Psychology of Sport and Exercise 30 (2017) 110–117

Contents lists available at ScienceDirect

Psychology of Sport and Exercise

journal homepage: www.elsevier.com/locate/psychsport

Temptations toward behaviors minimizing energetic costs (BMEC) automatically activate physical activity goals in successful exercisers

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A R T I C L E I N F O

Article history:
Received 6 October 2016
Received in revised form
21 February 2017
Accepted 22 February 2017
Available online 24 February 2017

Keywords:
Physical activity
Behaviors minimizing energetic costs
Temptations
Automatic goal activation
Linear mixed model

A B S T R A C T

Objectives: With regard to the pivotal role of physical activity (PA) in health protection, understanding how individuals maintain regular PA despite ubiquitous opportunities to adopt behaviors minimizing energetic costs (BMEC) appears crucial. The purpose of the present research was to test whether BMEC primes act as temptations and activate PA goals in successful exercisers.
Design: Within and between-subjects experiments.
Methods: Students in sports science (Experiment 1; N = 46) and individuals with high value of PA goals and low versus high PA levels (Experiment 2; N = 28) performed a primed-lexical decision task.
Results: Experiment 1 revealed that BMEC primes facilitated the recognition of PA-related words, whereas PA primes did not facilitate the recognition of words related to BMEC. Experiment 2 showed that this facilitative effect was specific to individuals who were successful in reaching their PA goals.
Conclusions: BMEC act as temptations that automatically activate the representation of PA goals in individual who manage to maintain regular PA.

Physical activity (PA), defined as any bodily movement produced by the contraction of skeletal muscles that requires energy expenditure (CDC, 2015), plays a pivotal role in health protection by reducing the incidence of, for instance, cardiovascular disease, stroke, type 2 diabetes and other metabolic disorders, hypertension, neurological diseases, osteoporosis, and cancer (e.g., Stranahan & Mattson, 2012; Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). However, the advent of modern technology has produced an environment in which opportunities to adopt behaviors minimizing energetic costs (BMEC) are ubiquitous (Neufer et al., 2015). The outcomes of this environment is a population that is motivated to be physically active, but fails to reach the public health PA guidelines of at least 150 min of moderate-to-vigorous intensity PA per week (Sjöström, Oja, Hagströmer, Smith, & Bauman, 2006). Accordingly, physical inactivity has been identified as the fourth leading risk factor for global mortality (WHO, 2009). At the same time, despite living in this same sedentary environment, some individuals are more successful in adopting regular PA behaviors. Understanding how these individuals manage to maintain an active lifestyle despite ubiquitous opportunities to adopt BMEC is crucial for health protection.

1. Self-regulation success in the context of dieting

In their seminal article describing their theory of temptation-elicited goal activation, Fishbach, Friedman, and Kruglanski (2003) argued that individuals with past success in exercising self-control in tempting situations develop cognitive associations between temptation cues and the mental representation of the goals that are relevant to withstand this temptation. As a result, the presence of temptation cues in the environment leads to the activation, rather than the inhibition, of these goals and enables individuals to control their behavior. Conversely, goal-related cues do not activate the mental representation of the temptations and could even potentially inhibit them, resulting in an "asymmetric activation pattern" between temptations and goals that might

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http://dx.doi.org/10.1016/j.psychsport.2017.02.006
1469-0292/

determine self-regulation success (Fishbach et al., 2003; Fujita & Sasota, 2011).

Particularly, Fishbach et al. (2003) tested their theory in a series of experimental studies in which they measured the cognitive accessibility of a goal directly after the subliminal presentation of words that represent temptations likely to interfere with this specific goal. In these studies, they used a primed lexical decision task in which participants were asked to indicate as quickly as possible whether a letter string appearing on a screen was an existing word or not. Importantly, unbeknown to the participant, this letter string was preceded by a short presentation of a prime stimulus. A shorter reaction time to detect a target word after the presentation of a prime stimulus (relative to a neutral prime) indicated that the prime stimulus automatically activated the target word. In the context of dieting, their results showed that the subliminal exposure to temptations (e.g., chocolate) increased the cognitive accessibility of the related goals (e.g., weight control), but only among dieters who perceived themselves as being successful in regulating their weight. These results were confirmed in a study showing that food primes increased the accessibility of weight-control goals for successful restrained eaters, but decreased this accessibility for unsuccessful restrained eaters relatively to the control condition (Papies, Stroebe, & Aarts, 2008). These findings suggested that the ability to activate goals (e.g., weight control) in situations in which these goals are being threatened (e.g., exposition to appetizing food) explains self-regulation success. To the best of our knowledge, no studies examined whether such mechanism is involved in successful self-regulation of PA behaviors when considering BMEC opportunities as temptations.

2. Behaviors minimizing energetic costs (BMEC) as temptations in the context of physical activity

BMEC can reasonably be assumed to act as temptations interfering with PA goals (e.g., Rouse, Ntoumanis, & Duda, 2013). Indeed, individuals consistently show a preference toward movements with minimum energetic costs (Selinger, O'Connor, Wong, & Donelan, 2015). For example, individuals automatically adapt their walking speed (Elftman, 1966; Molen, Boon, & Rozendal, 1972; Ralston, 1958) and step frequency (Bertram & Ruina, 2001; Elftman, 1966; Holt, Hamill, & Andres, 1991; Minetti, Capelli, Zamparo, Diprampero, & Saibene, 1995; Umberger & Martin, 2007; Zarrugh, Todd, & Ralston, 1974) to minimize the energy they use per distance unit. Moreover, this minimization of energetic costs is observed at multiple timescales such as the evolutionary (Alexander, 1996, 2001; Rodman & Mchenry, 1980; Sockol, Raichlen, & Pontzer, 2007), developmental (Ivanenko, Dominici, & Lacquaniti, 2007), and situational (Selinger et al., 2015) timescales. At the evolutionary timescale, the energy optimization is implemented through changes in body shape, muscle actions, and neural circuitry (Alexander, 1996, 2001; Rodman & Mchenry, 1980; Sockol et al., 2007). At the developmental timescale, motor practice results in most efficient movements (e.g., Ivanenko et al., 2007). At the situational timescale, gait in humans continuously optimizes energetic costs in real time (e.g., Selinger et al., 2015).

Based on this principle of energy optimization, BMEC may be intrinsically attractive and could prevent individuals from engaging in more active and energy-consuming behaviors. For instance, instead of taking the stairs, individuals may have an impulsive tendency toward a less energy-consuming option, such as taking the escalator. For the same reason, they may prefer to sit rather than to stand while waiting for the bus. In line with this reasoning, recent results suggested that individuals may have an impulsive attraction toward sedentary behaviors – i.e., a specific sub-part of BMEC involving both low levels of energy expenditure and a sitting or reclining posture (Spence, Rhodes, & Carson, 2016) – which negatively predicted PA (Cheval, Sarrazin, & Pelletier, 2014; Cheval, Sarrazin, Isoard-Gautheur, Radel, & Friese, 2015). Specifically, impulsive approach tendencies toward sedentary behaviors negatively predicted spontaneous effort in a handgrip task (Cheval et al., 2014) and objective PA as measured by accelerometers (Cheval et al., 2015). In sum, there is a consistent trend suggesting that BMEC, such as sedentary behaviors, might act as temptations (or attractors) in the context of PA, like unhealthy food in the context of dieting.

3. The present research

As the literature suggests that BMEC may act as temptations, the purpose of the present research was to test (1) whether BMEC primes activate PA goals in physically active individuals and (2) the extent to which being successful in achieving PA goals (i.e., being a “successful exerciser”) modulates this effect of BMEC temptations. Two experiments were conducted using a primed lexical decision task based on Fishbach et al. (2003) work, but in which participants were subliminally exposed to BMEC versus neutral primes. The activation of PA goals was operationalized as a shorter reaction time to detect a PA-related target word after a BMEC-related versus neutral prime. To control for the asymmetry of this activation pattern (Fishbach et al., 2003; Fujita & Sasota, 2011), PA primes and BMEC-related target words were used to test whether PA primes activated BMEC temptations. In Experiment 1, we examined whether priming BMEC-related words triggered the activation of PA goals in a sample of physically active individuals. To formally test if this effect was conditional to self-regulatory success, Experiment 2 included individuals who were either successful or not successful at achieving their PA goals. We hypothesized that subliminal exposure to BMEC primes increases the cognitive accessibility of PA goals, but only among individuals who are successful at achieving their PA goals.

4. Pilot study

For Experiment 1, a pilot study was conducted to identify four PA-related words and four BMEC-related words. Specifically, participants were asked the extent to which a word undermined versus promoted PA goals. For instance, participants were given a word (e.g., television) and were asked how much they associated this word with promoting the goal of being physically active and how much they associated the word with undermining the goal of being physically active on a 7-point Likert scale (1 = *not at all*; 7 = *extremely*). Thirty-two words were tested. For each word, a difference score was calculated by subtracting the average “promoting” score from the average “undermining” score. The four words with the most positive difference scores were chosen as PA-related words (i.e., sport, training, run, move) and the four words with the most negative difference scores were chosen as BMEC-related words (i.e., sofa, television, computer, elevator) (see Fujita & Sasota, 2011, for similar procedure). For Experiment 2, three experts in sport psychology selected eight PA- and eight BMEC-related words (see Fig. S1 of the online supplemental materials).

5. Experiment 1: activation of physical activity goals by BMEC temptations in active individuals

Experiment 1 assessed the extent to which BMEC primes activated PA goal in sports science students using a primed lexical decision task. Based on the results in the field of dieting and according to the assumption that BMEC act as temptations, we hypothesized that BMEC primes automatically activate PA goals in physically active individuals.

5.1. Methods

5.1.1. Participants

Forty-six undergraduate sports science students (28 females, 18 males; $M_{age} = 22 \pm 4.2$ yr; $M_{BMI} = 22 \pm 2.2$ kg/m^2, range 18–24 kg/m^2) who practiced at least 5 h of PA per week in their curriculum participated in Experiment 1 in exchange for course credits.

5.1.2. Procedure

This experiment used a Target (PA-related vs. BMEC-related words) × Prime (active and BMEC vs. neutral primes) within-subject design. Participants arrived individually in the lab and were seated in front of a desktop computer with a 85-Hz CRT screen to complete the primed-lexical decision task. Participants were asked to indicate as quickly and as accurately as possible whether a letter string appearing on the screen was an existing word by pressing a "Yes" or "No" key on the keyboard connected to a PS/2 port. The targets and primes in this task were PA and BMEC-related words. On each trial, a 35-ms pre-mask (i.e., "##########") preceded the prime. The prime then appeared for 35 ms and was followed by a 45-ms post-mask (i.e., "##########") preceding a target word that remained on the screen until the participant's response. After 16 practice trials with an equal number of words and non-words, participants completed 128 experimental trials with half of the trials using non-word targets (see Fig. 1 for a complete illustration of the procedure). All participants gave written informed consent prior to participation and received a debriefing at the end of the session.

5.1.3. Data analysis

Reaction times were analyzed using linear mixed models (LMM). Unlike traditional approaches (e.g., ANOVA) that disregard the sampling variability of stimuli despite numerous warnings about the shortcomings of this practice (Clark, 1973; Judd, Westfall, & Kenny, 2012), LMM allow correct estimations of the parameters with multiple crossed-random effects (e.g., participants and stimuli). As a consequence, the results obtained from LMM can be generalized to both participants and stimuli, and are less vulnerable to Type-1 errors (Boisgontier & Cheval, 2016). Furthermore, LMM avoid data averaging which keeps the variability of the responses within each condition and increases power (Fan, 2003; Judd et al., 2012). Here, we built a LMM using the lmerTest package of the R software and specified both participants and targets as random factors. Target (0.5 for BMEC-related words; −0.5 for active-related words) and Prime (0.5 for PA or BMEC primes; −0.5 for neutral primes), as well as their interaction, were included as fixed factors in the model. Because the differences in the number of letters and frequency of occurrence of the words used in the experiment influence reaction times (Balota & Chumbley, 1984), we included these two parameters in all models as control factors[1]. Trials with non-words, trials resulting in incorrect responses, and responses below 200 ms and above 1500 ms (i.e., 6.56% of the responses) were not included in the analysis, leaving a total of 2751 trials (e.g., Rossell & Nobre, 2004; Schoonbaert, Holcomb, Grainger, & Hartsuiker, 2011). In addition, we evaluated a range of power-law transformations using the Box-Cox method to normalize the distribution of the reaction times (Box & Cox, 1964; Osborne, 2010) and the optimal power-law transformation was lambda = −0.82. Finally, an estimate of the effect size was reported using the conditional pseudo R^2, which was computed using the MuMin package of the R software.

5.2. Results

Results revealed a significant Target × Prime interaction (Table 1; $b = -2.190$, $p = 0.006$). As illustrated in Fig. 2, this interaction indicated that participants were faster in recognizing a PA-related target word, when primed with a BMEC-related versus neutral word (mean = 520 vs. 540 ms, respectively; $b = 2.14\text{E-}04$, $p = 0.001$). However, participants were not faster in recognizing a BMEC-related target word, when primed with a PA-related versus neutral word (mean = 553 vs. 552 ms, respectively; $b = -4.61\text{E-}06$, $p = 0.944$). In this model, the variables under consideration explained 40.7% of the variance in the reaction time.

5.3. Discussion

Results of Experiment 1 demonstrated in a sample of active individuals that the subliminal exposition to a BMEC-related word facilitated the recognition of a PA-related word, relative to the subliminal exposition to a neutral word. Conversely, the subliminal exposition to a PA-related word did not facilitate the recognition of a BMEC-related word. This association between PA-related words and BMEC-related words is in line with the asymmetrical activation pattern between goals and temptations suggested by Fishbach et al. (2003) – whereas temptations activate the threatened goal, these goals tend to inhibit temptations. Here, as in other studies (Fishbach et al., 2003), this inhibition effect was not significant as PA primes, compared to neutral primes, did not significantly decrease the time to respond to BMEC targets.

Taken together, these results suggested that the activation of PA goals by BMEC primes could represent an important psychological mechanism associated with the achievement of these goals. Theoretically, these findings support the assumption that BMEC is a temptation that automatically activates representations of the PA goals in active individuals. Nevertheless, it should be noted that even if sports science students practiced at least 5 h of PA per week as part of their curriculum, their usual PA level and the value they assigned to PA goals were not directly assessed. To test whether the effect of BMEC temptations was dependent on the ability to self-regulate PA, Experiment 2 included individuals who were successful versus unsuccessful at achieving their PA goals.

6. Experiment 2: activation of physical activity goals by BMEC temptations: the moderating role of self-regulation success

The results of Experiment 1 suggested that in active individuals, BMEC behaviors represent temptations that automatically activate the PA goals they are threatening. Experiment 2 investigated the extent to which this effect was dependent of PA self-regulation success. Successful exercisers were individuals who assigned high

[1] The equation for the Model was the following: $Y_{ij} = (\beta_0 + \gamma_{0i} + \theta_{0j}) + \beta_1 \text{Target length}_{ij} + \beta_2 \text{Target frequency}_{ij} + \beta_3 \text{Prime length}_j + \beta_4 \text{Prime frequency}_j + (\beta_5 + \theta_{1j}) \text{Target}_j + \beta_6 \text{Prime}_j + \beta_7 \text{Target} \times \text{Prime}_j + \varepsilon_{ij}$, where Y_{ij} is the reaction time of participant at Target i, β_0 to β_7 are the fixed effect coefficients, θ_j and θ_{1j} are the random effect for the participant j (one random intercept and one random slope), γ_{0i} is the random effect for the target i (random intercept), and ε_{ij} is the error term.

[2] The equation for the Model was the following: $Y_{ij} = (\beta_0 + \gamma_{0i} + \theta_{0j}) + \beta_1 \text{Target length}_{ij} + \beta_2 \text{Target frequency}_{ij} + \beta_3 \text{Prime length}_j + \beta_4 \text{Prime frequency}_j + (\beta_5 + \theta_{1j}) \text{Target}_j + \beta_6 \text{Prime}_j + \beta_7 \text{Target} \times \text{Prime}_j + \beta_8 \text{ Level of physical activity}_j + \beta_9 \text{ Level of physical activity} \times \text{Prime}_j + \beta_{10} \text{ Level of physical activity x Target}_j + \varepsilon_{ij}$, where Y_{ij} is the reaction time of participant at Target i, β_0 to β_{11} are the fixed effect coefficients, θ_j and θ_{1j} are the random effect for the participant j (one random intercept and one random slope), γ_{0i} is the random effect for the target i (random intercept), and ε_{ij} is the error term.

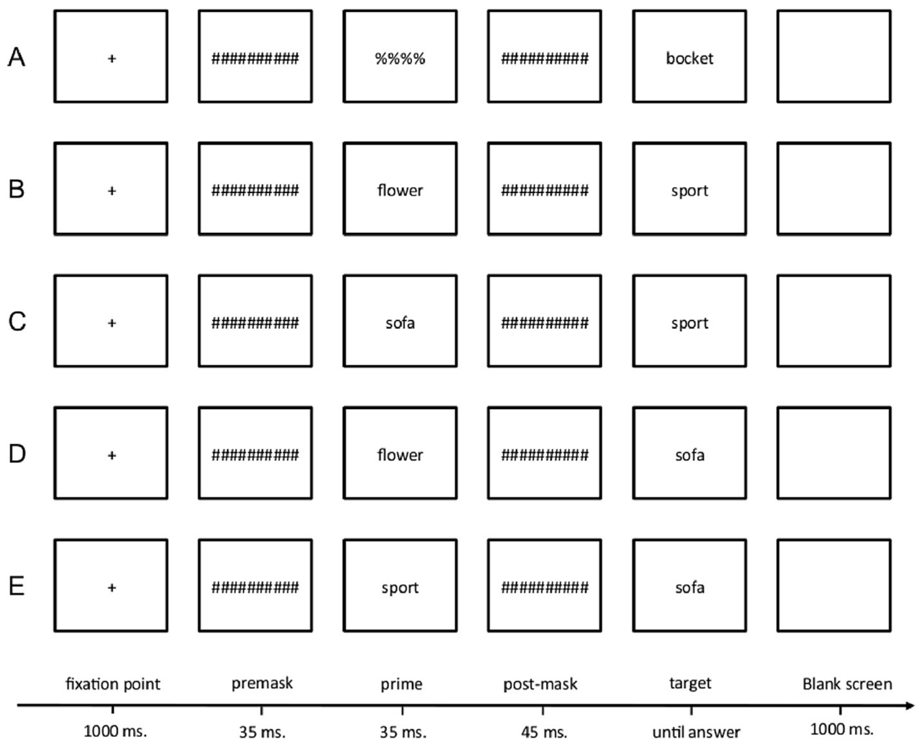

Fig. 1. Illustration of the primed lexical decision task. A. Illustration a trial with a non-word target (64 trials in Experiment 1 or 128 in Experiment 2). B. Illustration a trial with a neutral prime and a PA-related target (16 trials in Experiment 1 or 32 in Experiment 2). C. Illustration of a trial with a BMEC-related prime and a PA-related goal target (16 trials in Experiment 1 or 32 in Experiment 2). D. Illustration of a trial with neutral prime and a BMEC-related target (16 trials in Experiment 1 or 32 in Experiment 2). E. Illustration of a trial with a PA-related prime and a BMEC-related target (16 trials in Experiment 1 or 32 in Experiment 2). Note. BMEC = behaviors minimizing energetic costs.

importance to PA goals and managed to achieve high level of regular PA. Conversely, unsuccessful exercisers were individuals who assigned high importance to PA goals but failed to achieve high level of regular PA. We hypothesized that subliminal exposure to BMEC primes would increase the cognitive accessibility of PA goals, but only in successful exercisers.

6.1. Methods

6.1.1. Participants

A research assistant blind to the study hypotheses moved in some places close to the university in which the study was based (e.g., libraries, companies, restaurants) to randomly invite

Table 1
Results of the linear mixed models predicting the reaction time required to recognize BMEC-related and PA-related words.

Response time	Study 1			Study 2		
Fixed Effects	b	SE	p-value	b	SE	p-value
Intercept	1.21	1.41E-04	<0.001	1.45	7.44E-04	<0.001
Target length	2.47E-05	2.42E-05	0.340	6.30E-05	4.61E-05	0.179
Target frequency	9.15E-07	6.07E-06	0.880	−4.20E-07	1.02E-06	0.684
Prime length	1.57E-06	9.69E-06	0.871	3.16E-05	3.22E-05	0.325
Prime frequency	−6.24E-06	2.46E-04	0.015	4.83E-07	7.15E-07	0.501
Target[1]	2.46E-04	1.25E-04	0.084	1.74E-04	2.01E-04	0.392
Prime[2]	1.049E-04	4.81E-05	0.029	3.07E-04	1.60E-04	0.056
Target x Prime	−2.19E-04	7.90E-05	0.006	−3.48E-04	2.24E-04	0.120
Level of PA[3]				−4.90E-04	8.31E-04	0.561
Level of PA x Prime				−1.99E-04	2.20E-04	0.366
Level of PA x Target				−3.96E-04	2.23E-04	0.079
Level of PA x Prime x Target				6.34E-04	3.06E-04	0.038
Random Effects	σ^2	r		σ^2	r	
Participants						
Intercept	6.09E-07			4.46E-06		
Target	4.14E-08			2.34E-08		
Correlation (Intercept, Target)		0.15			0.57	
Targets						
Intercept	1.92E-08			5.84E-08		
Residual	9.79E-07			4.97E-06		
Pseudo R^2	0.408			0.483		

Note. [1] 0.5 = temptation; −0.5 = goal; [2] 0.5 = neutral prime; −0.5 = relevant (PA or BMEC-related) prime; [3] 0.5 = high habitual PA level; −0.5 = low habitual PA level; SE = standard error; PA = physical activity; BMEC = behaviors minimizing energetic costs.

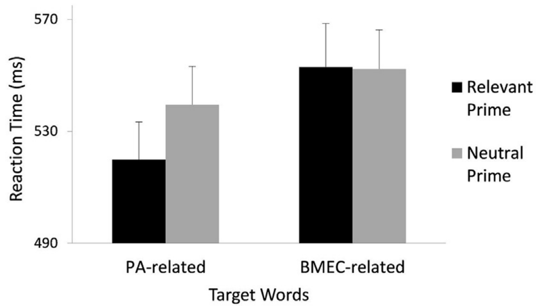

Fig. 2. Reaction time for the recognition of words related to BMEC and PA, following (relevant) PA and BMEC-related primes, respectively, versus neutral primes in active individuals. *Note.* Reaction time in lambda was back-transformed into milliseconds. Error bars represent standard errors of the mean. Neutral primes are neutral nouns. PA = physical activity; BMEC = behaviors minimizing energetic costs.

participants to take part in a study related to PA. Approximately 100 individuals were approached. Prospective participants were selected based on the results of a series of questions assessing (1) the value the participants assigned to PA goals and (2) their usual level of PA. Participants' value of PA goals was assessed using four questions (e.g., Fishbach et al., 2003; Fujita & Sasota, 2011; Papies et al., 2008): "To what extent do you avoid sedentary behaviors?", "How concerned are you about the importance of adopting physical activity on a regular basis?", "To what extent do you make an effort to adopt physical activity behaviors?", and "How guilty would you feel if you consistently adopted sedentary behaviors?". Participants responded using a 7-point Likert scale (1 = *not at all*; 7 = *extremely*). The usual level of PA was assessed with the short version of the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003). Participants included in Experiment 2 exhibited high value of PA goals (i.e., an average score above the midpoint of the scale) and a low or high usual level of PA (i.e., Category 1 or 3, respectively, according to the IPAQ scoring protocol). Thirteen participants with high value of PA goals and a low level of usual PA (Unsuccessful Exercisers; $M_{age} = 32 \pm 8$ yr; $M_{BMI} = 23 \pm 4$ kg/m^2, range 18–34 kg/m^2) and 15 participants with high value of PA goals and a high level of usual PA (Successful Exercisers; $M_{age} = 33 \pm 7$ yr; $M_{BMI} = 23 \pm 3$ kg/m^2, range 18–25 kg/m^2) participated in Experiment 2. All participants gave written informed consent prior to participation, and received a debriefing at the end of the session.

6.1.2. Procedure

This experiment used a Success (Successful vs. Unsuccessful Exercisers) × Target (PA vs. BMEC-related words) × Prime (PA and BMEC vs. neutral primes) mixed design.[2] As in Experiment 1, the associations between PA and BMEC were assessed with the primed-lexical decision task. As mentioned in the pilot study section, Experiment 2 used twice as many relevant stimuli as in Experiment 1 (i.e., eight PA-related words and eight BMEC-related words). This design was selected for two main reasons. First, we anticipated difficulties in the recruitment of this specific sample (i.e., individuals associating high subjective value to PA goals and with low or high usual level of PA). Doubling the number of observations per subject increases the power (Fan, 2003; Judd et al., 2012) and could compensate for recruitment difficulties. Second, this design increases the sampling variability of the stimuli, which allows the results to be generalized to the population of the stimuli with more confidence.

6.1.3. Data analysis

As in Experiment 1, reaction times were analyzed using a LMM, with the same random and fixed structures and with the addition of the fixed effect of Success (−0.5 for unsuccessful exercisers; 0.5 for successful exercisers). Trials with non-words, trials resulting in incorrect responses, and responses below 200 ms and above 1500 ms (3.91% of the responses) were not included in the analysis, leaving a total of 3444 trials (e.g., Rossell & Nobre, 2004; Schoonbaert et al., 2011). A range of power-law transformations using the Box-Cox method was used to normalize the distribution of the reaction times (Box & Cox, 1964; Osborne, 2010) and the optimal power-law transformation was lambda = −0.68. Finally, an estimate of the effect size was reported using the conditional pseudo R^2.

6.2. Results

Results revealed a significant three-way interaction between Success, Target, and Prime (Table 1; b = 6.342E-04, p = 0.038). As illustrated in Fig. 3, this interaction indicated that the automatic activation of PA-related words by BMEC primes significantly differed between successful and unsuccessful exercisers. Specifically, in line with the results of Experiment 1, successful exercisers were faster in recognizing a PA-related target word, when primed with a BMEC-related versus neutral word (mean = 617 and 637 ms, respectively; b = −3.94E-04, p = 0.006). However, successful exercisers were not faster in recognizing a BMEC-related target word, when primed with a PA-related versus neutral word (mean = 628 and 633 ms, respectively; b = −1.08E-04, p = 0.479). Conversely, unsuccessful exercisers were not faster in recognizing a PA-related target word, when primed with a BMEC-related versus neutral word (mean = 684 and 681 ms, respectively; b = −4.12E-05, p = 0.793). However, they were marginally faster in recognizing a BMEC-related target word, when primed with a PA-related versus

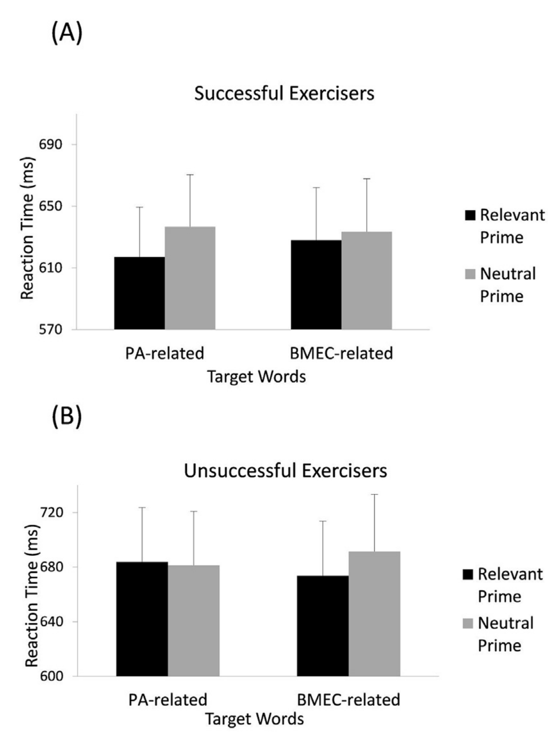

Fig. 3. Reaction time for the recognition of words related to BMEC and PA, following (relevant) PA and BMEC-related primes, respectively, versus neutral primes in (A) successful and (B) unsuccessful exercisers. *Note.* Reaction time in lambda scale was back-transformed into ms. Error bars represent standard errors of the mean. Neutral primes are neutral words. PA = physical activity; BMEC = behaviors minimizing energetic costs.

neutral word (mean = 674 and 691 ms, respectively; $b = 3.07E-04$, $p = 0.056$). In this model, the variables under consideration explained 48.3% of the variance in the reaction time.

6.3. Discussion

Results of Experiment 2 demonstrated that subliminal exposure to a BMEC-related prime increased the cognitive accessibility of a PA-related goal, but only in individuals who were successful in reaching their PA goals (i.e., successful exercisers). Furthermore, in line with the results of Experiment 1, the results of Experiment 2 showed that the subliminal exposure to a PA-related prime did not influence the accessibility of a BMEC-related temptation in successful exercisers. However, and importantly, results revealed that in unsuccessful exercisers, the subliminal exposure to a PA-related word tended to increase the cognitive accessibility of a BMEC-related word. To sum-up, in unsuccessful exercisers, BMEC primes did not automatically activate PA goals and PA primes tended to automatically activate BMEC temptations. This pattern of result may explain why unsuccessful exercisers fail to maintain regular PA in environment in which the opportunities to adopt BMEC are ubiquitous.

7. General discussion

With regard to the pivotal role of PA in health protection (e.g.,Warburton et al., 2010), understanding how some individuals manage to maintain regular PA despite ubiquitous opportunities to adopt behaviors minimizing energetic costs (BMEC) is crucial. In the context of dieting, previous researches revealed that food temptations automatically activate dieting goals in successful restrained eaters (Fishbach et al., 2003; Fujita & Sasota, 2011; Papies et al., 2008). Since BMEC may represent temptations likely to interfere with PA goals, just as unhealthy food does in the context of dieting, the purpose of the present research was to test whether BMEC primes act as temptations and activate PA goals in successful exercisers.

Experiment 1 revealed that BMEC primes facilitated the recognition of PA-related words in active individuals, whereas PA primes did not facilitate the recognition of BMEC-related words. Experiment 2 revealed that this effect was specific to individuals who were successful in achieving their PA goals. Specifically, this second experiment showed that BMEC primes facilitated the recognition of PA-related words, but only in successful exercisers. In unsuccessful exercisers, BMEC-related words did not facilitate the recognition of PA-related words. PA-related words even tended to facilitate the recognition of BMEC-related words.

These findings are in accordance with the theory of temptation-elicited goal activation (Fishbach et al., 2003) proposing that individuals with past success in exercising self-control in tempting situations develop cognitive associations between temptation cues and the mental representation of the related goals that are relevant to withstand this temptation. For such successful exercisers, it is interesting to note that when they consider that temptation words undermined their PA goals at a controlled (explicit) level (see pilot study), these temptations words, ironically, activated their PA goals at an automatic (implicit) level. Concurrently, inhibitory associations may develop between the representations of the goals and their related temptations. Here, like in the others studies (e.g., Fishbach et al., 2003), we did not find evidence for this inhibition of temptations by the exposure to goal-related stimuli. While a goal can certainly lead to inhibiting temptation, this is a relatively slow and controlled process (Heatherton & Wagner, 2011). Therefore, inhibition is unlikely to be observed in a primed lexical decision task that probes automatic processes such as cognitive accessibility. Other research paradigms would be better suited to examine this inhibitory process (e.g., Mc Culloch, Aarts, Fujita, & Bargh, 2008).

In sum, our results further validate the temptation-elicited goal activation theory (Fishbach et al., 2003) and extend its area of applicability to the field of PA. This conceptualization of BMEC as temptations we supported here is coherent with previous studies showing that individuals move in ways that minimize their energy costs (e.g., Alexander, 1996, 2001; Ivanenko et al., 2007; Rodman & Mchenry, 1980; Selinger et al., 2015; Sockol et al., 2007). As such, BMEC may be intrinsically attractive and impulsively attract individuals toward them rather than toward more energy-consuming, but initially intended behaviors (Cheval et al., 2014, 2015).

Furthermore, these results also provide a better understanding of how individuals manage to maintain regular PA behaviors despite ubiquitous opportunities to adopt BMEC. Specifically, they suggest that successful exercisers may have developed cognitive associations between BMEC cues and the mental representation of their PA goals, in such a way that the presence of BMEC cues leads to the automatic activation of their PA goals. In other words, this association between BMEC cues and PA goals enables successful exercisers to efficiently protect their PA behaviors against such threatening cues. Conversely, results revealed that unsuccessful exercisers fail to develop such cognitive associations. Particularly, BMEC primes did not facilitate the recognition of PA-related words, and PA primes tended to increase the recognition of BMEC-related words. These different impacts of BMEC primes may explain why some individuals manage to maintain regular PA despite ubiquitous opportunities to adopt BMEC and avoid more energy-consuming behaviors, whereas other individuals fail to reach their PA goals.

Finally, our findings suggest that interventions promoting PA should support the development of cognitive associations between BMEC cues and PA goals activation. For instance, recent works in the context of health behaviors showed that the implementation of intentions is time-efficient for the modification of automatic cognitions (Sheeran, Gollwitzer, & Bargh, 2013). Implemented intentions are if-then plans linking situational cues to a goal-directed behavior in the format of if (cue) − then (response). For example, to develop protective cognitive associations between BMEC opportunities and PA goals, individuals may form the following plan: “If I see a BMEC opportunity (e.g., escalator), then I will search for an active alternative (e.g., stairs)”. Implemented intentions have shown to build strong associations between the cue and the specified response (Webb & Sheeran, 2007, 2008), thereby enabling individuals to control their behaviors in an efficient and automatic manner (Gollwitzer & Sheeran, 2006, for a review). The development of such associations between BMEC cues and PA-related responses would modify PA behaviors and help intended exercisers to become successful in reaching their PA goals.

Overall, the present research had several strengths including: (a) a reaction-time paradigm allowing the assessment of processes occurring outside conscious awareness, (b) a statistical method appropriately treating data with multiple crossed-random effects (i.e., both participants and stimuli), and (c) a between-group comparison formally testing whether BMEC temptations automatically activate PA goals in successful but not in unsuccessful exercisers. However, some limitations should also be reported. First, our experiments included a limited number of participants. However, this limitation is compensated by the use of linear mixed models avoiding data averaging and taking into account the variability of all responses within each condition, thereby increasing power. Nevertheless, it was not possible to estimate the power because of the lack of information available in the literature to estimate an appropriate sample size using LMM. This difficulty to assess the power and thus to know our ability to detect a given effect when there is one, requires cautious interpretation of non-significant results. In the current work, the interactions of interest were significant. Second, we adopted the experimental procedure used in previous studies (Fishbach et al., 2003; Fujita & Sasota, 2011) which only assessed whether BMEC primes activate PA goals and whether PA primes activated BMEC temptations. Adding two experimental conditions to examine the effect of BMEC primes on BMEC-related target accessibility and of PA primes on PA-related target accessibility could be useful in future research. In the same vein and in line with the work of Fishbach et al. (2003), the automatic activation of PA goals was operationalized as a shorter reaction time to detect a PA-related versus neutral target word after a BMEC-related prime using a primed lexical decision task. Even if priming procedure has been extensively used to unconsciously activate specific goals (see Custers & Aarts, 2010 for a review), it is worth noting that this task could have reflected the increased cognitive accessibility of PA-related concepts rather than goal activation per se (Förster, Liberman, & Higgins, 2005). However, as the results differentiated physically active individuals from less physically active individuals, the primed lexical decision task was more likely to capture goal activation. Third, the usual level of sedentary was not assessed in the current study. Because BMEC, and especially sedentary behaviors, and PA are thought to be relatively distinct behaviors (e.g., Biddle, 2007), it would be interesting to examine whether the automatic activation of PA goals by BMEC temptations is also useful to understand how individuals avoid excessive sedentary behaviors. Fourth, in Experiment 2, the value of the PA goals was assessed by four items modeled in previous studies (Fishbach et al., 2003; Fujita & Sasota, 2011; Papies et al., 2008) which are mostly avoidance-framed and mainly reflect controlled (i.e., introjected) forms of regulation (Deci & Ryan, 2000). However, the type of motivation could influence the way in which individuals exert self-control (e.g., Rouse et al., 2013). Indeed, theory of temptation-elicited goal activation suggest that temptations will not elicit automatic self-control when they do not threaten a valued goal. Accordingly, the automatic activation of goals by temptations may reflect a rigid pattern of successful self-control resulting from an introjected form of regulation, in which BMEC cues threaten PA goals. By contrast, this automatic activation pattern may not be evident when the successful self-control results from an autonomous form of regulation in which BMEC cues no longer threaten PA goals, because the behavior is internalized. Futures studies should examine such possibility. Fifth, the BMEC temptations used in the current study were not actual ones but were in terms of primed words. Theoretically, we can expect that the current findings generalize to actual BMEC temptations – that is, BMEC opportunities (e.g., presence of an escalator on the way to the work; a free sitting position while waiting for an appointment) should facilitate the implementation of active alternative behaviors (e.g., taking the stairs; stay stand) for successful exercisers. Formally testing such hypothesis should be addressed in futures research. Finally, it is important to note that the automatic activation of PA goals by BMEC primes is observed at a very short time scale (i.e., reaction time ~25 ms shorter than the neutral condition). Accordingly, one may wonder if such short time advantage in favor of PA goals when threatened by BMEC temptations can impact PA behaviors. The current results only provided evidence about the relationship between previous usual level of PA and the automatic activation of PA goals by BMEC primes, but did not ensure that this automatic activation prospectively predicted PA behaviors. Even if, in other contexts, previous studies revealed that temptations primes not only influence goals activations, but also behavioral choices (e.g., Fishbach et al., 2003; Study 5), and that interventions influencing a few tenths of millisecond in a lexical decision task lead to significant changes in subsequent behaviors (Adriaanse, van Oosten, de Ridder, de Wit & Evers, 2011), this evidence is currently lacking in PA. Futures research should examine whether the automatic activation of PA goal by BMEC temptations impacts PA behavior. In the same vein, future studies should examine whether changes in the automatic cognitive association between BMEC cues and PA goals subsequently impact PA behavior to determine causality.

To conclude, our findings corroborate the theory of temptation-elicited goal activation within the context of PA, with BMEC representing the temptations. Moreover, our results provide a better understanding of the psychological processes involved in the successful self-regulation of PA behavior. Furthermore, to the best of our knowledge, this research is the first to suggest and to obtain preliminary evidence supporting the fact that BMEC act as temptations interfering with PA goals. Finally, our findings suggest that interventions designed to create adaptive cognitive associations between BMEC cues and PA hold great promise to help individuals being successful in the regulation of their PA goals.

Acknowledgement

MPB is supported by the Research Foundation Flanders (FWO) (1504015N).

We would like to thanks Silvio Maltagliati for his help in the data acquisition.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.psychsport.2017.02.006.

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