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Reflective and impulsive processes explain (in)effectiveness of messages promoting physical activity: A randomized controlled trial

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Abstract

Objective: The present study tested whether taking into account both the reflective and the impulsive processes of physical activity (PA) is helpful in understanding how and for whom PA-promoting messages will be (in)effective in changing behavior. Method: Participants (N = 101) were presented with a persuasive message promoting either PA (experimental condition) or healthy eating (control condition). Reflective intentions to be physically active were assessed both at baseline and after exposure to the message. Impulsive approach tendencies towards PA (IAPA) and sedentary behaviors (IASB) were assessed using a manikin task. The main outcome variable was accelerometer-assessed free time spent in moderate to vigorous physical activity (MVPA) over one-week after exposure to the message. Results: Although the PA-promoting message had no direct effect on MVPA, the results showed that (1) this message increased intentions to practice PA notably among participants with low or moderate (but not high) baseline intentions, (2) objective MVPA was positively predicted by post-message PA intentions and IAPA, and negatively predicted by IASB, (3) post-message PA intentions predicted MVPA for individuals with low or moderate (but not high) IASB. A follow-up moderated mediation analysis corroborated these earlier results, showing that PA-promoting messages positively predicted MVPA through post-message intentions only among individuals with low or moderate baseline intentions and low or moderate IASB. Conclusions: By identifying two boundary conditions, this study revealed important insights to explain when PA-promoting messages will be effective to predict objective MVPA and when they will not. Keywords: Health message, physical activity, sedentary behavior, reflective-impulsive model
Reflective and impulsive processes explain (in)efficacy of messages promoting physical activity: A randomized controlled trial

To accumulate at least 150 minutes of moderate-to-vigorous-intensity physical activity (MVPA) per week, in bouts of 10 minutes or more, has proven to be effective in the primary and secondary prevention of many chronic diseases (see Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010, for a review). However the majority of adults in the US (e.g., Haskell et al., 2007) and Europe (e.g., Sjöström, Oja, Hagströmer, Smith, & Bauman, 2006) fail to meet public health PA guidelines. One way to reach the large number of physically inactive individuals is to promote PA using media-based interventions (Marcus, Owen, Forsyth, Cavill, & Fridinger, 1998) such as print and information technologies (Napolitano & Marcus, 2002). One of the challenges for such interventions is how to communicate PA recommendations effectively. Recent work on persuasive communication advocated that in order to motivate individuals to adhere to regular PA, the message pertaining to PA guidelines must be supplemented with messages that convey why and how to achieve the recommended activity level (e.g., Latimer, Brawley, & Basset, 2010). This research also suggests the use of theories in order to identify change mediators and processes (e.g., Napolitano & Marcus, 2002; Marcus et al., 1998).

Many media-based PA interventions are grounded on the dominant theories of health behavior (e.g., Ajzen, 1991; Bandura, 1998) that focus on reflective, also called explicit, precursors of action. These theories assume that changing a person’s conscious cognitions (e.g., behavioral intentions, explicit attitudes, self-efficacy) will engender substantial change in behavior. A meta-analysis of experimental evidence from various domains indicated that such interventions are indeed quite effective in altering intentions ($d = 0.66$) (Webb & Sheeran, 2006). However, the results also revealed that this medium-to-large change in intentions only led to a small-to-medium change in behaviors ($d = 0.36$). Thus, changing
reflective processes does not guarantee health behavior change.

In recent years, dual-process models such as the Reflective-Impulsive Model (RIM; Strack & Deutsch, 2004) have suggested that impulsive processes such as implicit attitudes, or approach-avoidance tendencies, also exert some influence on health behaviors (e.g., Hofmann, Friese, & Wiers, 2008; Sheeran, Gollwitzer, & Bargh, 2013). Building on this work, we argue that approach-avoidance tendencies toward PA and sedentary behavior (SB) are helpful in understanding how and for whom PA-promoting messages will be (in)effective in changing behavior.

The Reflective-Impulsive Model

The RIM distinguishes two separate, but interacting systems: the *impulsive* and the *reflective* that jointly guide behavior. Personal standards, reasoned evaluations of pros and cons, and action plans reside in the reflective system. Typically seen as reasoned, conscious and intentional, these plans and decisions activate proper behavioral schemata (“I’m going to go for a run now to improve my health”). By contrast, the impulsive system consists of associative clusters that have been created or strengthened by temporal or spatial co-activation of external stimuli, affective reactions, and associated behavioral tendencies (Hofmann et al., 2008). Once a valence-laden association is established in the impulsive system, a mere perceptual input (e.g., seeing sportswear or people jogging) could automatically trigger affective evaluations that would in turn, lead to an impulsive approach (or avoidance) tendency towards PA (Strack & Deutsch, 2004).

The RIM allows for several ways in which reflective and impulsive processes can jointly guide behavior. Two patterns of prediction were highlighted in particular: the *additive* and the *interactive patterns* (see Perugini, Richetin, & Zogmaister, 2010). The former draws on the assumption that many behaviors are neither purely reflective nor purely impulsive, and that jointly considering both processes should therefore improve the prediction of PA
behaviors. For example, some PA-like exercise and sports carried out in a club are highly organized and therefore presumably guided predominantly by reflective processes. However, a great deal of PA associated with daily living (e.g., walking rather than taking the car) is much less organized and formalized. Their regulation is presumably more influenced by impulsive processes (Conroy, Hyde, Doerksen, & Ribeiro, 2010). The RIM also posits that reflective and impulsive processes interact synergistically to predict behavior. When both processes work hand in hand by activating similar behavioral schemata, the execution of the respective behavior is facilitated. By contrast, when they activate competing behavioral schemata the execution of the behavior can be impeded (Strack & Deutsch, 2004).

Recent evidence suggests that impulsive processes can predict health protective behaviors, such as dental flossing (Millar, 2011) or purchasing healthy food (e.g., Prestwich, Hurling, & Baker, 2011). With respect to PA, the few existing studies have mainly focused on the relationships between previous PA and impulsive processes (e.g., Bluemke, Brand, Schweizer, & Kahlert, 2010; Calitri, Lowe, Eves, & Bennett, 2009). On the whole, results showed that people who reported higher levels of PA were impulsively more predisposed towards PA than those who had been more inactive. To our knowledge, only one study has assessed impulsive processes to prospectively predict PA (Conroy et al., 2010). The study provided evidence for the additive pattern in that impulsive precursors predicted daily step counts above and beyond several reflective precursors (e.g., behavioral intentions) over a 7-day monitoring period. Nevertheless, the interactive pattern was not tested in this study. Moreover, while it does provide some evidence of the predictive validity of impulsive processes related to PA, this study did not focus on impulsive mechanisms related to some concurrent behaviors, such as SB, likely to hinder PA behavior.

Traditionally thought to be two sides of the same coin, PA and SB are now viewed as different constructs (e.g., Biddle, 2007). Given the increasing availability of technology,
people are spending more and more time on SB such as watching TV and other forms of screen-based entertainment. Population-based survey and correlational studies (e.g., Rhodes & Blanchard, 2008) showed that a higher preference for SB was negatively associated with time spent in PA. However, all these studies measured preference for SB using reflective precursors of behavior. Based on the RIM, we hypothesized that SB could be triggered by impulsive mechanisms that may compete with PA implementation.

**The Present Study**

The purpose of the current study was to analyze the impulsive processes related to PA and SB in order to try to understand how and for whom PA-promoting messages fostering PA intentions are effective in changing actual PA behavior. If impulsive processes conflict with PA intentions aroused by PA-promoting messages, these messages may be less effective. Participants were presented with a health-related message promoting either PA (experimental condition) or healthy eating (control condition). Reflective intentions to be physically active were assessed both at baseline and after message exposure. Impulsive approach tendencies towards PA (IAPA) and sedentary behaviors (IASB) were assessed using a manikin task based on work by De Houwer and colleagues (e.g., Mogg, Bradley, Field, & De Houwer, 2003), a well-validated measure of impulsive approach-avoidance tendencies (Krieglmeyer & Deutsch, 2010). Finally, MVPA was assessed with an accelerometer for one week after message exposure.

Given the mixed findings in the literature concerning direct effects of PA-promoting messages on objective MVPA (for reviews, see Bauman & Chau, 2009; Cavill & Bauman, 2004; Latimer et al., 2010; Marcus et al., 1998; Rhodes & Pfaeffli, 2010) we had no strong expectations concerning a significant direct effect of the PA-promoting message on MVPA. Instead, on the basis of the theoretical elaboration above, we expected a complex mediation mechanism in which the PA-promoting message exerts an indirect effect on MVPA through
post-intervention PA intentions depending on individual differences in variables such as baseline intention and impulsive processes related to PA and SB. In other words, we expected that this indirect effect of PA-promoting messages on MVPA through intentions could be conditional to boundary conditions. More precisely, we hypothesized, first, that exposure to a message emphasizing the benefits associated with PA and providing advice on reaching the recommended level of daily PA would lead to stronger reflective PA intentions (H1). Moreover, due to a ceiling effect, we expected that individuals who already held strong intentions would be less affected (H1bis). Second, consistent with an additive pattern of behavior prediction, we expected IAPA and IASB to predict variance in PA behavior over and above PA intentions (H2). Third, consistent with an interactive pattern of behavior prediction, we expected PA intentions to be more strongly related to PA behavior when IAPA levels were high and/or when IASB levels were low. By contrast, PA intentions would be less related to PA when IAPA levels were low and/or IASB levels were high (H3). Finally, if H1bis and H3 were corroborated, we expected a double conditional indirect effect of message condition on MVPA via post-message intentions which would depend on individual differences in baseline intentions and impulsive processes related to PA and SB (H4).

**Method**

**Participants and procedures.** A power analysis (conducted via GPower) that assumed an effect size of $d = .66$ for the intervention on intentions (based on the meta-analysis by Webb & Sheeran, 2006), indicated that a total of 82 participants (41 per condition) were required to have 90% power of detecting a significant effect at $p$-value of .05. Allowing for the possibility of accelerometer malfunction and missing data, 101 participants were recruited. It was a convenience sample recruited through contacts at tertiary sector companies close to the university where the research was based, to allow face-to-face meetings. Prospective participants were invited to take part in a study concerning PA through
work emails and posters displayed in the companies. As encouragement participants who completed the study were offered the chance of winning a lottery prize of a digital tablet or one of two mp3 players. Ethical approval for the study was granted by the University of Grenoble Research Ethics Committee. Approximately 1,000 people were approached but an accurate participation rate cannot be determined as we were unable to verify that companies had contacted all their staff. To be included in the study, participants had to be older than 18 years old and be willing to fill in a short online questionnaire, attend two meetings over one week, wear an accelerometer for one week, be free of any medical conditions that would prohibit PA without supervision, and not currently be receiving treatment for a psychiatric disorder. One hundred and one adult workers (52 women and 49 men; $M_{age}=38.44, SD=8.66$; see Table 1 for details) met the eligibility criteria and gave written informed consent (see the participant flow chart in online Supplementary Figure 1). Participants were randomly assigned to one of the two conditions (PA vs. healthy eating messages) using a random number generator.

After a (short) presentation of the weekly PA guidelines (i.e., a minimum total of 30 minutes per day of at least moderate-intensity physical activity, in bouts of 10 minutes or more, on 5 or more days), participants provided some demographic information (age, sex, type of job, family situation) and completed an online questionnaire assessing their intentions to meet these guidelines during the next week. One week later, participants came to the laboratory individually and were received by a research assistant blind to the study hypotheses. After being measured for height and weight, participants were invited to complete the manikin task on computer, to read one of the two health messages (PA or healthy eating), and finally, to fill out a short questionnaire assessing their intentions to follow the guidelines during the next week. Each participant was then given an accelerometer and instructed on how and when to wear it. They also received a notebook in which they were asked to record
for each day the times at which they woke up, put the accelerometer on their hip, were at work, were doing leisure activities, removed the accelerometer and went to bed. Eight days later, each participant returned their accelerometer and notebook to the laboratory and was debriefed.

**Persuasive messages.** Since 2001 the French government has been sponsoring the ‘Programme National Nutrition Santé’ (National Nutrition Health Program), with the aim of improving the population’s health by acting on two key determinants: nutrition and PA. Adapted from the core information on the Program’s website (http://www.mangerbouger.fr), two persuasive message presentations were created and pilot tested to promote either PA (experimental condition) or healthy eating (control condition). The messages have the same duration (210s), structure, layout, and number of slides. Each message is targeted at an adult audience and was structured to answer three questions: what, why, how? For example, the message promoting PA first of all gave information about the PA guidelines, namely 30min MVPA per day, stating that it was possible to break it up into smaller chunks of at least 10 minutes at a time. Then, the message highlighted meaningful short- and long-term benefits of being active (e.g., participating in PA will lead to toned and fit physique, to sleep better at night, increase chances of living longer). With the exception of saying that being inactive increases health risks, the message was predominantly gain-framed. Finally, the message provided advice on how anyone can meet the guideline recommendations each day (e.g., by building PA into daily routines and chores). The “active ingredients” used in the messages, following the CALO-RE taxonomy (Michie, Ashford, Sniehotta, Dombrowski, Bishop, & French, 2011) are: to provide information on (1) the consequences of the behavior in general, and (2) where and when to carry out the behavior.

**Measures.**
Physical activity intentions. Two items assessed participants’ willingness and intentions to engage in the recommended amount of PA over the next week (e.g., I intend to carry out at least 30 minutes MVPA per day on 5 or more days of the week) using a 7-point Likert scale (1=strongly disagree, 7=strongly agree). These items were strongly correlated ($r = .88$ and $.90$, at baseline and post-message respectively), so we combined them into a single score.

Manikin task. To assess participants’ spontaneous approach-avoidance tendencies toward PA and SB we used a manikin task (Krieglmeier & Deustch, 2010). Using Eprime software, participants were asked to move the manikin – i.e., a schematic image of a human figure – upwards or downwards by repeatedly pressing the “8” or “2” keys, respectively on a numeric keypad, with their middle finger. Each trial started with a fixation cross in the middle of the screen. On seeing the cross, participants had to press the “5” key and keep it pressed until they began to move the manikin. The initial key press triggered the manikin to appear in either the upper or the lower half of the screen with the same probability. Then, 750 ms after the appearance of the manikin, an image of PA or SB was presented at the center of the screen. A pilot study (see the online supplementary material) allowed the identification of 8 images representing “movement and active lifestyle” and 8 images representing “rest and sedentary lifestyle” (see online supplementary materials Figure 2). Depending on the condition, participants were asked to move the manikin toward a PA image and away from an SB image, or vice versa. They were instructed to respond as fast and as accurately as possible by pressing the respective “8” or “2” key three times to move the manikin across the screen. If an incorrect response was made, error feedback appeared on the screen. Five hundred ms after the third key press, the screen was cleared for 1000ms before the start of the next trial. The reaction time (RT) between the onset of the image and the first key press was used in the analyses. Participants completed two blocks, each consisting of 12 practice trials.
and 64 test trials (i.e., each of the 16 images appeared twice in the top and twice in the bottom of the screen). In one block, participants were instructed to approach PA images and to avoid SB images, and in the other block, they were instructed to do the opposite. The order of the blocks was counterbalanced across participants.¹

Before analyzing data we excluded incorrect responses (3.12%) as well as responses below 150 ms (0.15%) and above 1,500 ms (0.78%) as recommended by Krieglmeyer and Deutsch (2010). Results are presented with the median RT². Participants’ impulsive approach tendencies toward PA and SB were calculated by subtracting the median avoidance RT from the median approach RT toward PA and SB images respectively. A positive score always indicates a tendency to approach rather than avoid the behavior. The manikin task is a reliable and well-validated measure of impulsive approach-avoidance tendencies (e.g., De Houwer, Crombez, Baeyens, & Hermans, 2001; Krieglmeyer & Deustch, 2010; Mogg et al., 2003). In this study, reliability was good (α = .80 and .82 for PA and SB, respectively).

**Objective Physical Activity.** Each participant was asked to wear a three-axis accelerometer (Actigraph GT3X+; Pensacola, USA) for seven consecutive days. Accelerometers are preferable over pedometers as they allow PA to be assessed using the same metrics as those employed in public health guidelines (i.e., number of minutes of MVPA per week, in bouts of 10 minutes or more; Corder, Ekelund, Steel, & Wareham, 2008). Participants were instructed on how to wear it (over the right hip, affixed to an elastic belt, preferably worn under their waistbands). In the current study, 60s epochs were used and non-wear-time was defined as at least 59 consecutive minutes of zero counts. Data were included in the analysis if wear time exceeded 10 waking hours per day on a minimum of five days, including at least one weekend day (Matthews, et al., 2012). Almost all the participants provided seven complete days of accelerometer data (N = 100) with just one participant missing 1 day. The number of daily bouts of MVPA (i.e., superior to 1952 counts per minute;}
Freedson, Melanson, & Sirard, 1998) lasting at least 10 continuous minutes outside office hours was used as the dependent variable given its correspondence with guideline recommendations and previous accelerometer-based research (Warburton et al., 2010).

**Data analysis.** We used *t*-tests and chi-squared analyses to examine baseline differences between the two conditions. Then, we tested the direct effect of the PA-promoting message on MVPA. Next, we conducted two sets of hierarchical multiple regression analyses to predict post-message intentions (H1) and objective MVPA (H2 and H3) respectively. Finally, we carried out a moderated mediation analysis to test H4. In all analyses, the predictor variables were centered in the case of continuous variables and dummy coded in the case of dichotomous variables. The statistical assumptions associated with multiple regression analyses were examined. Plots of the residuals against the predicted scores of MVPA and against all independent variables showed no major signs of heteroscedasticity. Residuals were normally distributed and centered around zero. Predictors and covariates were checked for multicollinearity (using variance inflation factors) which was not found either. Finally, examination of the Cook’s distances for all cases showed that no case exerted undue influence on the regression parameters. Thus, the statistical assumptions associated with multiple regression analyses were met.

**Results**

**Preliminary Analyses.**

Examination of differences between the two conditions indicated no differences in any of the measures at baseline including gender (*p*=.48), age (*p*=.36), BMI (*p*=.68), IAPA (*p*=.37), IASB (*p*=.14), or PA intentions (*p*=.30). Means, standard deviations, and bivariate correlations are presented in Table 1.

**Direct effect of the PA-promoting message on MVPA.**

Multiple regression analyses were conducted to examine the effects of message
condition on MVPA, while controlling for age, sex and BMI. Results showed that objective MVPA was not significantly related to the message condition ($p>.28$). Even though no direct effect of the message condition on MVPA emerged, this does not necessarily imply that the PA-promoting message was ineffective. Indeed, as pointed out by many analysts (e.g., Hayes, 2009, 2013; Zhao, Lynch, & Chen, 2010), a significant direct effect is not a requisite for unconditional or conditional indirect effects to occur, which are the main focus of the present study. In fact, treating a direct effect as a requisite for testing indirect effects can even hinder the discovery of substantive mechanisms by which an IV may exert an effect on DV (Hayes, 2009). We therefore firstly tested our hypotheses concerning the relationships between message condition, baseline PA intentions and post-message intentions (the presumed mediator) (H1 and H1bis), and then between post-message PA-intentions, impulsive processes and MVPA (H2 and H3), before carrying out a moderated mediation analysis (H4).

**Effect of a PA promoting message on reflective intentions to practice PA.**

Hierarchical regression analyses were used to predict reflective PA intentions (see Table 2). In the first step, sex, age, BMI and baseline PA intentions were entered as control variables. Experimental condition was entered in the second step. The two-way interaction term Condition × Baseline PA Intentions was entered in the third step. Control variables explained 67% of the variance in PA intentions, $F(4, 92) = 52.93, p<.001$, with only baseline intentions making a significant contribution to the regression equation. In line with H1, the addition of the experimental condition increased the amount of explained variance, $\Delta R^2 = .018, \Delta F (1, 91)= 5.59, p < .05$. Compared to the control message condition, the message promoting PA condition was associated with greater PA intentions, controlling for baseline PA intentions. However, Step 3 interaction added a significant increase in explained variance, $\Delta R^2 = .012, \Delta F (1, 90)= 4.08, p < .05$. The interaction term was significant. In other words, in line with H1bis baseline PA intentions moderated the effect of condition on PA intentions.
Regression lines were computed at three levels of the hypothesized moderator (i.e., the mean level and one standard deviation above and below the mean) in order to explore the nature of the interaction. As we can see in Figure 1a, the impact of the message promoting PA on PA intentions was significant when baseline PA intentions were low ($b=0.789$, $t(96)=3.096$, $p<.01$) or moderate ($b=0.410$, $t(96)=2.303$, $p<.05$), but not when they were high ($b=0.031$, $t(96)=0.23$, $p=.90$).

Effect of post-message PA intentions and approach-avoidance tendencies on MVPA.

Hierarchical regression analyses were used to predict objective MVPA. In the first step, sex, age, and BMI were entered as control variables. Post-message PA intentions and the two impulsive approach biases (IAPA and IASB) were entered in the second and third step respectively to test the unique contributions of reflective and impulsive predictors of MVPA. The two-way interaction terms IAPA × PA intentions and IASB × PA intentions were entered in the fourth step. Finally, the three-way interaction term IAPA × IASB × PA intentions, with the required lower order term IAPA × IASB, were entered in the fifth step. Results showed that control variables explained 11% of the variance in MVPA, $F(3, 93) = 4.75, p<.01$, with only age and BMI respectively, making a positive and negative significant contribution to the regression equation. The addition of PA intentions at step 2, and of two impulsive approaches biases at step 3 increased the amount of explained variance, $\Delta R^2 = .08$, $\Delta F(1, 92)= 10.70, p<.01$, and $\Delta R^2 = .12$, $\Delta F(2, 90)= 9.09, p<.001$, respectively. In line with H2, these three variables made a distinct and significant contribution to the regression equations. Step 4 interactions added a significant increase in explained variance, $\Delta R^2 = .07$, $\Delta F(2, 88)= 5.81, p<.01$, with only the IASB × PA intentions making a significant contribution to the regression equation. Finally, step 5 variables did not add a significant increase in explained variance, $\Delta R^2 = .003, \Delta F(2, 86)= 0.79, p=.46$. The analyses were re-run dropping non-significant interaction terms in order to permit more powerful tests of the remaining terms and to
simplify the model as much as is possible (Aiken & West, 1991). Results are presented in Table 2. In the final regression equation, the variables under consideration explained 38% of the variance in objective MVPA. Controlling for age and BMI effects, objective MVPA was related to post-message PA intentions, IAPA and IASB. Moreover, in line with H3 the relationship between PA intentions and MVPA was moderated by IASB. As we can see in Figure 1b, simple slope analyses revealed that PA intentions significantly predicted MVPA when IASB levels were low \( (b=19.99, t(96)=4.21, p<.001) \) or moderate \( (b=8.61, t(96)=2.64, p<.01) \), but not when they were high \( (b=-2.56, t(96)=-0.52, p=.58) \). In fact, high IASB essentially blocked the effect of PA intentions on PA even for individuals with high PA intentions to perform PA.

**Effectiveness of a health message promoting PA: A Moderated Mediation Analysis.**

Previous analyses revealed that (1) the effect of persuasive messages on post-message PA intentions was stronger for individuals with low and moderate than for individuals with high baseline PA intentions, and (2) post-message PA intentions predicted objective MVPA for individuals with low and moderate, but not high IASB. To portray a more complete picture of the conditional indirect effects of messages on MVPA through post-message intentions, we modeled these findings in a joint moderated mediation analysis using Hayes’ (2013) PROCESS macro for SPSS (Model 21; see Figure 2). Specifically, this model tests if the indirect effect of message type (PA vs. healthy eating) on MVPA through post-message intentions is conditional on baseline intentions at the first stage and IASB at the second stage, controlling for sex, age, BMI and IAPA (Hayes, 2013). Corroborating the initial analyses reported above, there was no significant direct effect of the message manipulation on MVPA \( (t< 1.20, p >.25, 95\% CI = -34.51 to 8.78) \). Instead, the conditional indirect effect of message type through post-message intentions to MVPA was statistically significant among participants with low (i.e., at \( M-1SD \)) baseline intentions, and low (conditional indirect effect
16.83, 95% bias-corrected 5000 bootstrap confidence interval = 5.61 to 35.43) or moderate (i.e., at mean, conditional indirect effect = 8.29, 95% CI = 2.53 to 19.10) but not high (i.e., at M+1SD, conditional indirect effect = -0.26, 95% CI = -8.85 to 7.28) IASB. The effect was also statistically significant among participants with moderate baseline intentions, and low (conditional indirect effect = 9.21, 95% CI = 2.20 to 20.79) or moderate (conditional indirect effect = 4.53, 95% CI = 0.93 to 11.51) but not high (conditional indirect effect = -0.14, 95% CI = -4.91 to 4.17) IASB. Finally, whatever the IASB score, the conditional indirect effects were not significant when baseline intentions were high. As there is no tool, to date, for calculating the effect size of a conditional indirect effect in a moderated mediation analysis, the online supplementary materials Figure 3 shows the size of the conditional indirect effect of message condition on MVPA through post-message intentions at three values (i.e., -1SD, mean, +1SD) of baseline PA intentions and IASB with a 95%-confidence band. The model explained 73% of the variance in post-message PA intentions and 44% of the variance in objective MVPA.

**Discussion**

Due to its extensive health benefits, promoting regular PA is one of the public health priorities in many countries (Warburton et al., 2010), but participation rates still remain low (Haskell et al., 2007; Sjöström et al., 2006). The current study drew on the RIM to test the assumption that the interplay of reflective and impulsive processes can at least partly explain how and for whom messages promoting PA are more likely to be successful. Although there was no significant main effect of message condition on objective MVPA, four major findings were obtained: First, a PA promoting message specifying what, why and how to do PA increased intentions to practice PA particularly among participants with low or moderate (but not high) baseline intentions. Second, objective MVPA was positively predicted by post-message PA intentions and IAPA, and negatively predicted by IASB, an impulsive
predisposition at odds with PA. Third, post-message PA intentions predicted MVPA for individuals with low or moderate, but not high, IASB. For participants with high IASB, PA intentions were completely unrelated to MVPA. Fourth, a follow-up moderated mediation analysis corroborated the results: PA-promoting messages only positively predicted PA behavior through post-message intentions among individuals with low or moderate baseline intentions and low or moderate IASB. In sum, these findings reveal important insights into the psychological processes that determine the success or ineffectiveness of messages promoting PA.

The findings in this study are in accordance with results of reviews showing that health messages in general (e.g., Webb & Sheeran, 2006) and PA-promoting messages in particular (Latimer et al., 2010) are relatively good at altering intentions. According to Latimer et al. (2010) a printed message that describes not only what individuals should do (PA guidelines) but also why and how they should do it can motivate individuals to adhere to a regular PA regimen. However, such message was only effective among participants with low or moderate baseline PA intentions. Participants with high baseline PA intentions were not affected, presumably because they were already motivated enough to practice PA and there was not much room for change. Consistent with a ceiling effect, a simple PA-promoting message could not further increase PA intentions. From an applied perspective, this is a very satisfactory result – messages were most successful for those individuals who most needed a boost in motivation to exercise.

The present study goes well beyond extant research. It is the first to use both reflective (intentions) and impulsive (approach-avoidance tendencies) precursors of behavior to prospectively predict MVPA assessed objectively with an accelerometer and calculated using the same metrics as the ones used in public health guidelines (i.e., minutes of MVPA per week, in bouts of 10 minutes or more). In addition, it featured not only IAPA, but also IASB,
an impulsive disposition that is at odds with practicing PA. The inclusion of IASB broadens the perspective compared to previous research because it highlights the need to consider predispositions to perform certain behaviors that may not appear relevant to the researchers’ main focus in a given study. In the present investigation, PA behaviors were the main focus. In this context, an independent family of behaviors, such as sedentary behaviors, would appear to be of minor importance. However, given that people are spending more and more time on SB it is conceivable that strong predispositions for SB can interfere with practicing PA. Consequently, the prediction of PA behavior can be improved by taking into account such predispositions.

As expected, the two approach biases – IAPA and IASB – improved the prediction of MVPA. Together, they led to a sizable increment of 12% additionally explained variance in MVPA over and above post-message PA intentions. This additive effect of reflective and impulsive processes was expected given that the accelerometer assessment of PA included activities that vary with respect to the level of spontaneity versus deliberation (e.g., spontaneously taking the bike to work instead of the car versus planning to go running for 35 minutes in the park with a friend on Tuesday evening), and with respect to cognitive resources and motivation to control ones behavior. According to the RIM, deliberate actions and actions performed with sufficient resources and motivation should be particularly well predicted by reflective processes. By contrast, spontaneous actions and actions performed under conditions of low resources/low motivation should be particularly well predicted by impulsive processes (Friese, Hofmann, & Schmitt, 2008; Hofmann et al., 2008).

In addition, an interactive pattern of predictive validity between reflective and impulsive processes was also corroborated. Intentions to practice PA predicted MVPA, but only among individuals with low or moderate IASB. It appears quite remarkable that individuals reporting to have strong intentions to engage in PA did not do so when a reaction-
time based measure indicated strong predispositions toward engaging in activities that are at odds with PA.

A moderated mediation analysis highlighted the conditions in which the PA-promoting message was effective or ineffective in promoting PA behavior by means of post-message intentions. Two boundary conditions seem necessary: having low or moderate baseline intentions and low or moderate IASB. A PA-promoting message is not related to MVPA among individuals with high baseline intentions and/or high IASB. As discussed above, a PA message conveying information on the what, the why and the how is not effective among participants with high baseline PA intentions. On the other hand, high IASB seems to block any positive effects of post-message PA intentions on PA and thereby of the PA-promoting experimental manipulation for individuals with high IASB. Previous works (Berry, 2006; Calitri et al., 2009) showed that PA-promoting messages might be ineffective because preconscious processes such as attentional bias can lead individuals to not even pay attention to PA-related stimuli. Our results show that other automatic processes occurring later in the behavior execution process –impulsive approach tendencies towards sedentary behaviors – can also limit PA message effectiveness by competing with the reflective system.

These findings have implications for applied contexts as well as for future research. Interventions aiming to foster PA will have to target reflective and impulsive precursors of behavior such as approach-avoidance tendencies (Friese, Hofmann, & Wiers, 2011). For example, recent work in the domain of addiction shows that maladaptive approach-avoidance tendencies can be successfully retrained (e.g., Wiers, Erbel, Rinck, Becker, & Lindenmeyer, 2011). Other impulsive processes such as implicit attitudes are also known to influence health behaviors (Hofmann et al., 2008) and can be changed by evaluative conditioning procedures (see Sheeran et al., 2013, for a review of newly developed intervention techniques). Based on the present findings, these and other procedures could be aimed at either strengthening IAPA,
given that they appear to directly promote MVPA, or to reduce IASB, given that they blocked the effect of intentions to practice PA.

Several limitations to this study have been addressed. First, while this study did reveal an interesting process underlying message success, this effect was limited to a 7-day monitoring period. Longer monitoring periods would be valuable in future research. Second, baseline PA was not assessed. Consequently, the effects of intentions (and other variables) on PA could be spuriously high (Hagger, Chatzisarantis, & Biddle, 2002). However, given that this company-employee sample was inactive on the whole and that three PA correlates (sex, age and BMI) were controlled for in all the analyses, the risk of such attenuation effects from past behavior is limited. Third, the study did not feature a reflective counterpart for IASB such as reflective intention to engage in sedentary behavior. In the context of this study, such a measure would have been tarnished by social desirability bias. Thus, we cannot rule out that this reflective measure would have significantly interacted with intention or other variables. Fourth, given that participants read PA guidelines and provided several measurements (PA intention or weight) related to PA before the experimental manipulation, a pretest sensitization effect cannot be ruled out. Future studies should adopt a Solomon four-group design (e.g., Berry & Howe, 2005) to dismiss this possibility. A final potential limitation is that the use of MVPA as the dependent variable did not allow different types of PA behavior, such as incidental versus deliberative PA to be differentiated. Future research should test more accurately whether, as suggested by the RIM, the reflective processes only predict deliberative behavior while impulsive processes only predict incidental behaviors, and not vice versa, what Perugini et al. (2010) called a double dissociation pattern.

To conclude, the inclusion of impulsive precursors of behavior not only allowed for a better prediction of PA behavior in this study, but it also allowed light to be shed on the processes underlying the success or failure of PA-promoting messages. This study
demonstrated that impulsive processes play a direct (incremental) role, and also assume an interactive role with reflective processes in prospectively predicting PA, an important health behavior. A key finding of this study is that IASB, which has been overlooked so far, appears crucial to enable explicit intention to be translated into actual behavior. These basic findings about the psychological processes that underlie PA behavior provide a theoretically and empirically supported basis for elaborating dual-process models of motivation for PA behavior. Finally, a clear implication of the present findings is that changing PA is likely to be more effective if interventions are designed to directly target the impulsive system, and more precisely to reduce IASB and to increase IAPA. Such interventions based on dual-process models of PA behavior appear to hold great promise in improving public health promotion messages.
References


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Wiers, R. W., Eberl, C., Rinck, M., Becker, E., & Lindenmeyer, J. (2011). Retraining automatic action tendencies changes alcoholic patients’ approach bias for alcohol and improves treatment outcome. Psychological Science, 22, 490–497. doi:10.1177/0956797611400615

Footnotes

1. Models were also tested with the order of the blocks included in the regression equation. No significant effects were observed. Inclusion of this variable did not change any effects reported in the text.

2. Models were also tested with the mean RT and log RT and showed the same results.

3. We also tested if impulsive approaches tendencies toward SB and PA and their interaction with baseline intentions and with message condition predicted post-message intentions. No significant effects were observed. Inclusion of these variables did not change any of the effects reported in the text.

4. We are grateful to Kristopher J. Preacher for his advice on how to present the indirect effect changes across the ranges of the moderators.
Table 1. Characteristics across conditions, descriptive statistics and correlations between variables

<table>
<thead>
<tr>
<th>Predictors</th>
<th>AP Message (N=48)</th>
<th>Control (N=49)</th>
<th>Total (N=97)</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Messages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Baseline PA Intentions</td>
<td>3.95 (1.63)</td>
<td>3.60 (1.70)</td>
<td>3.77 (1.67)</td>
<td>.11</td>
</tr>
<tr>
<td>3. Post-message PA intentions</td>
<td>4.42 (1.41)</td>
<td>3.73 (1.75)</td>
<td>4.07 (1.62)</td>
<td>.21* .83**</td>
</tr>
<tr>
<td>4. IAPA</td>
<td>64.43 (134.56)</td>
<td>36.30 (171.34)</td>
<td>50.22 (154.09)</td>
<td>.09 .26** .17</td>
</tr>
<tr>
<td>5. IASB</td>
<td>-39.00 (169.89)</td>
<td>-89.94 (166.36)</td>
<td>-64.74 (169.19)</td>
<td>.15 -.20* -.16 -.22*</td>
</tr>
<tr>
<td>6. MVPA</td>
<td>47.54 (56.3)</td>
<td>58.69 (66.53)</td>
<td>53.17 (61.64)</td>
<td>-.09 .46** .36** .27** -.35**</td>
</tr>
<tr>
<td>7. BMI</td>
<td>24.20 (3.83)</td>
<td>23.83 (4.72)</td>
<td>24.01 (4.29)</td>
<td>.04 -.21* -.25* .01 -.07 -.16</td>
</tr>
<tr>
<td>8. Sex, women number (%)</td>
<td>27 (56.25)</td>
<td>24 (50)</td>
<td>51 (52.6)</td>
<td>-.07 .07 .04 .13 .19* .02 .27**</td>
</tr>
<tr>
<td>9. Age</td>
<td>39.10 (8.883)</td>
<td>37.51 (8.234)</td>
<td>38.30 (8.55)</td>
<td>.09 .03 .02 -.22* -.17 .28** .12 -.13</td>
</tr>
</tbody>
</table>

Note. 1 Control message = 0, PA message = 1; 2 Women = 0, Men = 1; PA = physical activity; IAPA= Impulsive approach tendency towards PA; IASB = Impulsive approach tendency towards sedentary behavior; MVPA = moderate to vigorous physical activity (in min/ week); 1 p<.10, * p<.05, ** p<.01
Table 2. Summary of hierarchical regression analyses for variable predicting post-message PA intentions (upper part) and objective MVPA (lower part).

### Dependent variable: Post-message PA intentions

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor</th>
<th>β</th>
<th>β</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sex†</td>
<td>0.003</td>
<td>0.16</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>0.001</td>
<td>-0.08</td>
<td>-0.10</td>
</tr>
<tr>
<td></td>
<td>BMI</td>
<td>-0.084</td>
<td>-0.096</td>
<td>-0.086</td>
</tr>
<tr>
<td></td>
<td>Baseline PA intentions</td>
<td>0.813***</td>
<td>0.795***</td>
<td>0.904***</td>
</tr>
<tr>
<td>2</td>
<td>Messages Condition†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline PA intentions × Messages Condition</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adjusted $R^2$ .684*** .699*** .709***

### Dependent variable: objective MVPA

<table>
<thead>
<tr>
<th>Step</th>
<th>Variables</th>
<th>β</th>
<th>β</th>
<th>β</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sex†</td>
<td>0.130</td>
<td>0.090</td>
<td>0.128</td>
<td>0.140</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>0.328***</td>
<td>0.307**</td>
<td>0.328**</td>
<td>0.246**</td>
</tr>
<tr>
<td></td>
<td>BMI</td>
<td>-0.232*</td>
<td>-0.198*</td>
<td>-0.195*</td>
<td>-0.176*</td>
</tr>
<tr>
<td></td>
<td>Post-message PA intentions</td>
<td>0.314**</td>
<td></td>
<td>0.219*</td>
<td>0.228**</td>
</tr>
<tr>
<td>2</td>
<td>IAPA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IASB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>IASB × Post-message PA intentions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>IASB × Post-message PA intentions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adjusted $R^2$ .105*** .189*** .311*** .382***

Note. †Women = 0, Men = 1; ‡Control message = 0, PA message = 1; PA = physical activity; IAPA = Impulsive approach tendency towards PA; IASB = Impulsive approach tendency towards sedentary behavior; MVPA = moderate to vigorous physical activity (in min/week); *p < .05, **p < .01, ***p < .001.
Figure 1. Interactions between PA message and baseline intentions on PA intentions (Figure 1a) and between Post-message intentions and IASB on MVPA (Figure 1b).

Figure 2. Conditional indirect effects of message manipulation on MVPA through intentions.
Figure 1a.

Figure 1b. Note. PA = Physical Activity, IASB = Impulsive approach tendency towards sedentary behavior; MVPA = moderate to vigorous physical activity (in min/week).
Note. \(^1\) Control message = 0, PA message = 1; \(^2\) Women = 0, Men = 1; PA = physical activity; IAPA = Impulsive approach tendency towards PA; IASB = Impulsive approach tendency towards sedentary behavior; MVPA = moderate to vigorous physical activity (in min/week).
Online supplementary materials

Pilot Study

A pilot study was carried out with the objective of identifying suitable PA and SB images to be included in the Manikin Task. Thirty-two participants with the same characteristics (i.e., adults working in administrative jobs such as financial services, human resources or administrative management) as those of the main study were asked to rate how much 24 images repressed movement and active lifestyle (1=not at all, 7=a lot) on one hand, and rest and sedentary lifestyle (1=not at all, 7=a lot) on the other hand. To minimize biases associated with images depicting real people, a designer drew pictograms to represent PA versus SB (see online supplementary materials Figure 1, for an example). The images had a size of approximately 200 × 250 pixels. For each image the “rest and sedentary lifestyle” score was subtracted to the “movement and active lifestyle” score. The sixteen images with the largest positive and negative difference were chosen as the PA and sedentary behaviors images, respectively. Statistical analyses confirmed that the eight PA images had a greater PA (M=5.97, SD=0.88) than a sedentary behavior (M=1.85, SD=0.69, t(31)=-15.33, p < .001) score, and that the eight SB images had a greater sedentary behavior (M=5.30, SD=1.02) than a PA (M=2.15, SD=0.89, t(31)=-10.23, p < .001) score, respectively.

Online supplementary Figure 1. Participant flow chart.

Online supplementary Figure 2. Images used in the manikin task.

Online supplementary Figure 3. Indirect effect of message condition on MVPA through intentions at three values (i.e., -1SD, mean, +1SD) of the two moderators.
Showed interest in participating (n=152)

Met criteria eligibility (n=101)

Randomized (n=101)

Allocated to physical activity message condition (n=51)

Returned material at one week (n=49)

Analysed (n=48)
  - Excluded from analysis (n=1)
    Accelerometer malfunction

Allocated to control message condition (n=50)

Returned material at one week (n=50)

Analysed (n=49)
  - Excluded from analysis (n=1)
    Accelerometer malfunction

Excluded (n=51)
  - Not meeting inclusion criteria (n=15)
    - Younger than 16 years old
    - Medication health reasons
  - Psychiatric disorders
  - Declined to participate (n=35)
Images associated with active behavior

Images associated with sedentary behavior
Note. PA = Physical Activity; IASB = Impulsive approach tendency towards sedentary behaviors. The conditional indirect effect of message condition on MVPA through post-message PA intentions is plotted at low, mean and high values of the moderators (i.e., baseline PA intentions and IASB) with a 95%-confidence band.