-response Combination interaction, *F*(1, 109) = 9.02, *p* = .003, η_p^2 = .08 (Figure 4). We analyzed the nature of the interaction by computing paired *t* tests separately for devaluation in the consistent and reversed conditions. In the consistent condition, stimuli were devaluated more after no-go stimulus-response pairings (*M* = -0.36, *SD* = 0.86) than after go stimulus-response pairings (*M* = 0.15, *SD* = 0.57), *t*(54) = 3.59, *p* < .001, d_z = .48. This difference in devaluation after no-go stimulus-response pairings (*M* = -0.01, *SD* = 0.44) compared with go stimulus-response pairings (*M* = -0.04, *SD* = 0.73) was not present in the reversed condition, *t*(55) = -0.25, *p* = .80, d_z = 0.03. The main effect of category-response combination was not significant, *F*(1, 109) = 0.86, *p* = .35.

Task performance. The mean accuracy (percentage of correct responses) was 99.5% (*SD* = 0.9%) and the mean go-latency was 326.7 ms (*SD* = 71.4 ms). Accuracy did not differ between no-go stimulus-response pairings (*M* = 99.5%, *SD* = 1.1%) and go stimulus-response pairings (*M* = 99.4%, *SD* = 1.4%), $t(170) = -1.00$, $p = .32$, $d_z = 0.08$. Category-response combination (consistent vs. mixed vs. control) did neither influence accuracy, $F(2, 168) = 0.22$, $p = .80$, $\eta_p^2 = .003$, nor go-latency, $F(2, 106) = 0.03$, $p = .97$, $\eta_p^2 < .001$ (Table 2).

Discussion

In Study 2, we found that persistent devaluation effects were more likely when the no-go response was consistently associated with unhealthy stimuli. We argued that, in this condition, it was easier for participants to perceive the devaluation as meaningful beyond the completion of the go/no-go task that was facilitated by the devaluation of the stimuli. However, it was also possible that the consistent pairings of the go/no-go responses with specific categories increased associative learning. The results of Study 3, however, limit this interpretation. Indeed, in Study 3, the consistent association of no-go cues with fruit did not lead to an immediate or persistent devaluation effect, whereas the consistent association of no-go cues with unhealthy food items did. If associative learning alone could explain the effects of the use of a consistent response-category pairing, we should have observed a persistent devaluation effect for both response-category combinations. Hence, the results further support the idea that devaluation is more likely to become persistent if it is meaningful, which is the case for the devaluation of unhealthy stimuli but not for the devaluation of healthy stimuli.

General Discussion

In a seminal paper, Veling et al. (2008) studied the effects of response inhibition in no-go stimulus-response pairings in a go/no-go task on evaluations. However, surprisingly little research has systematically explored the conditions under which devaluation effects can occur, and less is known about persistent devaluation effects after no-go stimulus-response pairings. We supposed that devaluation helps to ease the completion of go/no-go tasks but that the no-go response must be infused with additional meaning if the devaluation effect persists. In three studies, we replicated Veling et al.'s (2008) findings by showing that devaluation after no-go stimulus-response pairings is a robust phenomenon. However, we did not observe persistent devaluation effects after a delay of 10 min in Study 1. In line with our hypothesis, we observed a persistent devaluation effect only in the conditions in Study 2 and 3 in which we consistently paired unhealthy snacks with a no-go response across the different stimuli. When no-go responses were not paired consistently across a category of unhealthy food (Study 1 and 2) or paired with the category of fruits (Study 3), which are generally considered as a food for which avoidance is not desired, we did not observe a persistent devaluation effect.

First, the results of the present studies show once again that the pairing of food stimuli with no-go responses compared with pairing them with go responses leads to devaluation effects and are thus in line with a growing number of studies that have demonstrated this phenomenon (Chen et al., 2016; Lawrence, O'Sullivan, et al., 2015; Lawrence, Verbruggen, et al., 2015; Veling, Aarts, & Stroebe, 2013a; Veling et al., 2013b). The robustness of this phenomenon is further underscored by the fact that we used a slightly different procedure for the go/no-go task. Previous research has often presented (no-)go cues at the same time as when the food stimuli were presented on the screen (i.e., stimuli were presented simultaneously with food stimuli onset; Lawrence, O'Sullivan, et al., 2015; Veling et al., 2013a) or were added after a short time (Chen et al., 2016). By contrast, we presented the cues after the food stimuli: First, the food stimuli were presented for a fixed duration, and after the food stimuli disappeared, the (no-)go cue followed for a fixed duration. We adapted the procedure in this way to keep the presentation duration of all stimuli (as well as response cues) and the attention to all stimuli constant. Thus, we were able to rule out the possibility that mere exposure effects (Zajonc, 1968), distraction from the food stimuli (Dittrich & Klauer, 2012), or competition for attention between the food stimuli and (no-)go cues (Janiszewski et al., 2013) may have interfered with the observed effects. The evidence for devaluation effects across the three studies demonstrates that the applied procedure did not affect the possibility of observing a devaluation effect. Indeed, to rule out the possibility that the devaluation effect is based on evaluative conditioning Chen et al., (2016) applied variations of the common procedure of the go/no-task , as well, and still found devaluation effects. However, the most important contribution of the present studies is not the replication or the applied procedure but the finding that devaluation effects become more persistent when the pairings between the no-go responses and the stimuli carry meaning that goes beyond the completion of the task.

Researchers have regarded devaluation effects as highly adaptive for coping with the demands of the environment (Elster, 1983; Gross, Woelbert, & Strobel, 2015). Devaluation has been discussed as a tool that can be used to reduce cognitive dissonance (Shultz, Léveillé, & Lepper, 1999) and as a mechanism that can help people pursue their current goals and satisfy their needs (Brendl et al., 2003; Gollwitzer, Martiny-Huenger, & Oettingen, 2014). With respect to devaluation effects in a go/no-go task, we foremost understand devaluation as a mechanism that helps make task completion easier. In our view, it would not be adaptive to continue the devaluation for a longer period of time except when it is meaningful beyond the simple completion of the task. Indeed, research has shown that devaluation is a flexible phenomenon. For example, individuals devaluate objects that are unrelated to food when they are hungry but not when they are satiated (Brendl et al., 2003). Similarly, we expected a quick decay of the devaluation after the go/no-go task. The results supported this expectation. However, as outlined above, we also expected the devaluation effects to persist when they carried meaning that went beyond the completion of the task. The devaluation of stimuli is meaningful when the stimuli belong to a category for which devaluation is normative and desired. In Studies 2 and 3, we used unhealthy snacks as such a meaningful category and found persistent devaluation effects. Even if unhealthy snacks such as chocolate bars or ice cream are tempting, taste good, and tend to be met with positive evaluations, it is a common understanding that it is meaningful to devaluate them in order to maintain and promote one's own health (de Vries, Eggers, Lechner, van Osch, & van Stralen, 2014). By contrast, the devaluation of healthy food such as fruit is not a norm, nor do individuals directly and without further explanation understand why it should be meaningful to devaluate it. Indeed, individuals often consume too little rather than too much fruit (Stok et al., 2014).

A study by Lawrence, O'Sullivan, et al. (2015) already provided promising hints that persistent devaluation effects might be possible even over a longer period of time after extensive trainings. It is interesting that, in their study, the no-go responses were consistently paired with unhealthy food such as biscuits, chocolate, and chips, whereas the go responses were paired with healthy food items such as fruits and vegetables. Hence, the authors used a category-response combination that had immediate meaning in exactly the sense we described above. However, there was no systematic variation in whether unhealthy or healthy stimuli were associated with no-go responses in Lawrence, O'Sullivan, et al.'s (2015) study. Further, the authors did not apply a condition with inconsistent no-go stimulus-response pairings of healthy and unhealthy stimuli. By showing that the persistence of unhealthy stimuli is reduced when the no-go stimulus pairings lose their meaning beyond the go/no-go task, the present study represents an important extension of the study by Lawrence, O'Sullivan, et al. (2015).

Using a meaningful category might prolong the devaluation effect on the basis of several mechanisms that still have to be examined further. It might be the case that the pairing of unhealthy snacks with no-go responses makes participants aware that they should be careful about consuming unhealthy snacks. Hence, unhealthy snacks in general might be attached to a kind of a warning signal that causes an inhibition similar to a no-go response. In a similar way, working on a go/no-go task could train participants to develop an implementation intention. By consistently pairing unhealthy snacks with no-go responses, the category of unhealthy snacks might itself become a cue that elicits healthy consumption behavior. Moreover, as described in the BSI theory (Veling et al., 2008), devaluation might help to reduce the approach tendency usually linked to the stimuli and the resulting response conflict. What is unclear, however, is whether the response conflict itself continues or whether the devaluation has already been learned and the response conflict is no longer active. For instance, participants in Study 1 might have resolved their response conflict by indicating a decrease in how appealing the food was at Time 2. The resolved response conflict induced by the evaluation immediately after the go/no-go task might explain the diminished devaluation effect at a delayed Time 3 in Study 1. In this or a similar manner, the measurement at Time 2 might have interfered with the persistent devaluation effect (i.e., evaluation itself might strengthen or weaken the devaluation effect). It would be very interesting to test in future research whether devaluation effects continue to occur after a delay when the immediate measurement is omitted. Studies 2 and 3 already demonstrated that devaluation effects can continue to occur at a delayed Time 3 when evaluation is measured immediately after the go/no-go task. Also unclear at present is whether the devaluation is a consequence of participants gaining an understanding of what they should do because this is implied by the procedure of the go/no-go task or whether the answers are less shaped by conforming to such norms set by the experimental procedure.

It is also important to note that using a clear category might facilitate learning in and of itself. When a category is applicable, participants do not have to learn evaluations of every single stimulus but rather just for the general category. Participants can retrieve the category evaluation when evaluating the stimulus, and they can change the evaluation of the stimulus accordingly. Without doubt, changing the evaluation of the category might strengthen and facilitate devaluation effects. However, it has to be noted that we observed a short-term devaluation effect for mixed stimulus-response combinations that disappeared after 10 min. Further, we observed no learning advantage for the consistent (no-)go response category pairing in the accuracy (percentage of correct responses) and speed of the responses within the go/no-go task. Hence, associative learning alone is unlikely to explain the observed effect.

The goal of the current study was to show whether delayed devaluation can occur and under what conditions this is likely to happen. It was not the goal of the current study to examine whether the observed effect would generalize to other stimuli such as pictures of other kinds of unhealthy food. However, such an effect would be important for interventions applying the go/no-go task. Future research might test for such generalization effects across stimuli that were not used in the go/no-go task. Also, it is important to note that the present study does not allow any conclusions to be drawn about whether devaluation is the driving mechanism in interventions that apply go/no-go tasks to change consumption behavior. To draw such a conclusion, it would be necessary to test long-term effects on consumption or food choice that occur across a time period of at least a couple of days. Our reasoning applies to immediate effects and those that occur after a brief delay of a couple of minutes. We also did not study actual consumption behavior. However, recent findings by Veling et al. (2013a) suggest that the association of palatable food with no-go cues is effective at reducing the consumption of such food in the most dangerous situation: when appetite is high. Most important, the authors identified devaluation as an important mediator in this study. Therefore, we suggest that future research should explore the long-term effects of related training procedures with meaningful stimulus-response combinations on consumption while testing for the mediating effect of devaluation.

In conclusion, the present findings replicate previous research by showing that no-go stimulus-response pairings, compared to go stimulus-response pairings, lead to devaluations of the stimuli. But the present studies also show that this effect is short-lived except when stimuli from one clear category are consistently combined with no-go responses in a meaningful way. Future research is needed to show whether devaluations resulting from meaningful stimulus-response combinations can be observed for even longer periods of time (e.g., a week or a month) and to examine whether such long-term devaluation contributes to the effectiveness of interventions that are based on go/no-go tasks.

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Table 1. *Mean Evaluation of Food Stimuli According to Stimulus Status and Evaluation Time*

	prior to Go/No-Go Task (T1)			immediately after Go/No-Go Task (T2)			after a 10min Delay (T3)		
	Untrained [1]	Go [2]	No-Go [3]	Untrained [1]	Go [2]	No-Go [3]	Untrained [1]	Go [2]	No-Go [3]
Study 1	5.55 (0.80)	5.86 (0.76)	5.81 (0.84)	5.46 (0.80)	5.82 (0.78)	5.56 (0.87)	5.44 (0.79)	5.82 (0.80)	5.66 (0.90)
Study 2	6.11 (1.09)	6.22 (1.22)	5.12 (1.27)	6.02 (1.17)	6.26 (1.30)	4.88 (1.30)	5.95 (1.20)	6.27 (1.31)	4.82 (1.41)
control [a]	6.11 (1.09)	-	-	6.02 (1.17)	-	-	5.95 (1.20)	-	-
consistent [b]	-	6.87 (0.99)	4.52 (1.23)	-	7.04 (0.98)	4.22 (1.31)	-	7.04 (1.13)	4.04 (1.35)
mixed [c]	-	5.62 (1.07)	5.68 (1.05)	-	5.55 (1.14)	5.48 (0.96)	-	5.57 (1.06)	5.54 (1.05)
Study 3	5.68 (1.07)	5.80 (1.87)	5.67 (1.81)	5.61 (1.08)	5.78 (2.01)	5.45 (2.03)	5.55 (1.13)	5.73 (2.10)	5.37 (2.05)
control [a]	5.68 (1.07)	-	-	5.61 (1.08)	-	-	5.55 (1.13)	-	-
consistent [b]	-	7.14 (1.19)	4.35 (1.26)	-	7.25 (1.23)	3.79 (1.28)	-	7.25 (1.31)	3.79 (1.28)
reversed [d]	-	4.47 (1.42)	6.97 (1.22)	-	4.34 (1.51)	6.98 (1.36)	-	4.23 (1.60)	6.92 (1.35)

Note. Participants evaluated food items on a 9-point Likert scales (1 = *not at all appealing*, 9 = *extremely appealing*). Standard deviations (*SD*) are reported in parentheses. [1] items were not used in the go/no-go task; [2] items were paired with go cues in the go/no-go task; [3] items were paired with no-go cues in the go/no-go task; [a] participants worked on an unrelated go/no-go task; [b] fruit was consistently paired with go responses and snacks with no-go responses; [c] no clear general category was associated with (no-)go responses; [d] fruit was consistently paired with no-go responses and snacks with go responses

Table 2. *Task Performance according to Category-response Combination*

	Accuracy in %				Go-Latency in ms			
	control [a]	consistent [b]	mixed [c]	reversed [d]	control [a]	consistent [b]	mixed [c]	reversed [d]
Study 1	-	-	96.4 (3.9)	-	-	-	396.8 (97.6)	-
Study 2	99.3 (0.9)	99.1 (1.6)	97.1 (10.6)	-	317.1 (83.6)	325.7 (91.2)	356.7 (298.7)	-
Study 3	99.5 (0.9)	99.5 (0.9)	-	99.4 (1.0)	324.7 (62.6)	327.2 (65.1)	-	327.4 (86.1)

Note. Standard deviations (*SD*) are reported in parentheses. [a] participants worked on an unrelated go/no-go task; [b] fruit was consistently paired with go responses and snacks with no-go responses; [c] no clear general category was associated with (no-)go responses; [d] fruit was consistently paired with no-go responses and snacks with go responses

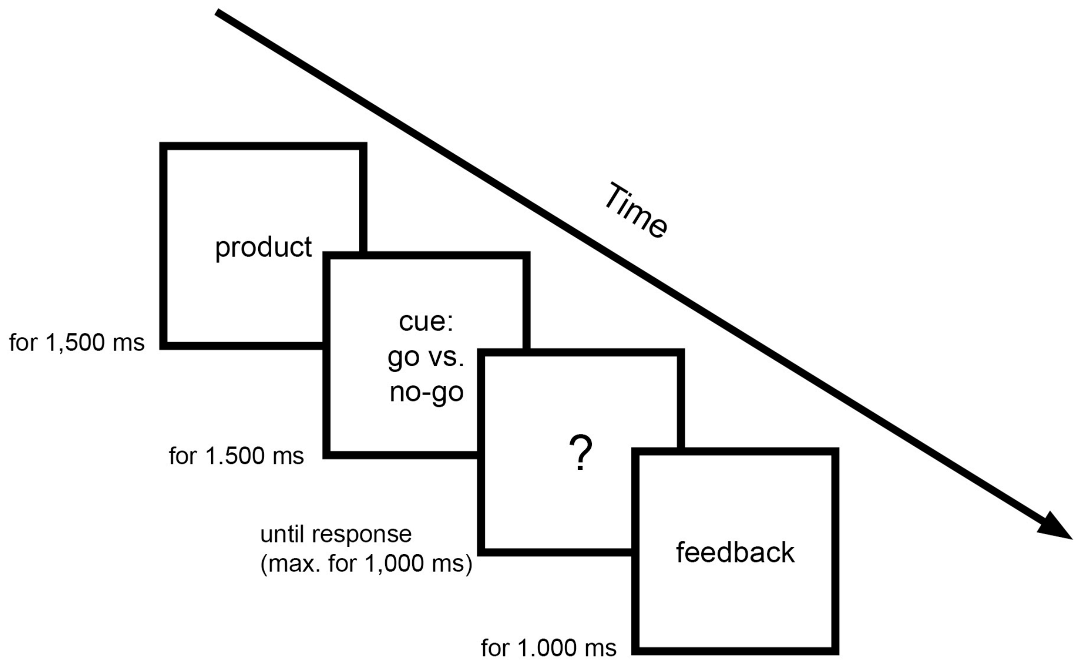

Figure 1. Sequence of a trial in the go/no-go task.

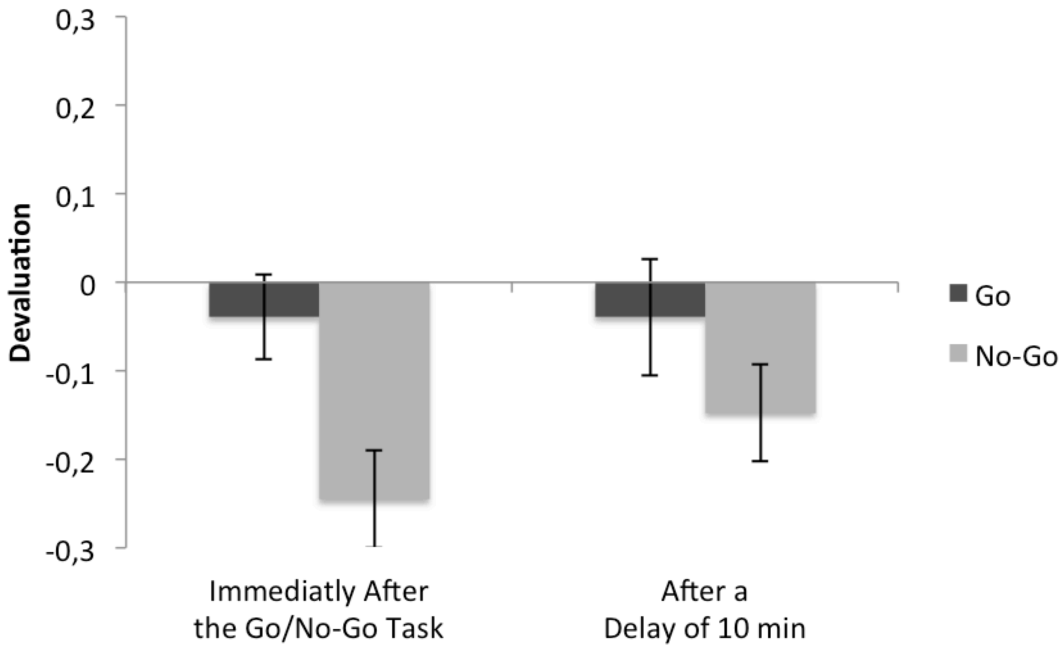

Figure 2. Product devaluation (Study 1) after go versus no-go stimulus-response pairings immediately after the go/no-go task and after a delay of 10 min. Devaluation is illustrated by the change in evaluation from an initial evaluation prior to the go/no-go task (9-point Likert scale; 1 = *not at all appealing*, 9 = *extremely appealing*). A more negative value indicates a stronger devaluation.

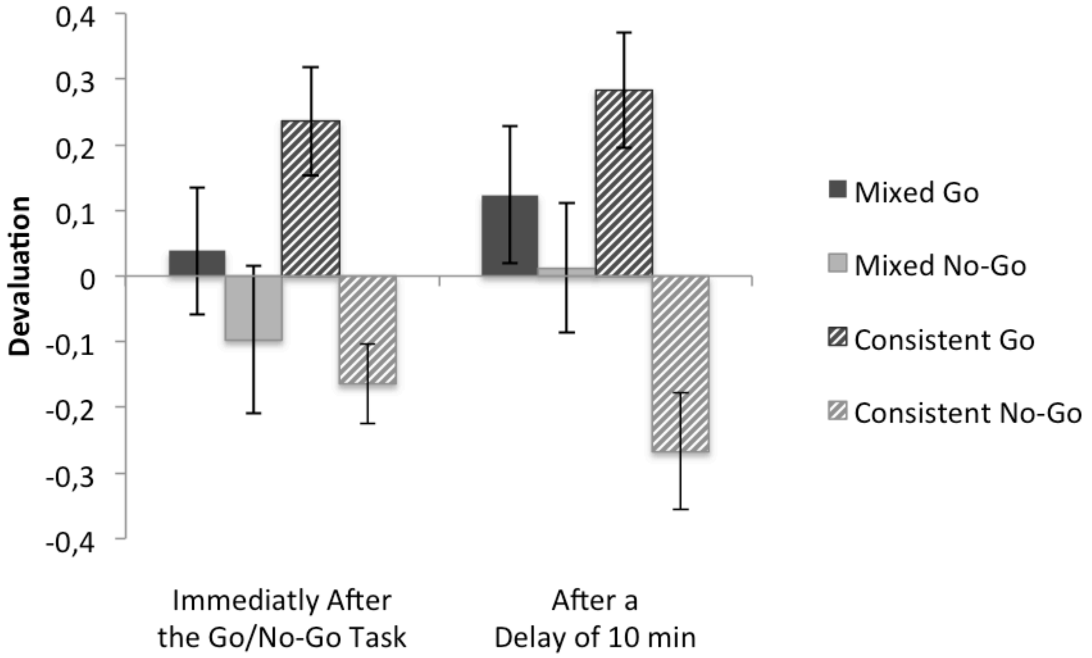

Figure 3. Product devaluation (Study 2) after go versus no-go stimulus-response pairings immediately after the go/no-go task and after a delay of 10 min. In the consistent condition, fruit pictures were consistently paired with go cues, whereas pictures of unhealthy snacks were consistently paired with no-go cues. In the mixed condition, half of the fruit pictures and half of the pictures of unhealthy snacks were paired with go cues. The remaining half of the food pictures in the mixed condition was paired with no-go cues. Product devaluation is illustrated by the change in evaluation from an initial evaluation prior to the go/no-go task (9-point Likert scale; 1 = *not at all appealing*, 9 = *extremely appealing*). Product devaluation was corrected for baseline measurements, which accounted for changes in evaluation over time that were independent from the go/no-go task. A more negative value indicates a stronger devaluation.

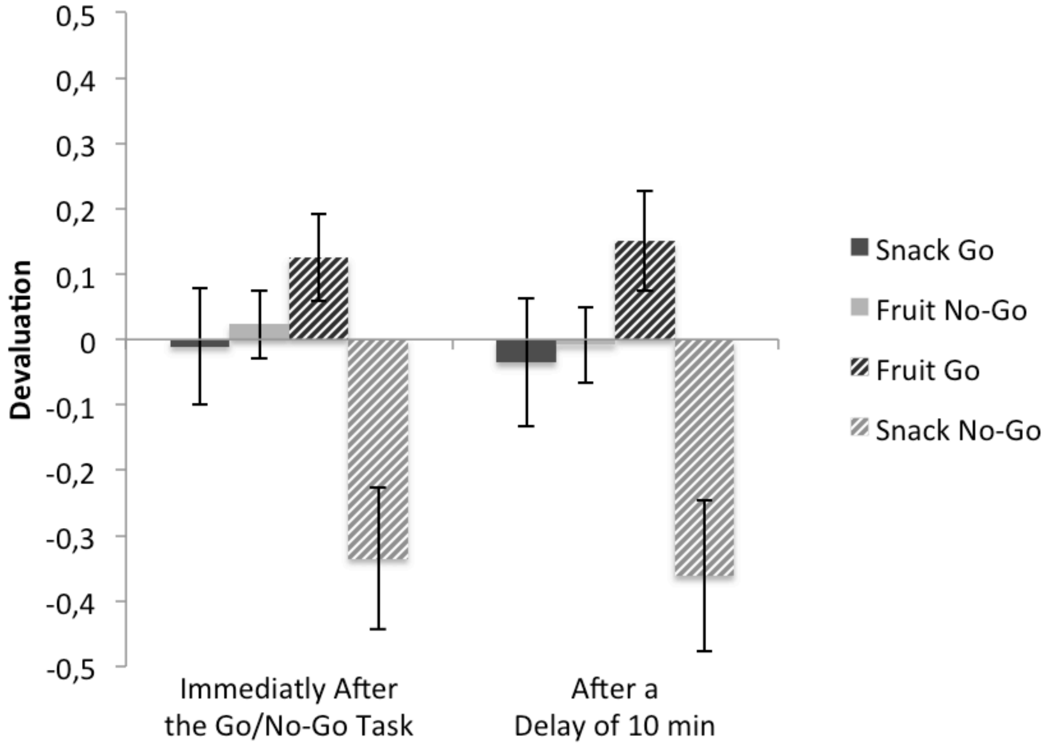

Figure 4. Product devaluation (Study 3) after go versus no-go stimulus-response pairings immediately after the go/no-go task and after a delay of 10 min. In the consistent condition, fruit pictures were consistently paired with go cues (fruit go), whereas pictures of unhealthy snacks were consistently paired with no-go cues (snack no-go). In the reversed condition, fruit pictures were consistently paired with no-go cues (fruit no-go), whereas pictures of unhealthy snacks were consistently paired with go cues (snack go). Product devaluation is illustrated by the change in evaluation from an initial evaluation prior to the go/no-go task (9-point Likert scale; 1 = *not at all appealing*, 9 = *extremely appealing*). Product devaluation was corrected for baseline measurements, which accounted for changes in evaluation over time that were independent from the go/no-go task. A more negative value indicates a stronger devaluation.