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### ► To cite this version:

Margaux de Chanaleilles, Aïna Chalabaev, Cyril Forestier, Alexandre Mazéas, Hervé Dubouchaud, et al.. Does exposure to sedentary temptations activate physical activity goals? A high-powered replication study.. *Motivation Science*, 2023, 10.1037/mot0000308 . hal-04597277

**HAL Id: hal-04597277**

**<https://hal.science/hal-04597277>**

Submitted on 6 Jun 2024

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Does exposure to sedentary temptations activate physical activity goals?

## **POST PRINT**

### **Does exposure to sedentary temptations activate physical activity goals? A high-powered replication study**

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## Does exposure to sedentary temptations activate physical activity goals?

### Abstract

Cognitive asymmetry is an effortless self-control strategy observed in successful self-regulators, for whom exposure to temptations (e.g., sedentary (SED) opportunities) increases the cognitive accessibility of long-term goals (e.g., physical activity (PA)), whereas exposure to goals should not increase the cognitive accessibility of the temptations. However, this mechanism has rarely been observed in the context of physical activity, and a recent high-powered study did not replicate it in the academic context. Therefore, additional replication studies are needed to support the existence of the phenomenon, or not. The present study attempted to replicate the cognitive asymmetry mechanism in the PA context based on a high-powered design. To do so, 257 participants completed a primed lexical decision task including PA-related (i.e., goal) and SED-related (i.e., temptation) stimuli target words preceded by a relevant SED-related and PA-related prime, respectively, or an irrelevant-related prime (i.e., neutral words). Results showed significant priming effects – SED-related primes increased the cognitive accessibility of PA-related words and PA-related primes increased the cognitive accessibility of SED-related words. However, we did not replicate the hypothesized cognitive asymmetry pattern between temptations and goals. These findings were consistent with a recent replication study by demonstrating that the automatic associations between goals and temptations were more likely to be symmetric (i.e., bi-directional linkage facilitation) than asymmetric (i.e., activation of the goal by temptations, but inhibition of the temptations by goals).

**Keywords:** Automatic goal activation; goals; temptations; prime; physical activity

# Does exposure to sedentary temptations activate physical activity goals?

## I. Introduction

Self-control is the ability to resolve motivational conflict between competing goals (e.g., Fujita, 2011; Gillebaart, 2018) through effortful (e.g., inhibition) or effortless (e.g., habits) strategies (e.g., Gillebaart, 2018; Gillebaart & de Ridder, 2015). One effortless strategy is the temptation-elicited goal activation process<sup>1</sup>. According to Fishbach et al. (2003), repeated success in overcoming tempting situations competing with a long-term goal, leads to the development of automatic mental associations between the temptations and the long-term goal representation. In this case, a temptation-related cue automatically activates the long-term goal in successful self-regulators. In contrast, goal-related cues are not supposed to activate the mental representation of temptations. This unidirectional association between temptation cues and long-term goals, called the cognitive asymmetry mechanism, is thought to play a key role in successful self-regulation.

Cognitive asymmetry has been observed in a variety of contexts, such as dieting (Fishbach et al., 2003; Papies et al., 2008) or physical activity (Cheval et al., 2017). Using a primed lexical decision task, Cheval et al. (2017) showed that temptation primes related to sedentary behaviors facilitated the recognition of goal-related target words related to physical activity in successful exercisers. In contrast, exposure to goal-related or neutral primes did not affect the cognitive accessibility of temptation-related constructs.

Although cognitive asymmetry is often considered as illustrating effortless self-control, very few studies, with small sample sizes, have replicated it (Cheval et al., 2017; Papies et al., 2008), and a recent high-powered study failed to replicate the phenomenon (Francis et al., 2022). In this recent replication failure, a priming effect was instead observed, where both temptation and goal primes facilitated the recognition of subsequent target words. This calls into question the existence of the phenomenon.

## The present study

This study examined whether the cognitive asymmetry process would be replicated in the context of physical activity, using a high-powered design as in Francis et al. (2022).

It should be noted that this study was originally designed to investigate whether exposure to weight stigma prevents the cognitive asymmetry process from occurring in people concerned about their weight. However, because we did not replicate the cognitive asymmetry process, this hypothesis was not testable, and only the cognitive asymmetry results are presented. However, the original complete rationale and analyses are available in the Supplementary Materials.

## II. Method

The present study was preregistered on AsPredicted (#52738). Data and supplementary materials are available on OSF ([https://osf.io/gax7j/?view\\_only=8a445aab14004937b7df8e1fbe7e98d0](https://osf.io/gax7j/?view_only=8a445aab14004937b7df8e1fbe7e98d0)). All procedures adhered to APA ethical principles. Informed consents were obtained from all participants

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<sup>1</sup> Currently, there are discussions about positioning cognitive asymmetry as a self-control strategy. Effortless strategies, even if they require automatic and unreflective processes, are considered "strategies" in some of the literature (see, e.g., Fujita, 2009; Gillebaart, 2018; Gillebaart & De Ridder, 2015). Note, however, that the term "effortless strategies" refers to automatic processes that require no effort to engage.

## Does exposure to sedentary temptations activate physical activity goals?

before the start of the study, who were informed that the study was anonymous and confidential: only a self-generated code allowed their identification.

### **Participants and power analysis**

We conducted at first an a-priori power analysis to estimate the sample size required to detect the initially hypothesized 3-way interaction between Goal-Target words (within factor: physical activity (PA) vs. sedentary (SED) words) x Temptation-Prime (within factor: relevant vs. neutral prime) x Weight Stigma Exposure (between factor: yes vs. no), which was tested using linear mixed-effects modeling (MEM), with a 90% power and an alpha level of 5%. The analysis showed that the sample size needed to reach 90% statistical power for the 3-way interaction was 72 participants per condition. To anticipate any problems with data collection, we planned to recruit at least 180 participants (See more details in Supplementary Materials). We recruited more participants to ensure that at least 180 of them met all the inclusion criteria, which were restrictive. Because we looked only at the Goal-Target words (within factor: physical activity (PA) vs. sedentary (SED) words) x Temptation-Prime (within factor: relevant vs. neutral prime) interaction in the current article, our study should have more power than expected (see Sensitivity Analysis).

### **Procedure and data collection**

Three hundred fifty-five participants were recruited at Le Mans University and Grenoble Alpes University, via mailing lists, university classes, and social media over a three-month period, and were compensated with course credit. Two participants were excluded because they did the study two times. 254 participants ( $M_{age} = 19.70$  years; 119 women) met the inclusion criteria. Specifically, seven participants were excluded for not giving enough importance to physical activity (i.e., it was not a goal for them), 91 in this new subsample were not sufficiently active and three participants did not fully complete the study. The entire study was conducted online on Inquisit Web (e.g., the study of Francis et al., (2022), used a half online and half in-person design, and found no difference in results across these two samples). Participants were first invited to read and sign an informed consent form before performing the lexical decision task. They were then randomly assigned to one of two conditions (weight stigma exposure vs. control), by reading either a text exposing them to weight-stigmatizing information or the control text (see Supplementary Materials), based on Araiza and Wellman (2017). The texts discussed workplace discrimination against overweight individuals (Weight Stigma Condition) or against Inuit Canadians (Control Condition). This manipulation did not moderate the reported cognitive asymmetry results, and is not discussed further here (but see Supplemental Materials). Finally, they completed a questionnaire measuring the variables described below.

### **Measures**

#### ***Inclusion criteria***

##### **Physical activity goal value**

The value of physical activity goal was measured with a 3-item questionnaire (Cheval et al., 2017). Participants answered to what extent they: 1) avoid sedentary behaviors, 2) are concerned about the importance of adopting physical activity on a regular basis, 3) make an

## Does exposure to sedentary temptations activate physical activity goals?

effort to adopt physical activity behaviors, and 4) feel guilty if they consistently adopt sedentary behaviors, on a 7-point scale (1= *not at all*; 7= *extremely*). Participants were included only if they reported at least a score of 4 on the scale. This ensured that physical activity was at least moderately important for them, to optimize conditions of occurrence of the cognitive asymmetry process.

### **Physical activity and sedentary behaviors**

Physical activity and sedentary behaviors were measured using a self-reported questionnaire (short International Physical Activity Questionnaire adapted from Craig et al., 2003), where participants were asked to indicate how many times (in minutes) they spent the last 7 days in vigorous and moderate physical activities, walking and sitting. Participants were included only if they reported at least 150 minutes of moderate to vigorous physical activity per week, thus achieving the minimum health recommendations guidelines (World Health Organization, 2019). This ensured that participants were successful exercisers, to optimize conditions of occurrence of the cognitive asymmetry process.

### **Other measures**

Participants also completed weight concerns, weight stigma concerns, weight perception, and physical activity beliefs measures. However, these measures did not significantly moderate the results (see the Supplemental Materials).

## ***Outcome***

### **Lexical decision task**

The task was the same as in Cheval et al. (2017), with a Target (PA vs. SED words) x Prime (PA and SED vs. neutral-primed) within-subject design. Participants were asked to indicate as accurately and quickly as possible, whether the letter string presented on the screen was an existing word or not, by pressing specific keys on their keyboard. Targets included PA and SED-related words. Primes included neutral, PA and SED-related words. Primes were characterized as relevant when a temptation (SED) primed the goal (PA), or when the goal (PA) primed the temptation (SED), and as irrelevant when neutral. At first, a fixation cross appeared for 1 second and was followed by the 50-ms prime presentation, and then by the target word that remained on the screen until the participant responded. Targets were related to physical activity (PA) or sedentary behaviors (SED). Participants performed a 10-trial practice before completing the 256 experimental trials. In these trials, items of interest were assessed both 36 times (i.e., PA targets primed by SED words and SED targets primed by PA words). Other trials composed the control condition (e.g., neutral primes and non-words targets combinations).

### ***Demographics***

Finally, participants answered socio-demographic items about their sex (Male; Female; I prefer to not answer), age, height, weight, how many persons lived with them, their mother's and father's level of education (Compulsory schooling; Apprenticeship; Secondary school or baccalaureate; Higher professional school; University education; Don't know), their financial status (I can't cope; I have to be careful; I'm fairly comfortable; I'm very

## Does exposure to sedentary temptations activate physical activity goals?

comfortable), and income (1000 euros or less; 1000 to 2500 euros; 2500 to 5000 euros; More than 5000; Don't know).

### Data analysis

#### *Reaction time data exclusion*

Trials with non-words, trials resulting in incorrect responses, and responses below 200 ms and above 1500 ms were not included in the analyses (Cheval et al., 2017), leaving a total of 34720 trials.

#### *Statistical models*

We followed the procedure described in the preregistration and analyzed reaction times in the lexical decision task following the procedure described in Cheval et al. (2017), using linear mixed effects modeling (MEM). We conducted a MEM using the package *lmerTest* in R-Studio (Team, 2015). Target x Prime interaction was specified as a fixed factor and participants as a random factor, and we included, at the level of the participant, the random effects Target x Prime interaction.

### III. Results

#### *Sensitivity analyses*

To ensure our study was sufficiently powered to detect the main interaction effect of interest, we conducted a sensitivity power analysis with the *SIMR* R package (Green & MacLeod, 2016) as described in Francis et al. (2022). We found that our sample had more than 96% power (lower bound = .964; upper bound = 1) to detect an interaction effect of 20 ms ( $r = .04$ ) in the 2-way analysis; this effect size is the one found by Cheval et al. (2017) and is four times smaller than the effect size found in study 1 of Fishbach et al. (2003).

#### *Analysis for the 2-way interaction*

Contrary to our hypothesis that temptation-related primes should lead to faster recognition of goal-related target words, and that goal-related primes should not lead to faster recognition of temptation-related targets (asymmetrical activation pattern), the results revealed a non-significant Target x Prime interaction (Table 1;  $b = -.98\text{ms}$ ,  $p = .775$ ), indicating that no cognitive asymmetry occurred.

Further analyses showed that the nature of target words significantly predicted reaction time, which was faster for words related to PA than SED ( $M = 670_{\text{PA}}$  vs.  $682_{\text{SED}}$  ms; table 1;  $b = 11.68\text{ms}$ ;  $p < .001$ ) – participants responded ~12ms faster to PA targets than to SED targets. Primes also significantly predicted reaction time, which was faster for relevant prime words than for irrelevant ones ( $M = 670_{\text{relevant}}$  vs.  $683_{\text{irrelevant}}$  ms; table 1;  $b = -12.23\text{ms}$ ;  $p < .001$ ) – participants responding ~13ms faster when Targets (either PA or SED words) were preceded by relevant prime words.

# Does exposure to sedentary temptations activate physical activity goals?

**Table 1.**

Results of the linear mixed models predicting the reaction time required to recognize SED-related and PA-related words.

<i>Predictors</i>	<i>Estimates</i>	<b>Reaction Time</b>	
		<i>CI</i>	<i>p</i>
Intercept	<b>681.98</b>	<b>669.75 – 694.22</b>	<b>&lt;0.001</b>
Target	<b>11.68</b>	<b>6.66 – 16.71</b>	<b>&lt;0.001</b>
Prime	<b>-12.23</b>	<b>-16.99 – -7.47</b>	<b>&lt;0.001</b>
Target x Prime	-0.97	-7.66 – 5.72	0.775
<b>Random Effects</b>			
$\sigma^2$	25223.88		
$\tau_{00}$ ID	9151.70		
$\tau_{11}$ ID.target	183.38		
$\tau_{11}$ ID.prime	26.15		
$\tau_{11}$ ID.target:prime	4.32		
$\rho_{01}$	0.29		
	0.46		
	0.78		
$N_{ID}$	254		
Observations	34720		
Marginal $R^2$ / Conditional $R^2$	0.003 / NA		

## Discussion

This pre-registered study aimed to replicate the cognitive asymmetry process in the physical activity domain found in Cheval et al. (2017).

Despite a high power (with more than 96% power to detect an effect size one quarter smaller than the one found in Study 1 of Fishbach et al., 2003), the temptation-elicited goal activation process was not observed. Instead, two main effects of Prime and Target on reaction time were found. Specifically, participants were faster to detect PA goal-related words after being primed by SED temptations and were also faster to detect SED temptations after being primed by PA goals. This finding is consistent with the recent well-powered replication study by Francis et al. (2022), which found no evidence for the temptation-elicited goal activation pattern, but rather observed that both goal and temptation-related primes



## Does exposure to sedentary temptations activate physical activity goals?

facilitated recognition of temptation- and goal-related target words, respectively. The current study replicated and extended the prime effect found by Francis et al. in the academic context to the physical activity domain. As proposed in Francis et al., “the asymmetry between temptations and goals may not exist at the most automatic level of processing, even for those individuals high in self-regulatory success” (p.8; Francis et al., 2022). Nevertheless, it is possible that the asymmetric activation is observed when inhibitory processes are at work. One way to test it is to manipulate the duration of the stimulus onset asymmetry (SOA) (i.e., the time between the onset of two stimuli), which determines the amount of processing and cognitive accessibility of the prime. Papiés et al. (2008 study 1) showed that Primes facilitated goal activation in successful self-regulators only when the SOA duration was 540 ms, which relatively long. In our study, the SOA duration was 80 ms, based on the only study conducted in the physical activity context (Cheval et al., 2017), which may be too short to allow the activation of inhibitory processes. Future studies manipulating the SOA duration are warranted to test this possibility.

Moreover, we found a main effect of Target, with participants being faster to detect PA-related words (e.g., “effort”) than SED-related words (e.g., “rest”). This suggests that the cognitive accessibility of the PA goals was higher than the sedentary temptations one. This observation may be explained by our sample’s characteristics. Indeed, inclusion criteria were to be physically active and consider physical activity as important. Previous studies showed that PA-related cues could be particularly relevant for active participants (Cheval et al., 2020; Pool et al., 2016), resulting in an automatic tendency to approach physical activity (e.g., Bluemke et al., 2010; Calitri et al., 2009; Eves et al., 2007), and thus in faster recognition of physical activity targets versus non-relevant targets (Cheval et al., 2017, study 1). This explanation is supported by a review of literature, which highlights that people pay more attention to the stimuli that are relevant to them than to non-relevant ones (e.g., physical activity stimuli for physically active participants) (Cheval et al., 2020; Corbetta & Shulman, 2002), thus facilitating recognition of the former, suggesting that goal accessibility may be stronger than temptation accessibility in successful self-regulators.

### **Limitations and strengths**

This study has limitations. First, although validated in pilot studies, the words used to describe sedentary temptations and physical activity goals were generic, and therefore may not always have been meaningful to participants (Maltagliati et al., 2023, under review). Second, the self-reported measure of physical activity may not accurately capture the actual physical activity level of the participants. Indeed, using self-reported questionnaires participants have a tendency to overstate their physical activity level (e.g., Celis-Morales et al., 2012).

However, these limitations are outweighed by at least two major strengths. First, our study was well powered. The sensitivity analyses revealed that our study has more than 96% power to detect an effect size similar to the that found in Cheval et al. (2017), and our study has much more trials included in the analyses than the two studies we relied on (Cheval et al., 2017; Fishbach et al., 2003). In fact, 34720 were included in our study vs 2751 trials and a maximum of 5538 trials (the number of trials excluded was not reported) in Cheval et al. (2017) and Fishbach et al. (2003), respectively. Second, we set up practices considered as

## Does exposure to sedentary temptations activate physical activity goals?

good research practices (Boisgontier, 2022; Caldwell et al., 2019). Specifically, the study was preregistered and our sample size was based on an a priori power analysis.

### **Conclusion**

To conclude, our results are in line with the recent study of Francis et al. (2022), which did not replicate the asymmetric phenomenon despite a robust design. We also found evidence that participants recognized goal-target (i.e., related to physical activity) faster than temptation-target (i.e., main effect of the Target). In addition, participants recognized words faster after priming, regardless of whether they were related to a goal or a temptation, suggesting a symmetrical pattern of the automatic associations between goals and temptations representations. Finally, further studies should be conducted to better identify the conditions that favor the occurrence of the temptation-elicited goal, even if at the most automatic level cognitive asymmetry seems unlikely to occur.

### **Acknowledgment**

We would thank the editor and anonymous reviewers who helped to strengthen the manuscript and improve its quality.

## Does exposure to sedentary temptations activate physical activity goals?

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