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Changing implicit attitudes for physical activity with associative learning

Null findings from an experimental study conducted in pulmonary rehabilitation

Electronic supplementary material

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Introduction

Studies conducted during the past decade indicate that physical activity (PA) behavior is not only driven by explicit (i. e., reasoned) processes, but also by implicit (i. e., automatic) processes (Rebar et al., 2016; Schinkoeth & Antoniewicz, 2017). Theoretically, implicit and explicit motivational processes differ according to their automaticity features (Bargh, 1994). Explicit processes are cognitively costly (i. e., require important attentional resources), operate consciously, under individual cognitive control, and are driven by individual's intentions. On the other hand, implicit processes are less conscious, less intentional, less controllable and more cognitively efficient (De Houwer & Moors, 2012). Because of these features, implicit processes are assumed to be activated spontaneously, in particular in contexts or moments where attentional or cognitive resources are limited (Hofmann, Friese, & Wiers, 2008). For this reason, there were calls to base health-related behavior change interventions on implicit processes (Marteau, Hollands, & Fletcher, 2012).

Amongst the different implicit processes (see Sheeran et al., 2016), implicit attitudes have received a large amount of attention in the PA literature (Rebar et al., 2016). The concept of implicit attitudes refers to automatic associations[1], activated with low individual control, between an object (e. g., PA behavior) and pleasant or unpleasant attributes (Greenwald & Banaji, 1995). Theoretically, implicit attitudes toward PA are based on associations learned over time and through experience with PA. They are theorized to influence PA behavior directly, or indirectly through automatic motivation (e. g., non-conscious goal pursuit, impulsive approach-avoidance tendencies) and explicit/reasoned processes (e. g., intentions, anticipated affects; Brand & Ekkekakis, 2018; Conroy & Berry, 2017). In the PA literature, several correlational studies have shown that more favorable implicit attitudes toward PA (i. e., positive automatic evaluations of PA stimuli) were associated with higher levels of self-reported and objectively measured PA (see Schinkoeth & Antoniewicz, 2017 for a review). Moreover, recent quasi-experimental and experimental studies have highlighted that implicit attitudes toward PA are modifiable (Antoniewicz & Brand, 2016; Hyde, Elavsky, Doerksen, & Conroy, 2012; Markland, Hall, Duncan, & Simatovic, 2015), and thus represent a promising new target for PA promotion (Conroy & Berry, 2017).

According to the Associative-Propositional Evaluation (APE) Model (Gawronski & Bodenhausen, 2006), implicit processes could either be changed through the formation of new associations in memory, or be specifically activated through contextual cues. In accordance with this assumption, Papies (2016) proposed two specific kinds of interventions called *training interventions*, aiming at directly changing implicit processes, and *cueing interventions*, aiming to change the features of the environment in order to influence the activation of implicit processes. In terms of behavior change techniques, training intervention mainly refers to the principles of associative learning, using for example evaluative conditioning or mental imagery to change the valence of an object (i. e., PA behavior) by pairing that object with another positive or negative stimulus (Michie et al., 2013). By contrast, a cueing intervention refers to the utilization

[1] The label 'automatic associations' is used here in reference to the automaticity features (i. e., consciousness, intentionality, controllability and efficiency) proposed by Bargh (1994). We assume that the theoretical concept of implicit attitudes refers to associations between an object and pleasant or unpleasant attributes that are automatically activated. We use the term 'implicit attitudes' knowing that there is no consensus in the literature regarding terminology and that the process defined here may be referred to with other terms such as automatic associations.

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of priming, prompting, or nudging techniques, which consist in altering features of the environment to activate mental processes and behaviors in a specific time and place (Hollands et al., 2017). Hence, in comparison to training interventions that aim to modify implicit processes, cueing interventions seek to activate an existing implicit process in a certain situation. Given the objective of this study (i. e., changing implicit attitudes to impact PA behavior), the present research focused on a training intervention.

To date, a few quasi-experimental and experimental studies have manipulated implicit attitudes toward PA by applying principles directly in line or very close to the paradigm of evaluative conditioning (De Houwer, 2007). Evaluative conditioning aims to change the valence of a stimulus (conditioned stimulus) by pairing that stimulus with other positive or negative stimuli (unconditioned stimuli), through repeated exposure. Theoretically, when topics (e. g., PA) are repeatedly paired with positive or negative stimuli, associative links are formed in memory, and these changes may be reflected in the evaluation of implicit attitudes (e. g., implicit attitudes could become more favorable to PA; Hofmann, Houwer, Perugini, Baeyens, & Crombez, 2010). In the PA context, one study using mental imagery showed that implicit attitudes toward exercise significantly differed between a group of students who just listened to an audio script designed to associate positive feelings with exercise, compared to those in a control group (Markland et al., 2015). Using a similar post-test-only comparison, other researchers reported that students who had completed a computerized task in which PA stimuli were paired with positive stimuli (i. e., image of people displaying positive feelings) (*i*) presented significantly more favorable implicit attitudes compared to those from control groups just after the intervention, and (*ii*) selected significantly higher intensities of exercise during a subsequent ergo-bicycle task for participants with preexisting negative implicit attitudes (Antoniewicz & Brand, 2016). These results indicate that implicit attitudes could be sensitive to an intervention pairing PA with positive stimuli. However, the authors did not examine change in implicit attitudes and whether this change could subsequently impact PA behavior. This limitation implies that the mediating role of implicit attitudes change on physical activity behavior has not been yet tested.

To our knowledge, only one experimental study has examined if a change in implicit processes toward PA (i. e., approach-avoidance tendencies) could subsequently impact this behavior (Cheval et al., 2016). In that study, students were trained on a computer (*i*) to approach PA stimuli and avoid sedentary behavior stimuli, or on the contrary (*ii*) to approach sedentary behavior stimuli and avoid PA stimuli. Results revealed that approach-avoidance tendencies toward PA were enhanced in the first group, decreased in the second, and remained stable in a third control group, while approach-avoidance tendencies toward sedentary behavior were not impacted by the intervention. Subsequently, students from the first group spent significantly more time on a behavioral task (i. e., doing squats) compared to those from the other groups. These results support the idea that implicit processes toward both PA and sedentary behavior could be targeted, resulting in a modification of PA behaviors (Cheval et al., 2016). Nonetheless, this study presents two main limitations: a strong lack of ecological validity, and the absence of measure of explicit attitudes. Due to this second limitation, it is impossible to affirm that the retraining procedure tested in this previous study impacted PA behavior through a modification of implicit processes or explicit processes (Cheval et al., 2016). Indeed, according to Hollands, Marteau, & Fletcher (2016) an intervention may be described as principally targeting implicit processes if changes in implicit processes mediate the effect of the intervention on behavior, and if explicit processes are unaffected and do not mediate behavioral effects.

The present study

To increase the ecological validity of previous laboratory experiments conducted among university students (Antoniewicz & Brand, 2016; Cheval et al., 2016; Markland et al., 2015), this study was conducted in a pulmonary rehabilitation context. Although PA represents a key issue among people living with chronic respiratory diseases (Esteban et al., 2014), they are on average less physically active than healthy matched control individuals (Pitta et al., 2005). Hence, experimentally targeting implicit attitudes during pulmonary rehabilitation could simultaneously contribute to the enhancement of future specific interventions delivered in respiratory medicine, and a better understanding of the role of implicit processes toward PA behavior in general.

In the present study, an intervention where PA stimuli were repeatedly paired with positive stimuli through the principles of associative learning was developed. However, in contrast to past studies, we did not deliver the intervention through computerized individual sessions, but through the environment, using posters. Over one week, study participants were exposed over four days to posters combining (*i*) photos of older adults practicing PA (i. e., in the 'PA group') or being sedentary (i. e., in the 'sedentary group') while having fun, with (*ii*) one pleasant adjective inserted in the poster to reinforce the positive valence of these two behaviors (the posters used for the interventions are presented in supplemental materials). This implementation strategy was chosen because it does not require one-on-one coaching, and thus could be less time-consuming and more easily implemented in real-life or clinical settings, such as a rehabilitation program. Despite the low personal involvement of the participants with the posters and the utilization of visual "cues" (i. e., posters) for the intervention, we labelled this intervention as a training intervention and not a cueing intervention. This is justified by the fact that this study was initially designed to change implicit attitudes over a week, and subsequently impact an ecological

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Changing implicit attitudes for physical activity with associative learning. Null findings from an experimental study conducted in pulmonary rehabilitation

Abstract

Background. This study evaluated the impact of 4-day exposure to posters pairing physical activity or sedentary behavior with positive stimuli on implicit attitudes toward physical activity *versus* sedentary behavior, and physical activity measured with accelerometers.
Methods. This study was conducted among participants enrolled in a pulmonary rehabilitation program. Participants ($N = 79$) were randomized into groups exposed to (*i*) posters of people being physically active, (*ii*) posters of people engaged in sedentary behaviors, or (*iii*) control, not exposed. Over four days, different posters were put in patients' bedrooms. Participants were not informed of the link between the intervention and the evaluations. Implicit attitudes were measured with an Implicit Association Test at the start and at the end of the intervention. Physical activity was measured with accelerometers the weekend after the intervention.
Results. Regarding implicit attitudes, results showed a non-significant time × group interaction. There were also no significant differences between groups regarding physical activity. Bayesian analyses confirmed these null hypotheses.
Conclusion. Putting posters pairing physical activity stimuli with positive stimuli in patients' bedroom during a rehabilitation program did not impact their implicit attitudes or physical activity behavior. Other studies are needed to develop effective interventions targeting implicit attitudes.

Keywords

Automatic processes · Automatic evaluation · Non-conscious processes · Dual processes · Bayesian analyses

Veränderung impliziter Einstellungen zu körperlicher Aktivität durch assoziatives Lernen. Nullergebnisse einer experimentellen Studie im Rahmen der pneumologischen Rehabilitation

Zusammenfassung

Hintergrund. In dieser Studie wurde der Einfluss einer 4-tägigen Exposition mit Postern, die körperliche Aktivität oder ein sitzendes Verhalten mit positiven Stimuli paarten, auf implizite Einstellungen gegenüber körperlicher Aktivität vs. sitzendem Verhalten und auf die mit einem Akzelerometer gemessene körperliche Aktivität untersucht.
Methoden. Die Teilnehmer dieser Studie ($N = 79$) befanden sich in einem Programm für pneumologische Rehabilitation. Sie wurden in Gruppen randomisiert, die (*i*) Postern von körperlich aktiven Personen bzw. (*ii*) Postern von Personen mit sitzendem Verhalten ausgesetzt waren oder (*iii*) als nichtexponierte Kontrolle fungierten. Über einen Zeitraum von 4 Tagen wurden in den Schlafzimmern der Patienten verschiedene Poster aufgehängt. Die Teilnehmer wurden nicht über die Verbindung zwischen der Intervention und den Untersuchungen in Kenntnis gesetzt. Implizite Einstellungen wurden mit einem darauf ausgelegten Test (Implicit Association Test) zu Beginn und am Ende der Intervention gemessen. Körperliche Aktivität wurde am Wochenende nach der Intervention mit Akzelerometern bestimmt.
Ergebnisse. Bezüglich impliziter Einstellungen zeigten die Ergebnisse eine nichtsignifikante Zeit × Gruppen-Interaktion. Auch signifikante Unterschiede zwischen den Gruppen hinsichtlich der körperlichen Aktivität fanden sich nicht. Bayes-Analysen bestätigten diese Nullhypothesen.
Schlussfolgerung. Das Aufhängen von Postern, die Stimuli körperlicher Aktivität mit positiven Stimuli paaren, in den Schlafzimmern von Patienten eines Rehabilitationsprogramms hatte keinen Einfluss auf ihre impliziten Einstellungen oder ihr Verhalten bezüglich körperlicher Aktivität. Für die Entwicklung wirksamer Interventionen, die auf implizite Einstellungen abzielen, sind weitere Studien erforderlich.

Schlüsselwörter

Automatische Vorgänge · Automatische Auswertung · Unbewusste Vorgänge · Duale Prozesse · Bayes-Analyse

measure of PA, instead of activating implicit attitudes in a particular context and time window and targeting a specific behavior (e. g., taking the stairs instead of the elevator), which refers to a cueing intervention (see Papies, 2016).

Three experimental groups were considered in the present study. The first group of participants was exposed to posters representing physically active people; a second was exposed to posters representing sedentary people; and a third control group was not exposed to posters. It was first hypothesized that exposing participants in a rehabilitation program to posters of physically active people would significantly enhance participants' implicit attitudes toward PA *versus* sedentary behavior, compared to those exposed to posters representing sedentary people, and a control group. Second, it was hypothesized that participants exposed to posters of physically active people would report higher levels of accelerometer-assessed PA after the intervention, compared to those in the two other groups. In accordance with Hollands et al. (2016), it was finally expected that the effect of the intervention on PA behavior would be mediated by a change in implicit attitudes but not in explicit attitudes.

Methods

Participants

Participants were first enrolled in the rehabilitation programs following a prescription by a medical doctor and for the purpose of chronic respiratory disease management. The rehabilitation

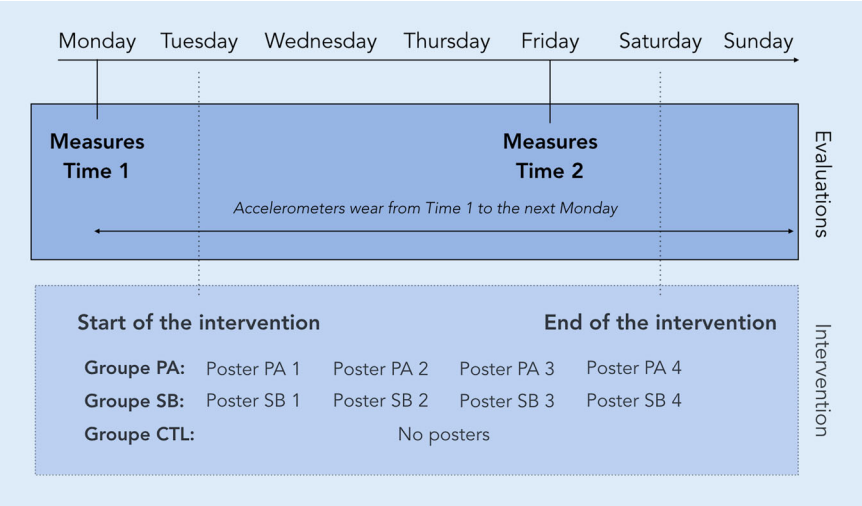

Fig. 1 ▲ Study design. *PA* physical activity, *SB* sedentary behavior, *CTL* control

program was a 5-week in-patient pulmonary rehabilitation program focusing on exercise and comprising daily lectures on nutrition, tobacco, and general disease management according to current recommendations (Spruit et al., 2013; for a more precise description of the program see Chevance, Héraud, Varray, & Boiché, 2017a). None of the health care professionals of the clinic were trained in the behavior change theories and techniques used in this study.

During the rehabilitation program, participants were considered eligible for the present study according to their exercise prescription, such that the groups who received the highest and lowest exercise prescription during their rehabilitation program were not included. This methodological precaution was taken to ensure that different levels of exercise did not impact the psychological processes and PA behavior measured during the program. Participants spent an average of 18 h ($SD = 1$) per week exercising (i. e., including light exercises such as stretching) as part of the rehabilitation program. Moreover, only participants aged between 55 and 75 years old, and who were not diagnosed as depressed by a physician at their entrance in the clinic were included in the present study. Finally, to avoid any stress due to the start of the rehabilitation program and tiredness at the end of the program, patients were enrolled in the middle of their 5-week rehabilitation program.

Procedure

According to Hollands et al. (2016), an intervention can be considered as specific to implicit processes depending on the extent to which the participants are aware of (*i*) the presence of the intervention, (*ii*) the ensuing behavior, and (*iii*) the presence of a causal link between the intervention and the behavior. Accordingly, participants were not explicitly informed of the study hypotheses and intervention. Indeed, each Monday, the principal investigator contacted potential participants and asked them if they were interested to participate in a study on *sleep and rehabilitation*. They were told that, if they accepted, they should wear an accelerometer day and night until the next Monday and would complete two evaluations comprising questionnaires and a computerized test on Monday (Time 1) and Friday (Time 2; see **Fig. 1**). To avoid information transfer, rehabilitation professionals in the clinic were also blinded to the study hypotheses and received the same information as the study participants (with the exception of senior managers). According to the aforementioned framework (Hollands et al., 2016), participants were thus aware of the presence of the intervention, but presumed to be unaware of the behavior under scrutiny as well as the link between the intervention and the behavior (this was controlled for, see the *Manipulation check* section).

All participants gave written consent to participate in a study designed to improve future rehabilitation programs. Given that participants were not informed of the intervention at the start of the study, it was explicitly mentioned to the person responsible for administering the intervention to remove the posters if participants reported being disturbed. In this case, participants were excluded from the statistical analyses. Finally, participants were invited to provide their email and were informed that they would be debriefed after their rehabilitation program.

During the study period, participants were excluded from the current investigation if they were not interested in completing Time 2 evaluations, or did not participate normally in the rehabilitation program due to injury or acute illness. Participants who identified a possible link between the evaluations and the experimental manipulation (i. e., posters) were also excluded from the analyses. Finally, study participants were informed that they were free to stop their participation at any time. This study was approved by the ethics committee of the Group *5 Santé*.

Experimental manipulation

Each Monday, after study inclusion, participants were randomized in a 1:1:1 ratio (i. e., PA group; sedentary behavior group; control group) and the principal investigator sent a list of participants to the hotel manager of the clinic, indicating which patients were included in the two experimental groups (participants included in the control group were not exposed to posters, thus their name were not communicated to the hotel manager). Next, the hotel manager asked a room attendant, blinded to the hypothesis, to conduct the intervention (i. e., put specific posters in patients' bedroom). Room attendants and patients were told that the clinic was trying novel room decorations and was testing patients' perception of this decoration. Participants were informed that a different poster would be put in their room each day from Friday to

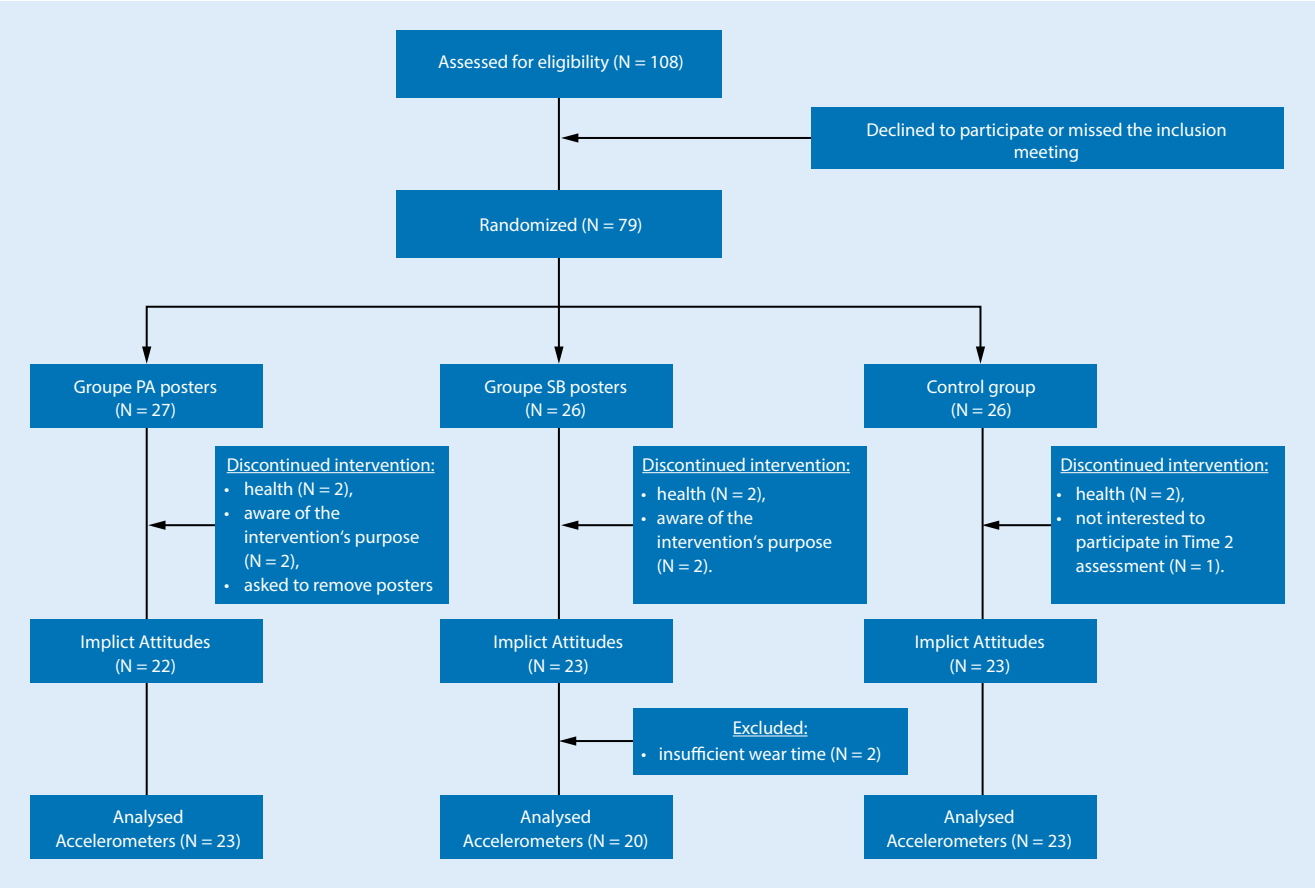

Fig. 2 ▲ Study flowchart. *PA* physical activity, *SB* sedentary behavior

Saturday (i. e., $N = 4$ posters) and that they would be invited to express their opinion on Saturday through a questionnaire (see the *Manipulation check* section).

The intervention was based on principles of associative learning and especially evaluative conditioning (De Houwer, 2007). Evaluative conditioning aims to change the valence of a stimulus (conditioned stimuli) by pairing that stimulus with other positive or negative stimuli (unconditioned stimuli). In the present study, conditioned stimuli were PA and sedentary behaviors, and unconditioned stimuli were positive emotions expressed by the people shown engaging in the behaviors. The posters combined (*i*) photos of older adults practicing PA (i. e., PA group) or engaging in a sedentary behavior (i. e., sedentary group) and having fun, with (*ii*) one pleasant adjective inserted in the poster to reinforce the positive valence of the posters (i. e., *pleasant*, *fun*, *happy*, *relax*; these words were similar for the PA and sedentary behavior posters). The final eight photos (i. e., four per behavior) were selected from a larger sample of twenty photos (see supplemental material).

Four different posters were used per participant through the week to try to maximize the impact of the intervention on both implicit attitudes change and behavior, while avoiding habituation (i. e., the posters no longer attract attention and therefore do not significantly affect implicit processes and behavior; see **Fig. 1**). To ensure that participants paid attention to the posters, they were placed in front or on the side of their bed. Finally, a clinic logo was inserted in each poster to enhance source credibility (Latimer, Brawley, & Bassett, 2010). The four posters targeting PA and the four posters targeting sedentary behavior are provided in the supplemental material.

Measures

Implicit attitudes. Implicit attitudes were measured with a computerized Implicit Associations Task (IAT) and using reaction time as the indicator of attitude (Greenwald, McGhee, & Schwartz, 1998; see supplemental material for a precise description of the test and stimuli used). Implicit attitudes scores were computed according to recent recommendations (package *IATscores* from the software R; Richetin, Costantini, Perugini, & Schönbrodt, 2015). The score was between –2 (implicit attitudes in favor of sedentary behavior compared with PA) and +2 (implicit attitudes in favor of PA compared with sedentary behavior), 0 representing no preferences for either of the two concepts. The IAT and this scoring algorithm were preferred to other methods due to (1) its relative similarity with the conditioning procedure employed in this study (i. e., pairing PA stimuli with positive and negative stimuli); and

Table 1 Descriptive data

Characteristic	Total M (SD)	PA Group M (SD)	SB Group M (SD)	Control Group M (SD)	*F* or X^2	*p*
Demographic						
Age	61.84 (6.23)	63.37 (5.86)	61.81 (6.28)	60.27 (6.43)	$F = 1.67$	0.20
BMI	31.09 (6.52)	32.17 (6.55)	30.39 (6.08)	30.66 (7.00)	$F = 0.57$	0.57
% Female	46.8	51.9	46.2	42.3	$X^2 = 0.49$	0.78
% Employed	33.5	31.3	37.5	31.3	$X^2 = 4.6$	0.59
% Common law	42.1	40.6	12.5	46.9	$X^2 = 13.29$	0.01
% >2300 € income	25	22.2	28	25	$X^2 = 0.23$	0.89
% University degree	29.5	29.6	24	34.6	$X^2 = 0.69$	0.71
Pathology of admission						
% COPD	35.4	18.5	53.8	34.6	$X^2 = 10.26$	0.11
% Sleep apnea	32.9	40.7	23.1	34.6	–	–
% Asthma	11.4	7.4	11.5	15.4	–	–
% Other	20.3	33.3	11.5	15.4	–	–
Clinical						
Previous stay	1.90 (2.20)	2.85 (2.60)	1.24 (1.62)	1.42 (1.92)	$F = 4.67$	0.01
Exercise capacity	89.16 (15.75)	91.73 (13.73)	85.54 (17.83)	89.92 (15.60)	$F = 1.01$	0.37
Self-reported behavior						
GLTQ	10.58 (10.78)	8.7 (10.26)	10.8 (10.5)	12 (11.6)	$F = 0.77$	0.47

BMI Body Mass Index, *COPD* Chronic Obstructive Pulmonary Disease, *M* mean, *SD* standard deviation, *PA* physical activity, *SB* sedentary behavior, *GLTQ* Godin Leisure Time Questionnaire

(2) its stronger test–retest reliability and internal consistency compared to other measures of implicit attitudes demonstrated in a similar sample of patients (Chevance, Héraud, Guerrieri, Rebar, & Boiché, 2017b). In the present study internal consistency (i.e., split-half reliability calculated using the function *Split-Half* from the package *IATscores*; Richetin et al., 2015) was satisfactory both pre- ($r_S = 0.82$) and post-intervention ($r_S = 0.84$).

Explicit attitudes. Explicit attitudes toward PA and sedentary behavior were measured through 7-point semantic differentiation scales. The item for PA was: *For you, practicing physical activity (for example a brisk walk) is something*.... The item for sedentary behavior was: *For you, spending time sitting (for example reading, watching tv) is something*.... After each item, two pairs of positive and negative adjectives were used (i.e., pleasant *versus* unpleasant, agreeable *versus* disagreeable). Mean scores between 1 and 7 for each behavior were computed, and then the score of explicit attitudes toward sedentary behavior was subtracted from the score of explicit attitudes toward physical activity (Gawronski & Lebel, 2008). This provides a score of relative preference between PA and sedentary behavior between −6 (explicit attitudes in favor of sedentary behavior compared with physical activity) and +6 (explicit attitudes in favor of physical activity compared with sedentary behavior), 0 being a neutral score suggesting no distinct preferences between behaviors. Internal consistency (i.e., Cronbach's α) was satisfactory both pre- ($\alpha = 0.78$) and post-intervention ($\alpha = 0.74$).

Physical activity behavior. Participants were asked to wear an ActiGraph GT3X+ (ActiGraph, Pensacola, FL, USA) accelerometer on their non-dominant wrist 24 h per day for an entire week. They were told that the device would collect sleep information during the week; however the PA scores were computed only during the weekend, when participants were not supervised in the course of their program (i.e., engaging in structured activity as part of the rehabilitation program). In this study the accelerometer captured triaxial accelerations at 80 Hz. Data in raw format were processed with R using the GGIR package and the default parameters of the function g.shell.GGIR (van Hees et al., 2014). Participants included in the analyses displayed at least 20 h of data per day (Saturday and Sunday). For each participant, the mean duration of light PA (LTPA) and moderate-to-vigorous PA (MVPA) was computed. To qualify as LTPA the activity needed to be comprised of 44.8 to 100 milligravity units; to qualify as MVPA, ≥80% of the activity needed to be ≥100 milligravity units, for at least a period (bout) of 1 min, using moving 10-minute windows (Hildebrand, Hansen, van Hees, & Ekelund, 2017). Both scores were reported in mean minutes per day.

Descriptive characteristics. Employment, marital status, income, and education were self-reported. Age, sex, body mass index (BMI), previous stays in other inpatient rehabilitation programs, and the main reason for the inclusion in rehabilitation were recorded at the start of the program during an interview with a physician. Exercise capacity was estimated at baseline with the *six-minute walking test* or the *shuttle-walking test* when ceiling effects were encountered on the *six-minute walking test*. The tests were performed twice at baseline, and the best distance covered expressed in percentage of theoretical value was used as an estimate of exercise capacity (Singh, Morgan, Scott, Walters, & Hardman, 1992; Troosters, Gosselink, & Decramer, 1999). The Godin Leisure-Time Exercise Questionnaire (Godin & Shephard, 1997) was used to determine patients' PA outside the supervised rehabilitation sessions during the week before study inclusion. According to the recommendations, the number of reported bouts of light, moderate and strenuous PA were multiplied by 3, 5 and 9 respectively, and the scores were summed (Godin & Shephard, 1997).

Table 2 Means (M) and standard deviations (SD) for the implicit and explicit attitudes

		Total M (SD)	PA Group M (SD)	SB Group M (SD)	Control Group M (SD)
Implicit Attitudes	Pre	0.64 (0.70)	0.63 (0.81)	0.72 (0.52)	0.58 (0.75)
	Post	0.68 (0.61)	0.59 (0.73)	0.71 (0.60)	0.75 (0.50)
Explicit Attitudes	Pre	0.47 (1.64)	0.26 (1.48)	0.20 (1.56)	0.92 (1.81)
	Post	0.53 (1.27)	0.60 (1.16)	0.52 (1.09)	0.48 (1.55)

PA physical activity, *SB* sedentary behavior

False evaluations. Given that this research was presented as an investigation interested in sleep and rehabilitation, and to limit the awareness of the participants regarding the PA purpose of the study, we asked the participants to complete a 6-item questionnaire assessing their subjective sleep quality during the week. These data were not analyzed.

Manipulation check. On Saturdays, after being exposed to the four posters, participants from the two experimental groups were asked to complete a questionnaire administered by the room attendant responsible of the intervention. This questionnaire was presented as a survey to collect their opinion about the posters put in their room during the week, and was used as a manipulation check (items are provided as supplemental material).

Statistical methods

Compromise power analyses were conducted to estimate the total sample required to ensure sufficient statistical power ($1 - \beta = 0.80$) using G-Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007). For the test of the first hypothesis (i. e., repeated measure ANOVAs) compromise power analysis indicated that at least 80 participants in total would be required (considering a small effect size $f = 0.15$; a β/α ratio of 1; 3 groups; 2 measurement times; a correlation of 0.60 between the IAT at time 1 and time 2; and non-sphericity correction $\varepsilon = 1$). This sample size's estimation was also valid for the test of the second hypothesis (i. e., one-way analyses of variance, ANCOVAs).

First, data distribution (i. e., skewness and kurtosis comprised –1 and 1) and outliers were checked (i. e., based on the inter quartile range, IQR). One-way analyses of variance (ANOVAs) and chi-squared tests were then conducted to examine potential baseline differences between the three groups. To examine the first hypothesis (i. e., change in implicit attitudes), and to control the effect of the intervention on explicit attitudes, a 2 (times) × 3 (groups) repeated measure ANOVA was conducted. To examine the second hypothesis (i. e., effect of the intervention on PA), one-way ANCOVAs were carried out, with LTPA and MVPA as dependent variables and self-reported PA the previous weekend as the covariate.

In case of null findings, Bayesian analyses were conducted to examine the likelihood that the observed data fitted with the null hypothesis *versus* the alternative hypothesis, in accordance with recent recommendations (Depaoli, Rus, Clifton, Schoot, & Tiemensma, 2017; Wagenmakers et al., 2015). Bayes factors (BF_{01}) between 3 and 10, 10 and 30, and >100 pointing to moderate, strong and decisive evidence respectively for the null hypothesis (Jeffreys, 1961; software's default prior option was selected for Bayesian analyses). Statistical analyses were performed with the software *JASP* (2016).

Results

Participant flow

Among the 108 participants approached, 79 showed interest in the study, completed Time 1 assessments and were allocated to one of the three groups. At Time 2, 68 and 66 participants provided valid implicit and PA measures (see the study flowchart, **Fig. 2**).

Descriptive statistics

The majority of study participants were admitted to pulmonary rehabilitation for either chronic obstructive pulmonary disease (COPD, 35%) or sleep apnea (33%). Mean age was 62 ($SD = 6.2$) years, mean BMI was 31 ($SD = 6.5\,kg/m^2$) and approximatively half of the participants were female (47%). Participants' characteristics were comparable between groups regarding demographic variables (i. e., except for marital status), self-reported behaviors and exercise capacity (see **Table 1**). Post-hoc analyses revealed that at baseline participants from the PA posters group reported significantly more previous rehabilitation programs ($M = 2.9$, $SD = 2.6$), than those from the group exposed to sedentary behavior posters ($M = 1.2$, $SD = 1.6$, $p = 0.02$) and those in the control group ($M = 1.4$, $SD = 1.9$, $p = 0.04$).

Perception of the posters and manipulation check

Participants in both experimental groups paid attention to the posters ($M = 3.86/5$, $SD = 1.23$), with no significant differences between the group exposed to PA posters ($M = 4.08$, $SD = 1.06$) and sedentary behavior posters ($M = 3.63$, $SD = 1.38$, $F(1, 48) = 1.71$, $p = 0.20$). As a whole, 56% reported that the posters had an influence on their feelings and behaviors during the week; this percentage was significantly higher in the group exposed to PA posters (73%) compared to the group exposed to sedentary behavior posters (62%, $X^2 = 6.4$, $p = 0.01$). Approximately two thirds of the participants (70%) reported that putting posters in their bedroom was a good idea; with no significant difference between the group exposed to PA posters (76%) and the group exposed to sedentary behavior posters (64%, $X^2 = 0.86$, $p = 0.36$).

First hypothesis: effect of the intervention on implicit and explicit attitudes

Implicit attitudes at both Time 1 and Time 2 demonstrated a strong negative skewness and were thus transformed following recommendations (i. e., NewX = 1/(K – X); Tabachnick & Fidell, 2007). Explicit attitude scores were normally distributed. Means and stan-

dards deviations for implicit and explicit attitudes are provided in **Table 2**.

Regarding implicit attitudes, results showed a non-significant time × group interaction, F (2, 65) = 0.462, p = 0.632, η^2 = 0.014. Bayesian repeated measure ANOVA confirmed that the data were 96 times more likely to be observed under the null hypothesis than under the alternative (BF_{01} = 95.85), suggesting a decisive evidence for the null hypothesis. Simple effects were non-significant (all F < 0.95, p > 0.34, η^2 < 0.01).

Concerning explicit attitudes, results showed a non-significant time × group interaction, F (2, 65) = 2.895, p = 0.063, η^2 = 0.084. Bayesian repeated measure ANOVA confirmed that the data were 18 times more likely to be observed under the null hypothesis than the alternative (BF_{01} = 17.69), which indicates strong evidence for the null hypothesis compared to the alternative. Simple effects were non-significant (all F < 0.95, p > 0.40, η^2 < 0.03).

This pattern of results, for both implicit and explicit attitudes, remained similar when self-reported PA was controlled for.

Second hypothesis: effect of the intervention on physical activity behavior

Regarding PA scores, LTPA and MVPA scores were normally distributed after removing three outliers (i. e., IQR). To analyze differences in both LTPA and MVPA between groups, one-way ANCOVAs (experimental groups: PA posters *versus* sedentary behavior posters *versus* control group) were conducted, with self-reported PA the weekend before the study inclusion as covariate.

Regarding LTPA score, there were no significant differences between groups, F (2, 64) = 0.840, p = 0.436, η^2 = 0.026 (PA posters: 272.9 [SD = 104 min]; sedentary behavior posters: 289.6 [SD = 112 min]; control group: 315.8 [SD = 97 min]). Bayesian ANCOVA indicated that the model (including covariate) were 11 times more likely to be observed under the null hypothesis than the alternative (BF_{01} = 11.147), which indicates strong evidence in favor of the null hypothesis.

Concerning MVPA score, there were no significant differences between groups, F (2, 61) = 0.259, p = 0.773, η^2 = 0.008 (physical activity poster: 33.93 [SD = 33 min]; sedentary behavior posters: 37.87 [SD = 37 min]; control group: 43.98 [SD = 39 min]). Bayesian ANCOVA indicated that the model (including covariate) was 3 times more likely to be observed under the null hypothesis compared to the alternative (BF_{01} = 3.27), which indicates moderate evidence for the null hypothesis.

Ancillary analyses

For both implicit and explicit attitudes, as well as LTPA and MVPA, results remained similar when baseline differences between groups (i. e., marital status, previous stay), and variables from the manipulation check for the two experimental groups only were controlled for (i. e., participants' attention, influence of the posters, positive *versus* negative perception of the posters).

Discussion

We hypothesized that patients repeatedly exposed to posters pairing PA with positive stimuli would enhance their implicit attitudes in favor of PA, which would subsequently impact their PA behavior. Results from this study, however, do not confirm these hypotheses. Exposure to posters did not change implicit attitudes toward PA relative to sedentary behavior, and did not significantly impact patients' behaviors.

Ineffectiveness of the intervention on implicit attitudes

Results from the present study do not support the effect of exposure to posters pairing PA with positive stimuli on implicit attitudes, with strong evidence for the null hypothesis. Several reasons are advanced to discuss this result. In past experimental research including implicit measure as a study outcome, participants were asked to actively participate to the experimentation, usually through a computer task (Antoniewicz & Brand, 2016; Cheval et al., 2016). In the present study, participants were only exposed to different images, and the interventions did not imply personal involvement from the participants. Accordingly, it is possible that a longer time and more posters would be needed to change implicit attitudes with a more "passive" intervention (Baeyens, Eelen, Crombez, & Van den Bergh, 1992). Hence, it could be interesting to reproduce the present experiment over the entire duration of a rehabilitation program, by exposing some participants from the start until the end of their stay (see previous study highlighting that a classical five-week rehabilitation program has a small, but significant, impact on implicit attitudes toward PA, Cohen's d = 0.20; Chevance et al., 2017a). In other words, it could be that the present intervention was not intense enough and therefore not effective. It is also possible that "active interventions" (i. e., where people are directly involved in, see Antoniewicz & Brand, 2016; Cheval et al., 2016; Markland et al., 2015) are necessary to change implicit attitudes. Moreover, implicit attitudes are theoretically more distal behavioral determinants than other implicit processes (e. g., it has been proposed that implicit attitudes are one of the cognitive precursors of approach-avoidance tendencies; Chen & Bargh, 1999). Accordingly, it could be hypothesized that more proximal implicit determinants of behavior, such as attentional bias or approach-avoidance tendencies, are more sensitive to this kind of intervention compared to implicit attitudes. In the same vein, the IAT used in this study is not representative of all implicit measures, thus multiple assessments of implicit attitudes might be preferred in future experimental studies (see Gawronski & De Houwer, 2014).

More broadly, despite the hypothesis that repeated passive exposure to images may change individuals' mental associations, this hypothesis has received limited empirical support yet. Studies conducted in the field of marketing have highlighted that images could lead participants to infer health functions to food products on the explicit level, by questioning people about their inferences (Carrillo, Fiszman, Lähteenmäki, & Varela, 2014), or on the implicit level, using false-recol-

lection methods (Klepacz, Nash, Egan, Hodgkins, & Raats, 2016). Nonetheless, the effect of these interventions on participants' cognitive structures was observed in laboratory context, and just after exposure, while a longer period was considered in the present study. Moreover, even if the images used in the present study were selected on their pleasantness and concordance with the behaviors, it is possible that the exposure to other kinds of images, such as younger people, would have been more effective. Other experimental and qualitative studies are needed to better understand the impact of images on implicit processes in real-life settings (see Cope et al., 2018; for a recent study investigating implicit responses to exercise images).

Finally, at Time 1, participants from the present study already reported implicit attitudes in favor of PA compared to sedentary behavior (i. e., implicit score >0; see **Table 2**); and complementary analysis revealed that only 16% (N = 13/79) of study participants displayed neutral implicit attitudes or implicit attitudes in favor of sedentary behavior compared to PA (i. e., implicit score ≤0). This may explain, in part, the ineffectiveness of the intervention, considering that people who already have implicit attitudes in favor of PA are less likely to be impacted by an evaluative conditioning procedure (Gibson, 2008). Accordingly, future interventions targeting implicit attitudes may preferentially focus on people presenting low implicit preferences for PA at baseline (see Antoniewicz & Brand, 2016; for an empirical demonstration of this hypothesis in the PA context, and Crutzen, Peters, & Noijen, 2017 for a statistical discussion of this previous point).

It's also interesting to note that explicit attitudes were neutral (i. e., no distinct preferences for PA or sedentary behavior) in the present study, while implicit attitudes were between 0.58 to 0.72, indicating an implicit preference for PA in comparison to sedentary behavior. These results confirm those from a previous study exploring implicit and explicit attitudes toward both PA and sedentary behavior in a rehabilitation context (Chevance et al., 2017b). In that study, patients reported—from the start and at the end of the program—favorable implicit attitudes toward PA compared to sedentary behavior, and favorable explicit attitudes toward both PA and sedentary behavior (Chevance et al., 2017b). This challenges theoretical assumptions that health-related problems can be framed in terms of a conflict between "unfavorable" implicit processes on the one hand and "favorable" explicit attitudes on the other (see Brand & Ekkekakis, 2018; Cheval et al., 2018; Hofmann et al., 2008). It is possible that these results are specific to the rehabilitation context where implicit attitudes would be more impacted by the environment (i. e., participants are strongly prompted to be active, and exposed to PA primes all day through exercise educators and exercise materials in the clinic) than explicit attitudes (see for example, Schwarz, 2007 or Wittenbrink, Judd, & Park, 2001; about how environmental settings can shape implicit attitudes evaluation). In future, the study of the discrepancies between explicit and implicit attitudes, as both and outcome of an intervention and a predictor of PA, could help to better understand this pattern of attitudes in the PA context (see Brand & Antoniewicz, 2016).

Ineffectiveness of the intervention on physical activity behavior

The second hypothesis of this study postulated that repeated exposure to posters would result in higher levels of PA after the intervention in the group exposed to PA posters. However, this hypothesis was not supported for either LTPA or MVPA scores. Beyond the reasons evoked previously concerning the lack of impact of the intervention on implicit attitudes, two mains arguments can be advanced.

The first argument concerns the nature of the behavior targeted in the present study. Previous research investigating the impact of training interventions, such as evaluative conditioning, on PA were restricted to short bouts of exercise as the dependent variables (i. e., two minutes on a bicycle ergometer and five minutes on a behavioral task; Antoniewicz & Brand, 2016; Cheval et al., 2016). Conversely, the dependent variables used in this study were more ecological and representative of daily PA behavior, but ultimately more difficult to impact during an intervention. It is possible that interventions specifically targeting implicit processes have an impact on more spontaneous behaviors such as taking the stairs instead of the elevators (Houten, Nau, & Merrigan, 1981) or non-exercise activity thermogenesis (Cheval, Sarrazin, & Pelletier, 2014). Further, it would be interesting to reproduce this study with sedentary behavior (i. e., time spent sitting) as the main dependent variable, estimated for example with inclinometers.

The second argument that could be advanced to explain the lack of effect of the intervention on behavior concerns the environment in which this study was performed. During a rehabilitation program, participants are strongly prompted to be active, and exposed to PA primes all day through exercise educators and exercise materials in the clinic. Thus, it is possible that the intervention used in this study were not sufficiently strong for an additional impact beyond other interventions and environmental cues (and this argument is also valid for the ineffectiveness of the intervention on implicit attitudes). For these different reasons, the present study should be replicated in a more neutral environment. Finally, it could also be argued that participants were tired due to their exercise prescription inside of the rehabilitation program, resulting in resting periods during the weekend. However, mean PA levels during the weekend were relatively high and heterogeneous (i. e., M_{LTPA} = 292, SD = 107 min; M_{MVPA} = 37, SD = 35 min). This suggests that PA performed the weekend could be an accurate marker of autonomous PA.

Study strengths, limits and perspectives

This study is the first to experimentally target both implicit processes and PA in an ecological context. Strengths include: a sample of participants living with chronic diseases, an experimental design conducted over one week in a real-life context, and a measure of PA with ac-

celerometers. A main limitation however concerns the study's sample size. This did not seem to impact the information provided by the data (i. e., Bayesain analyses confirmed that the data were informative in favor of the null hypotheses); however a larger sample size would allow the test of more complex analyses. For example, it has been hypothesized that interventions specific to implicit processes could be more effective among more socially deprivated or cognitively impaired participants (i. e., behavior change techniques that involve individual-level education may widen inequalities, whereas environmental manipulation do not appear to do so; McGill et al., 2015). Hence, examining moderators, such as socio-economic status or self-regulation's markers (i. e., executive functions), may help to identify "good and bad responders" to the intervention (Chevance, Stephan, Héraud, & Boiché, 2018). Contextual moderators were also tested in this study such as the participants' attention towards the poster. These analyses allowed for testing of the hypothesis that the effect of evaluative conditioning is stronger for higher than low contingency awareness (Hofmann et al., 2010). Nonetheless, the pattern of results was unchanged when controlling for attention.

In summary, future research targeting implicit attitudes through posters and principles of associative learning should first pay attention to the (*i*) duration of the exposure and (*ii*) number of posters required to change implicit attitudes in similar "passive" interventions. Past research underlined that evaluative conditioning effects become stronger when the number of paired stimuli increases, but that overexposure has also adverse effects (Baeyens et al., 1992); these conditions might be manipulated in future studies to identify a necessary "dose". Second, more experimental and qualitative studies are needed to understand how the feature of images can impact implicit processes in the PA context. Recently, Cope et al. (2018) highlighted that independent of age, people tend to associate images with exercise if the images include young adults as opposed to middle-aged adults. More research into specific types of cues is needed. Third, several implicit processes are likely to be impacted by an intervention pairing PA and positive stimuli and, if possible, multiple assessments of theoretically distinct implicit processes, with different implicit measures, should be used (e. g., implicit attitudes, attentional bias and impulsive approach-avoidance tendencies measured respectively with an IAT, dot probe task and manikin task). Fourth, future studies targeting implicit processes may focus on people presenting low implicit preferences for PA at baseline, and thus presenting larger potential for improvement (see Antoniewicz & Brand, 2016; Crutzen et al., 2017). The control of moderators (i. e., self-regulation) to identify "good responders" to the intervention may also be revelant. Finally, neutral environment, in regards of PA and exercise, should be preferred to implement this kind of intervention. Rehabilitation clinics, or any sport and exercise structure, are likely to contain too many PA cues to observe any additional effects of an intervention using posters.

To conclude, this study does not support the effectiveness of posters pairing PA with positive stimuli on implicit attitudes and PA. It is important to communicate null results because of the potential biases caused by the publication of "positive results" only (e. g., Open Science Collaboration, 2015; Munafò et al., 2017). Other studies are needed to develop more effective interventions targeting implicit processes.

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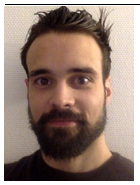

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Compliance with ethical guidelines

Conflict of interest. G. Chevance, T. Berry, J. Boiché and N. Heraud declare that they have no competing interests.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1975 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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