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**Not Just for Your Health Alone:
Regular Physical Activity and Decision Making in Unrelated Domains**

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Abstract

Do regularly physically active individuals differ in their decision making from people who are not regularly physically active? Across five studies, we document a novel benefit of being regularly physically active for decisions that require the appropriate weighing of goal-relevant versus goal-irrelevant information. Usually, when faced with a mix of relevant and irrelevant attribute information, decision makers find it difficult to ignore the irrelevant information, and as such, “dilute” their judgments (i.e., judgments become less extreme). Such a dilution effect has been amply documented in past research. In contrast, we find that people who engage in regular leisure physical activity are less susceptible to dilution effects. Beyond the dilution effect, we also find similar benefits of being regularly physically active for decisions involving desirability-feasibility trade-offs. The results hold across multiple replicates, diverse samples, and different measures of regular physical activity. We also rule out several potential alternative accounts (e.g., demographics, personality traits). The results cannot be explained by physical effort alone as these benefits are observed only for regular leisure physical activity and not for occupational physical activity.

Keywords: regular physical activity, irrelevant information, dilution effect, trade-offs

Public Significance Statement

This study proposes that individuals who engage in regular physical activity during their leisure time tend to differ in their decision making from less active individuals. The study suggests that regularly active individuals are better at focusing on goal-relevant information and ignoring goal-irrelevant information, thus showing less biased judgments.

Not Just for Your Health Alone:

Regular Physical Activity and Decision Making in Unrelated Domains

Do regularly physically active individuals differ in their decision making from people who are not regularly physically active? More specifically, is regular physical activity (RPA) linked to an individual's decision making quality in an unrelated domain (i.e., unrelated to exercising, sports, or, say, healthy eating)? Across several studies, we find that individuals who are regularly physically active for leisure show less biased decision making in unrelated contexts where it is important to appropriately distinguish between goal-relevant and goal-irrelevant information. Specifically, we find individuals who engage in RPA for leisure, to be less susceptible to the commonly observed dilution bias and feasibility neglect effects. We rule out several potential alternative accounts of the observed finding (e.g., demographics, personality traits, mood, self-control, regulatory focus, construal level, inhibitory mechanisms). The results cannot be explained by physical effort alone as these benefits are observed only for leisure RPA (i.e., exercise, sports, and physically active hobbies done in one's leisure time) and not for occupational physical activity (i.e., activity undertaken as part of one's employment).

Our Contribution Relative to Existing Research on RPA

Defining Regular Physical Activity

At the outset it is important to define physical activity and related terms more precisely. Physical activity is defined as any bodily movement produced by the contraction of skeletal

muscle that substantially increases energy expenditure. Physical exercise on the other hand is a sub-type of physical activity that involves planned, structured, and repetitive bodily movement with the motivation to maintain or improve one or more components of physical fitness.¹ Hence, physical exercise is included under the umbrella term of physical activity which we are investigating. To achieve substantial health benefits, the World Health Organization (WHO, 2020) recommends that adults undertake physical activity that is *regular*: throughout the week, at least 150–300 minutes of moderate-intensity aerobic physical activity; or at least 75–150 minutes of vigorous-intensity aerobic physical activity; or an equivalent combination of moderate- and vigorous-intensity activity.

Previously Documented Benefits of RPA

There is a long-standing body of research that attests to the *physiological health benefits* of RPA. From the pioneering research by Morris and Raffle (1954) that compared London double-decker bus conductors to the more sedentary bus drivers, to the more recent large scale studies like the one conducted by Moore et al. (2016) involving 1.44 million adults, RPA has been associated with a significantly lower risk of all-cause mortality, cardiovascular disease, type-2 diabetes, obesity, hypertension, and thirteen different cancers. Warburton and Bredin (2017) provide a recent systematic review of this literature; however, our focus on decision making is different from this extant physiological-benefits literature.

¹The National Center for Health Statistics provides more information about different terminologies: https://www.cdc.gov/nchs/nhis/physical_activity/pa_glossary.htm

More recently, evidence regarding the *affective, cognitive, and neurological* benefits of physical activity has emerged. Physical activity has been shown to lead to improvements in executive control and math achievement (Davis et al., 2011), cognitive flexibility (Masley, Roetzheim, & Gualtieri, 2009), as well as working memory (Hillman, Erickson, & Kramer, 2008; Northey, Cherbuin, Pumpa, Smee, & Rattray, 2017). Such improved cognitive functions were found in both children (Best, 2010; Kamijo et al., 2011) and older adults (Ahlskog, Geda, Graff-Radford, & Petersen, 2011). An extensive and in-depth summary of exercise-cognition interactions among all types of population groups (children, young adults, elderly, children with ADHD and/or diabetes, gender, etc.) is provided by McMorris (2016).

These cognitive benefits of RPA occur due to a range of multifaceted neurological adaptations, including changes to cerebral structure (i.e., gains in grey and white matter) and cerebral functions (i.e., functional connectivity, event-related potential) as well as changes in neurotrophic factors, most prominently an increase in brain-derived neurotrophic factor (BDNF) (Etnier, Shih, & Piepmeier, 2016). BDNF has been linked to increased neuronal outgrowth, improved synaptic functions and survival of neurons. It has been described as one of the most fundamental neuronal factors for learning, memory and cognition (Hillman, 2008).

In contrast, acute (rather than chronic/regular) physical activity appears to facilitate mostly the speed of performance in cognitive tasks, but not the accuracy (McMorris, Turner, Hale, & Sproule, 2016). According to the Reticular-Activating Hypofrontality (RAH) model (Dietrich, 2011), acute physical activity activates various arousal systems in the brain via noradrenergic and dopaminergic pathways, thus leading to a facilitative effect on sensory processing and speed of performance. The model further argues that during vigorous exercise,

prefrontal brain areas are deactivated, leading to detrimental effects on tasks tapping executive and explicit processes. Thus, it is important to distinguish between acute and regular physical activity since their effects on cognitive task performance can differ. The primary focus of our research is on RPA (although we return to acute exercise in study 3).

In terms of affective benefits, RPA has been linked to higher self-esteem and positive affect, and a lowering of anxiety, depression, negative affect, and rumination (Bauman et al., 2012; Dietrich & Audiffren, 2011; Hopkins, Davis, Vantieghem, Whalen, & Bucci, 2012; Lathia, Sandstrom, Mascolo, & Rentfrow, 2017). Please see Chan et al. (2019) for a systematic review of RPA and mood-related outcomes.

What Research Gap in RPA Knowledge Do We Propose to Address?

Despite this large body of work, the literature is less clear on the question of whether and how individuals who engage in RPA might differ in their general decision making (i.e., unrelated to exercise, sports, or health). There are two distinct sets of reasons for this.

First, most of these cognitive, affective, and neuro-cognitive benefit studies simply do not observe decision making outcomes. The studies that do investigate decision making do so in highly related domains, like sports-related choices and judgments (e.g., McMorris & Graydon, 1997; Raab & Johnson, 2007) and food and diet choices (Fenzl, Bartsch, & Koenigstorfer, 2014; Werle, Wansink, & Payne, 2015). However, it is not altogether surprising that RPA is associated with, say, dietary choices, because exercising and eating are both highly related to the overall goal of being healthy. Thus, previous research has not examined the relationship between RPA and decision making in *unrelated* domains, such as consumer product judgments.

Second, and more importantly, decision processes like the weighing and integration of different information to arrive at an overall judgment or decision in an unrelated domain, have largely not been examined so far. For example, some of the most commonly used cognitive and affective assessments in RPA research involve measures of inhibition via the flanker task or its variants (Berchicci et al., 2015; Chaddock et al., 2010; Chaddock-Heyman et al., 2013; Chang, Tsai, Chen, & Hung, 2013; Hillman, Buck, Themanson, Pontifex, & Castelli, 2009; Hillman et al., 2014; Kamijo et al., 2011; Krafft et al., 2014; Pontifex et al., 2011; Stroth et al., 2009), measures of working memory (Herting & Nagel, 2012; Lee et al., 2014), or measures of affect and positive mood (Chan et al., 2019; Hansen, Stevens, & Richard Coast, 2001; Hopkins, 2012).

While RPA confers affective, cognitive, and neurological benefits, it is unclear whether these will necessarily translate into better decision making. For example, greater positive affect has been shown to be detrimental in analytical tasks (e.g., Isen & Daubman, 1984). Similarly, superior memory and schema have been shown to exacerbate false-recall effects, leading to poorer decision quality (Mehta, Hoegg, & Chakravarti, 2011). Thus, the previously documented benefits of RPA do not tell us whether such individuals would necessarily make better decisions in contexts where it is important to appropriately distinguish between relevant and irrelevant information and form an overall judgment. Indeed, McMorris (2016, p. 466) noted in his summary of research on exercise-cognition interactions that more studies “on the more complex central executive tasks, e.g., planning, problem solving, and *decision making*” are needed. We address this gap by looking at how RPA is linked to decision making in unrelated domains.

RPA and the Dilution Effect

To investigate RPA and decision making, we chose to look at domains where individuals are faced with options described on a mix of relevant and irrelevant attributes. Past research shows that individuals do not ignore the irrelevant information but instead, take it into account when forming judgments. As such, their judgments become “diluted” by the irrelevant information (Nisbett, Zukier, & Lemley, 1981). The dilution effect can be described as follows: When adding non-diagnostic or irrelevant evidence to already existing positive evidence, it weakens people’s overall belief about a hypothesis (Hotelling, Cohen, Shiffrin, & Busemeyer, 2015; Meyvis & Janiszewski, 2002).

As an example, imagine, you have forgotten that today is Mother’s Day. You are looking for a delivery service that can send flowers quickly. You find a company that guarantees a same day delivery. Now, imagine that the company also provides additional information: they sponsor art events, have headquarters in Chicago, and were founded in 1972. Would this additional information influence your judgment of how *fast* the service is?

Normatively, irrelevant information should not influence judgments because it is not diagnostic of the desired outcome. However, research has shown that people do consider irrelevant information and dilute their judgments, that is, their judgments become less extreme.² Since the original demonstration by Nisbett et al. (1981) in a person perception context, the dilution effect has been replicated in a wide variety of domains like consumer judgments (Simonson, Nowlis, & Simonson, 1993), fraud risk (Hoffman & Patton, 1997), negotiations

² If the relevant information is of positive valence, the diluted judgments become less positive. If the relevant information is of negative valence, the diluted judgments become less negative.

(Wiltermuth, 2011), law (Smith, Stasson, & Hawkes, 1998), and climate change (DeVries, Terwel, & Ellemers, 2014). Dilution effects tend to be more pronounced for linguistic information when people integrate information in a controlled fashion rather than when automatically processing perceptual information (Hotaling et al., 2015), and when people are being held accountable for their judgments (Tetlock & Boettger, 1989).

Our research investigates whether an important lifestyle variable—engaging in RPA—as an individual-level difference factor, is linked to a reduction of the dilution effect. In the next section, we offer some preliminary hypotheses as to why this might be the case.

Why Should Regularly Physically Active Individuals Be Less Susceptible to the Dilution Effect?

We propose that the very nature of RPA reinforces selective attention and inhibition in the individual by training their general ability to both focus on what is important or relevant to achieve a goal, and ignore the goal-unimportant, distracting information. This reinforcement comes about through two effects that are inherent to RPA.

Planning-Induced Cognitive Effects. First, consider, at a cognitive level, what it takes to become regularly physically active. While intentions to engage in RPA might be widely prevalent, there is a significant gap between such intentions and actual behavior. To be truly “regularly” physically active, one needs to be a good planner (Barz et al., 2014; Pfeffer & Strobach, 2021). You repeatedly have to engage in planning, action control, and goal shielding (Sniehotta, Scholz, & Schwarzer, 2005), which includes inhibiting distractors and concentrating on goal-relevant aspects. Overall, such planning-related cognitions involve action plans and

copied plans (Pfeffer & Strobach, 2021). Action plans are task-facilitating cognitions that help to enact a specific behavior (e.g., making entries in one's calendar for jogging during the upcoming weekend mornings). In contrast, coping plans are distraction-inhibiting cognitions that help the pursuit of a goal intention if obstacles arise (e.g., setting up a reminder to not party late on a Friday night and to go home by 9:00pm). Thus, over time, with the repeated setting up and execution of action plans and coping plans, individuals who engage in RPA enhance their ability to focus on the goal-relevant and ignore the goal-irrelevant.

Embodied Cognition Effects. Second, consider what goes on during physical activity itself, that is, the cognitions that are embodied in the very act of a physical activity (e.g., regular 20-minute runs). During physical activity, one has to integrate complex information (Raichlen et al., 2016) from internal sources (e.g., feelings of exertion, pain, and other biofeedback) and external sources (e.g., a sudden obstacle, other runners), of which some have to be ignored (e.g., feelings of exertion), some anticipated (e.g., an obstacle), while others have to be attended to (e.g., the target distance, time, or calories). As Raichlen et al. (2016) point out, even the simple act of running, which is considered an automated repetitive task, engages multiple cognitive actions including planning, inhibition, monitoring, attentional switching and multi-tasking, in combination with motor control. Thus, beyond the cognitive effects of planning out one's RPA, cognitions related to attending to goal-relevant information and ignoring goal-distracting information, are embodied in the very act of executing a physical activity.

Cognitions, when grounded in a physical activity, often get internalized and ingrained in the individual much better than when such target cognitions are not physically embodied. For example, in a study on embodied cognition (Kontra, Lyons, Fischer, & Beilock, 2015), students

who physically participated in an experiment on the mechanics of movement forces, demonstrated greater activation of sensorimotor regions during learning and during recall, and achieved notably better results than sedentary peers in a test on the subject matter. Sensorimotor circuits are adding kinetic detail and meaning to cognitions (Barsalou, 2008; Beilock, Lyons, Mattarella-Micke, Nusbaum, & Small, 2008; Glenberg, 1997). Indeed, such cognitions have been shown to become embodied in the motor experience itself without conscious deliberation (Gigerenzer, 2007; Raab, 2020). For example, similar research on embodied cognition (Raab, 2020) shows that engaging motor control in a climbing task can unconsciously facilitate cognitive planning processes and lead to better choices in a subsequent, unrelated planning task.

Relatedly, other studies show that combining cognitive training elements with physical activity leads to superior outcomes (e.g., language acquisition, spatial ability, working memory capacity) (Heisz et al., 2017; Liu, Sulpizio, Kornpetpanee, & Job, 2017; Moreau, Morrison, & Conway, 2015). Findings from the sports decision making literature also concur with the idea that embodied cognitions can have a significant impact on the individual's cognitive apparatus. For example, Hüttermann et al. (2014) find that expert athletes' attentional spotlight is malleable and matches the attentional demands of the sport they are playing. They find that expert athletes had greater attention breadth (around 25%) than novices, and a spatial attention distribution (horizontal vs. vertical) that matched the primary attentional demands of their particular sport (e.g., soccer vs. volleyball).

In a similar vein, we believe that cognitions grounded in the very act of RPA itself – that is, focusing on goal-relevant and ignoring goal-distracting (or deemphasizing goal-irrelevant) information – will get repeatedly trained and spill over to unrelated decision tasks. Over time,

this is ingrained in individuals' mindsets and can, as the literatures on transfer effects (e.g., Barnett & Ceci, 2002; Green & Bavelier, 2003; Jaeggi, Buschkuhl, Jonides, & Perrig, 2008; Klingberg, 2010) suggest, carry over to unrelated tasks—as long as the task structure requires focusing on goal-relevant and ignoring goal-distracting information. Note that RPA should not accord any benefits in decision tasks that do not involve the integration of relevant and irrelevant information. Based on this reasoning, we expect that regularly physically active individuals are less susceptible to the dilution effect because of their ability to focus on goal-relevant information and ignore goal-irrelevant, distracting information (i.e., their judgments are *not* lowered when seeing irrelevant in addition to positive, diagnostic information).

Leisure Versus Occupational Physical Activity

We distinguish between two motivations for RPA: Leisure RPA includes exercise, sports, and physically active hobbies done in one's leisure time as a recreational activity (e.g., brisk walking, dancing, or swimming). Occupational RPA includes activities undertaken as part of one's employment or unpaid work (e.g., laboring, household chores). We expect only *leisure* RPA (but not occupational RPA) to confer decision making benefits. Our distinction between leisure vs. occupational RPA is consistent with findings from a nascent but mounting body of evidence which shows that the context and motivation of physical activity matter for health outcomes (Coenen et al., 2018; Crum & Langer, 2007; Holtermann, Hansen, Burr, Sjøgaard, & Sjøgaard, 2012) as well as neurocognitive outcomes (Burzynska et al., 2020; Rovio et al., 2007). In brief, occupational physical activity does not confer the same benefits as leisure physical activity. For example, investigating hippocampal volume and memory, Burzynska et al. (2020)

found that, independent of socioeconomic factors, occupational physical demands were negatively correlated, while leisure physical activity was positively correlated with hippocampal volume. They summarize that "... physical demands at work and leisure physical activity may have largely independent and opposite effects on brain and cognitive health."

So why might leisure RPA be more beneficial than occupational activity? While the reasons for the differential effects of leisure versus occupational physical activity are likely manifold, we suggest the following. As we hypothesized earlier, the facilitative effects of RPA come from two sources: planning-induced cognitive effects and the effects of embodied cognition. Both are likely to be much weaker for occupational (vs. leisure) RPA. For most workers (e.g., factory workers, foremen, construction workers), the details of their physical activity are predetermined, like the venue (e.g., the factory), time slots (e.g., 9:00am-5:00pm), frequency (e.g., 5 days a week, Monday-Friday), task priority (e.g., what to do first), and even intensity (e.g., how many boxes to be moved). Workers have limited ability, if at all, to engage in extensive planning related cognitions, including setting up and executing action plans. For the most part the employers set these up for them. Furthermore, given that the average worker signs up for an uninterrupted, eight-hour work shift, 9:00am-5:00pm, that does not conflict with any other activities, there is not much opportunity to engage in goal shielding (e.g., via coping plans). Thus, occupational physical activity is typically performed with low worker control and agency over the environment, schedule, work task and speed (Holtermann, Krause, van der Beek, & Straker, 2018). As low personal agency reduces self-determination and thus intrinsic motivation to perform the physical activity, any positive affective, cognitive, and behavioral outcomes are not only likely to be less pronounced (Vallerand, 2007), but can also get entirely 'crowded out'

(Mellström & Johannesson, 2008; Ruff, Ugazio, & Fehr, 2013; Sapolsky, 2014).

Additionally, the scope for embodied cognition benefits is also likely to be less at the workplace. According to Holtermann et al. (2018), occupational physical activity is often of low intensity and is composed of static and constrained postures and activities that are performed for a long duration and without sufficient recovery time which can lead to negative physiological responses. More importantly, the motor experiences involved in occupational RPA are unlikely to consistently involve both a focus on the goal-relevant and an inhibition of the goal-irrelevant like we outlined earlier. Thus, while modern workplaces have evolved to afford more discretion to their workers, overall, occupational RPA is unlikely to confer the same planning-induced cognitive benefits and embodied cognition benefits that occur for leisure RPA.

Caveat on Individual-Level Covariates

Of course, it is entirely plausible that leisure RPA individuals have several other individual-level correlates that distinguish them from their more sedentary or occupational RPA counterparts. Indeed, past research shows that leisure RPA individuals are more likely to be male, younger, of a higher socioeconomic status (e.g., income and educational level; Bauman et al., 2012), exhibit high extraversion and conscientiousness and low neuroticism personality traits (Rhodes & Smith, 2006), and enjoy higher self-efficacy and self-motivation (Bauman et al., 2012). Our strategy for addressing these potential individual-level confounds is an empirical one—in all our studies we examine a whole range of alternative explanations by measuring variables that are either related to RPA (see table 1 for an overview) or that may influence responses in the decision making tasks.

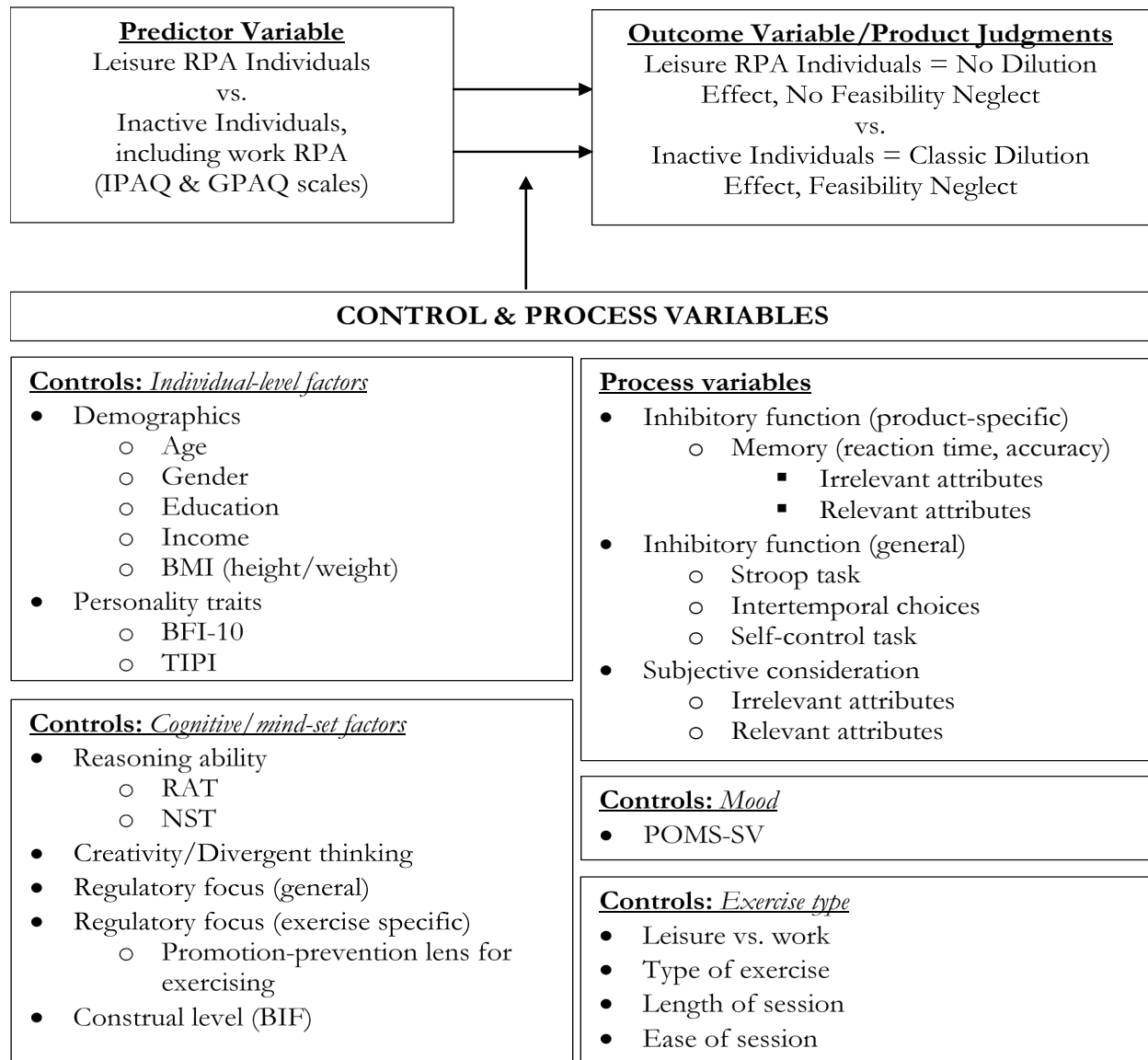
Table 1*Correlates of Regular Physical Activity*

Factors associated with RPA	Relationship	Source	Measured in
<i>Demographics</i>		Bauman et al. (2002, 2012)	
• Age	Inverse correlate		Study 1 - 5
• Gender: Male	Correlate		Study 1 - 5
• Education level	Correlate		Study 1 - 3, 5
• Income and socioeconomic status	Correlate		Study 1, 2, 5
<i>Personality traits</i>		Rhodes & Smith (2006)	Study 1, 2, 5
• Extraversion	Correlate ($r = 0.23$)		
• Agreeableness	No correlate		
• Openness	No correlate		
• Conscientiousness	Correlate ($r = 0.23$)		
• Neuroticism	Inverse correlate ($r = -0.11$)		
Mood	Correlate ($r = 0.03 - 0.08$)	Lathia et al. (2017), Chan et al. (2018)	Study 1, 4
Regulatory focus: Promotion orientation	Correlate ($r = 0.21$)	Joireman et al. (2012)	Study 3, 4

Taken together, we measured demographics (including age, gender, educational and income level), personality, reasoning ability, mood, divergent thinking skills, inhibitory skills and self-control, regulatory focus as well as construal level. While we did not obtain specific measures of IQ, a combination of educational level along with measures of critical thinking (e.g., reasoning ability, divergent thinking), can act as a proxy of intelligence. Thus, informed by past research, we deployed extensive individual-level, mind-set, and situational measures to examine alternative accounts of the data. Figure 1 provides an overview of these measures across all studies.

Figure 1

Summary of Key Findings, Controls and Process Measures in Studies 1 to 5



Overview of Studies

We present five studies, four of which examine the key hypothesis using well-tested stimuli from past dilution effect studies (Meyvis & Janiszewski, 2002), and one which examines the desirability-feasibility paradigm (Lieberman & Trope, 1998). Studies 1 and 2 investigate the effect of irrelevant information on product judgments among RPA individuals versus less active individuals, explore alternative explanations, and provide suggestive evidence on the process mechanism. Specifically, study 2 tests the hypothesis that individuals who engage in RPA are less susceptible to the dilution effect because of improved inhibitory control (Barenberg, Berse, & Dutke, 2011). Studies 3 and 4 which were conducted with gym members and seasoned runners, test the robustness, and explore other alternative accounts. Finally, study 5 shows that findings extend beyond the dilution effect.

Study 1: RPA and Susceptibility to the Dilution Effect

Methodology

Study 1 investigated whether those who engage in leisure RPA show a reduced dilution effect when compared to less active individuals or those who are occupationally active. Participants were recruited via Amazon Mechanical Turk (MTurk) for a \$2 payment. Based on previous studies investigating the same outcome variable in the dilution paradigm and a design with two experimental conditions (Meyvis & Janiszewski, 2002), we aimed to recruit 300 participants. Participants completed an adapted version of Meyvis and Janiszewski's (2002) test

of the dilution effect which manipulates the presence of irrelevant information experimentally in a between-subjects design. A 2 (type of information: control condition vs. dilution condition) x 7 (product replicate: toothpaste, computer, delivery, apartment, car, airline, stereo) mixed design was used with type of information as the between-subjects factor. Self-reported RPA was crossed with this design. We describe the dilution task in more detail next. Please note that all measures and data are available at OSF³.

Dependent variable—product judgments: After providing informed consent, participants were instructed that they would receive information about seven products or services. Their task was to indicate whether the product/service delivered a particular benefit. Participants were presented sequentially with the description of seven products/services in random order. For each replicate, participants were first given the desirable benefit (“You are looking for a safe apartment”) and then received the attribute information. In the control condition, participants received one piece of supportive and diagnostic information (“24-hour on-site security”). In the dilution condition, this was followed sequentially by three pieces of irrelevant information (“complex name: Haywood park”) which had been pretested extensively in the original paper. For each replicate, participants rated to what extent it would deliver the desirable benefit while the product information remained visible (e.g., 0 = definitely not safe, 100 = definitely safe).

Independent variable—RPA: To identify RPA individuals, a well-established scale—the Global Physical Activity Questionnaire (GPAQ; Bull, 2009) developed by the WHO was used.⁴ The GPAQ provides reproducible data and shows moderate to strong positive correlations with

³ https://osf.io/q79yr/?view_only=c22388f9a87244c5ae4f79280b2cd083

⁴ URL for materials: <https://www.who.int/ncds/surveillance/steps/GPAQ/en/>

other measures of physical activity (Bull, 2009). A detailed explanation of vigorous and moderate physical activity during work and for leisure was provided combined with examples and images to help participants assess their personal amount of physical activity reliably. Participants indicated the number of days in a typical week they were physically active as well as the duration of moderate and vigorous physical activity for work and leisure.

Based on the WHO guidelines, a participant was categorized as regularly physically active during leisure if they engaged in vigorous physical activity on three or more days for at least 20 minutes; or five or more days of moderate physical activity for at least 30 minutes; or five or more days of any combination of moderate or vigorous activity achieving at least 600 metabolic equivalent (MET) minutes per week.⁵ If a person engaged in less leisure physical activity than that, they were categorized as *not* regularly physically active during leisure. This classification takes into account the *frequency*, *intensity*, and *duration* of the physical activity. Additional analysis using a continuous variable (i.e., average physical activity minutes per day) and propensity score matching yielded similar results.

Controls for alternative accounts: We measured several control variables as they might attenuate the dilution effect rather than leisure RPA. For example, a superior reasoning ability, a high-conscientiousness personality, a positive mood, or better education—as opposed to RPA—might enable individuals to not dilute their judgments and make better decisions.

We elicited reasoning ability with the Remote Associates Task (RAT; Mednick, 1968)

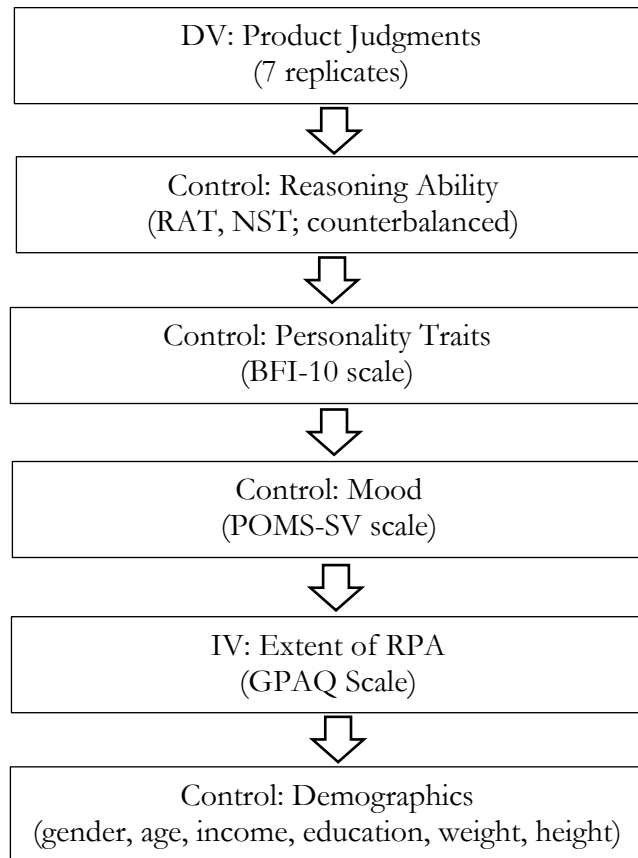
⁵ The MET is a unit used to estimate the amount of oxygen used by the body during physical activity. The harder the body works, the higher the MET. 1 MET = the energy (oxygen) used while sitting quietly. Any activity that burns 3 to 5.9 METs is considered moderate-intensity physical activity. Any activity that burns 6.0 METs or more is considered vigorous-intensity physical activity.

and the Nonsense Syllogism Task (NST; Ekstrom, French, Harman, & Dermen, 1976). For each of the 15 RAT items, participants were shown three words. The task was to identify a new word associated with all three words (e.g., *elephant–lapse–vivid*, *solution: memory*). Participants' RAT score was the number of correct answers. For the NST, participants saw several syllogisms each consisting of two premises and one conclusion (“*All alligators are art collectors. Some art collectors live in caves. Therefore some alligators live in caves*”). Participants had to assume that the first two statements were true and indicate whether the conclusion drawn showed good or poor reasoning. Participants' NST score was the number of correct answers.

Next, participants completed a personality test—the Big Five Inventory-10 (BFI-10; Rammstedt & John, 2007). Specifically, they completed a ten-item scale which measures individual differences in extraversion, agreeableness, conscientiousness, neuroticism, and openness on a Likert scale from 1 = disagree strongly, to 5 = agree strongly.

To measure mood, participants completed the shortened version of the Profile of Mood States (POMS-SV; Shacham, 1983) which consists of 37 mood adjectives. Participants indicated how they had been feeling during the past week on a Likert scale from 0 = not at all to 4 = extremely. The POMS-SV consists of six subscales: tension-anxiety, depression-dejection, anger-hostility, fatigue-inertia, vigor-activity, and confusion-bewilderment. A total mood disturbance score was also calculated by subtracting the vigor-activity score from the sum of the other subscales.

Finally, participants answered questions regarding demographics (gender, age, income, education), and BMI (weight, height). Figure 2 describes the order of the measures.

Figure 2*Key Measures Elicited in Study 1***Results and Discussion**

Participants: Three hundred and one individuals were recruited via MTurk. Nineteen individuals either failed an attention filter or were excluded as they provide unreasonable physical activity responses in the GPAQ. The final sample comprised 281 participants (see table 2 for demographics).

Table 2*Sample Demographics for Studies 1-5*

	Study 1	Study 2	Study 3	Study 4	Study 5
Recruitment	MTurk	MTurk	UK Gym	Parkrun UK	MTurk
Sample size	281	289	120	268	257
Female	44%	52%	61%	49%	47%
Age	<i>Mdn</i> = 35-44 years	<i>M</i> = 36 (<i>SD</i> = 1.26)	<i>M</i> = 38 (<i>SD</i> = 14.83)	<i>Mdn</i> = 45-49 years	<i>M</i> = 34 (<i>SD</i> = 11.61)
Annual salary	<i>Mdn</i> = \$25,001- \$50,000	<i>Mdn</i> = \$25,001- \$50,000	-	-	<i>Mdn</i> = \$25,001- \$50,000
Highest education	<i>Mdn</i> = 2- year college degree	<i>Mdn</i> = 2- year college degree	<i>Mdn</i> = undergraduate degree	-	<i>Mdn</i> = college degree
Leisure RPA	40%	34%	49%	-	36%
5 kilometer run time	-	-	-	<i>M</i> = 29 min (<i>SD</i> = 5.01)	
Number of runs	-	-	-	<i>M</i> = 73 (<i>SD</i> = 69.5)	

Independent variable—RPA: The physical activity responses were processed according to the GPAQ guidelines for data processing and analysis.⁶ Based on the WHO guidelines, a person was classified to be regularly physically active during leisure if they met the criteria outlined previously. For a person to be classified as regularly physically active at work, the same criteria were applied but in the domain of occupational physical activity. Table 3 shows the classification into the physical activity categories. Leisure RPA ($n = 113$) constituted our primary

⁶ Only responses which were greater or equal to ten minutes of physical activity were included. Physical activity data, which exceeded four hours per day per category was truncated to equal 240 minutes.

independent variable. Overall, 41% of participants were classified as being inactive ($n = 115$); that is, they did not perform RPA for leisure or work. Note that inactive individuals might still engage in some level of physical activity—but not enough to meet the requirements for RPA.

Table 3

RPA Groups for Work and Leisure in Study 1

		Leisure RPA		
		No	Yes	Total
Occupational RPA	No	115	80	195
	Yes	53	33	86
	Total	168	113	281

Dependent variable—product judgments: We first checked whether there was a higher-order interaction between the within-subject product replicate factor and the type of information. All interactions with the product replicate factor were non-significant in this and the following studies. Thus, for brevity we will not discuss them further. We collapsed the product judgments across the product replicate factor. The resulting average product judgement across all replicates constituted our key dependent variable.

We then compared participants' product judgment in the control and dilution condition. Participants who received only relevant information reported more extreme (i.e., positive) judgments than those who also received irrelevant information ($M_{\text{Control}} = 74.55$, $M_{\text{Dilution}} = 70.81$; $t(279) = 2.81$, $p = .005$, $d = 0.33$). Adding irrelevant information weakened participants' beliefs in the product's benefit, thus demonstrating the classic dilution effect.

Next, we tested our key proposition. We submitted the product rating to a 2 (type of

information: control, dilution) x 2 (leisure RPA: yes, no) x 2 (occupational RPA: yes, no) between-subjects ANOVA. As hypothesized, all interactions and main effects involving occupational RPA were non-significant (three-way interaction: $p = .817$, two-way interaction with type of information: $p = .965$, two-way interaction with leisure RPA: $p = .919$, main effect: $p = .114$). Hence, we are not reporting any follow-up analysis for occupational RPA.

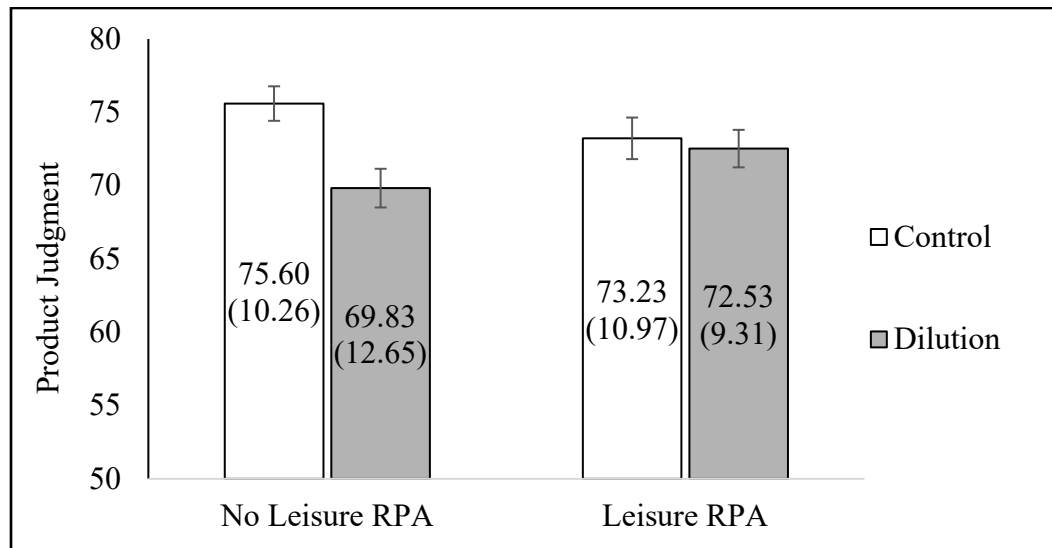
There was a marginally significant interaction effect between leisure RPA and the type of information ($F(1, 273) = 3.63, p = .057, \eta^2 = 0.013$). Post-hoc comparisons of the leisure RPA factor across the dilution condition showed the following. We controlled for multiple comparisons using the Bonferroni alpha-level correction. Participants who did not engage in leisure RPA significantly diluted their judgments when seeing irrelevant information ($p = .007$) while leisure RPA individuals did not show a dilution effect ($p = .999$, see figure 3 and table 5 for means and standard deviations). No other contrasts were significant.

Finally, the ANOVA showed no main effect of leisure RPA ($p = 0.913$), and the dilution condition (type of information) had a significant main effect on judgments ($p = .029, \eta^2 = 0.017$).

Controls as alternative accounts: None of the controls—reasoning ability, personality traits, mood, and demographics—affected the key pattern when using ANCOVA analysis. More specifically, either the controls were not significantly different for leisure RPA individuals, or the controls were significant but left the key interaction unaltered. We describe the results in more detail next. Please see the supplemental online material (SOM) for more information about descriptive and test-statistics for all studies.

Figure 3

Effect of Irrelevant Information on Judgments for Leisure RPA versus Other Individuals



Reasoning ability: Leisure RPA participants did not have different scores in the NST ($p = .311$) and the RAT ($p = .285$) than other participants. Neither were the reasoning scores associated with the product judgments, nor did they impact the interaction effect between the type of information and leisure RPA.

Personality traits: Leisure RPA individuals reported higher levels of extraversion ($M_{\text{No_RPA}} = 4.06$, $M_{\text{RPA}} = 5.84$; $t(279) = 3.55$, $p < .001$, $d = 0.43$), conscientiousness ($M_{\text{No_RPA}} = 7.55$, $M_{\text{RPA}} = 8.07$; $t(279) = 2.59$, $p < .010$, $d = 0.31$) and lower levels of neuroticism ($M_{\text{No_RPA}} = 5.39$, $M_{\text{RPA}} = 4.47$; $t(279) = 3.65$, $p < .001$, $d = 0.44$) than other participants. There was also a marginally significant difference for openness, with leisure RPA participants scoring higher than the less active ($p = .076$, $d = .21$). There was no difference for agreeableness ($p = .167$, $d = 0.16$). Thus, extraversion, conscientiousness and neuroticism were added as covariates to the ANCOVA model. Extraversion and neuroticism did not impact the product judgments.

Conscientiousness was positively associated with the product judgments ($\beta = 1.06$, $SE = .44$, $t = 2.43$, $p = .016$, $\eta^2 = 0.02$). However, the interaction effect between the type of information and leisure RPA remained marginally significant after controlling for these personality traits ($p = .063$, $\eta^2 = 0.012$).

Mood: Leisure RPA participants reported higher scores on the vigor-activity subscale ($M_{No_RPA} = 1.43$, $M_{RPA} = 1.96$; $t(279) = 4.51$, $p < .001$, $d = 0.54$) and a marginally lower total mood disturbance score ($M_{No_RPA} = 2.32$, $M_{RPA} = 1.50$; $t(279) = 1.88$, $p = .092$, $d = 0.20$). Neither variable was associated with the product judgments, nor did they impact the interaction effect between the type of information and leisure RPA, which was significant ($p = .045$, $\eta^2 = 0.014$).

Demographics: There were no gender and age differences ($p = .832$ and $p = .478$, respectively). However, leisure RPA participants reported higher income ($p < .001$, $d = 0.39$) and educational level ($p = .008$, $d = 0.32$). Neither education nor income was associated with the product judgments ($p = .773$ and $p = .834$, respectively). Importantly, the marginally significant interaction between the type of information and leisure RPA persisted after adding income and education ($p = .055$, $\eta^2 = 0.013$ and $p = .061$, $\eta^2 = 0.012$, respectively) as control variables.

Further, a propensity-score matching analysis in studies 1-3 to estimate the treatment effect from the observational leisure RPA data (vs. controlling for the covariates via ANCOVA), did not change the key patterns of results.

Study 1 shows that individuals who engage in leisure RPA exhibited no dilution effect. This finding persisted controlling for a variety of factors that are typically associated with leisure RPA like demographics (education, salary), mood, and personality traits (Bauman et al., 2012; Lathia et al., 2017; Rhodes & Smith, 2006). In line with our reasoning, we did not find the same

result for individuals active at work.

Study 2: Direct Replication and Test of Other Alternative Accounts

Methodology

Study 2 is highly similar to study 1 barring some key differences discussed next. First, we manipulated the order of the dependent measure (dilution task first vs. last; see figure 4) to reduce demand effects, fatigue, and hypothesis guessing. Second, we used a different measure of RPA (i.e., the IPAQ vs. GPAQ scale) to increase generalizability. The IPAQ is a highly accepted self-report measure of physical activity with reasonable measurement properties in diverse settings (Craig et al., 2003). Third, as additional controls, we included a different personality trait measure (i.e., Big-5 TIPI; Gosling, Rentfrow, & Swann, 2003) to increase concurrent validity, as well as a measure of divergent thinking—the Unusual Uses test (Guilford, 1967). The reason to include the latter was based on Oppezzo and Schwartz’s (2014) finding that physical activity can improve divergent/creative thinking. Creativity may allow individuals to construe alternative meanings of irrelevant information and therefore not dilute judgments. Participants were asked to generate as many creative uses as possible for a ping pong ball within two minutes.

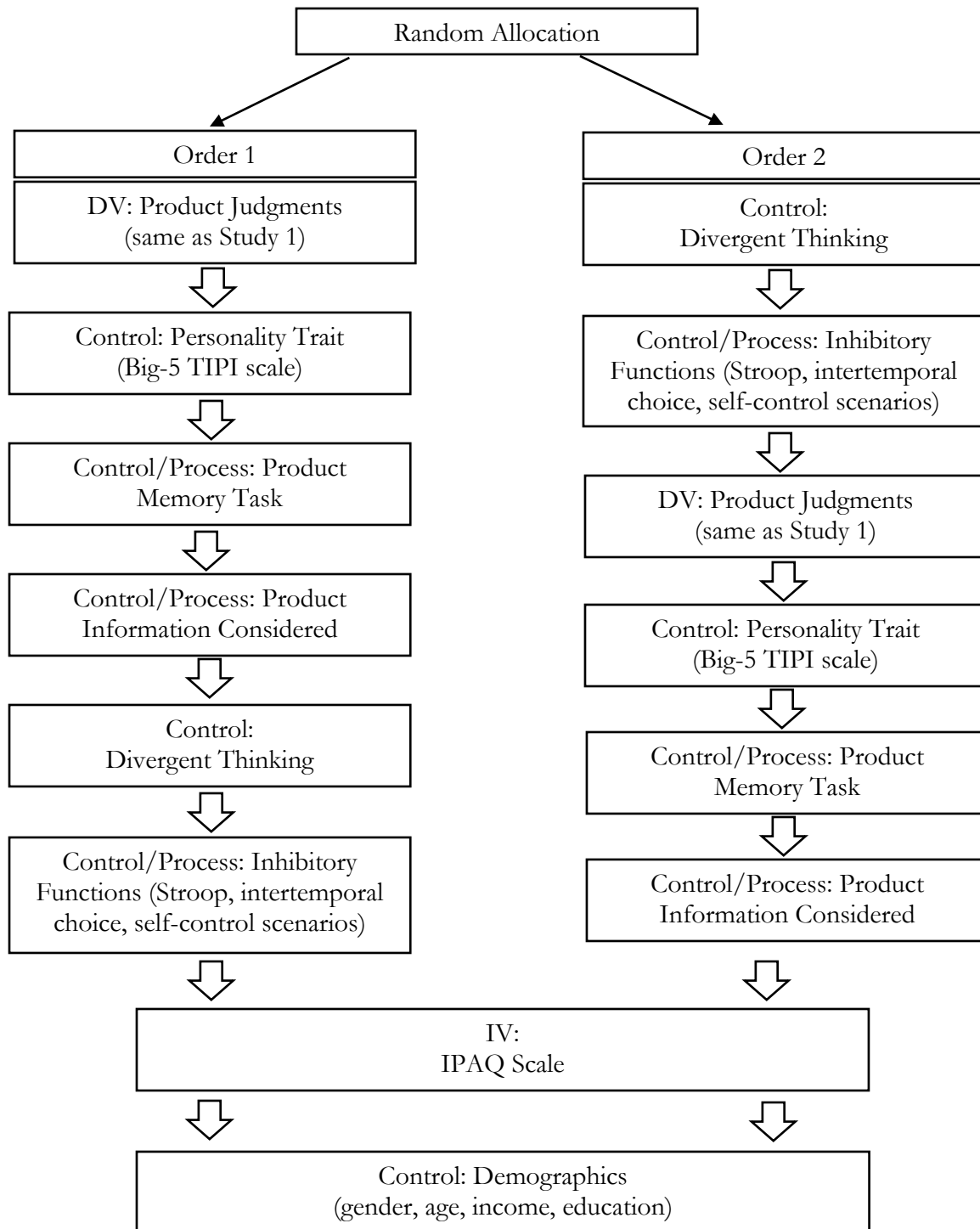
For suggestive evidence on a potential mechanism, study 2 tested the hypothesis that individuals who engage in leisure RPA are less susceptible to the dilution effect because of improved inhibition (Barenberg et al., 2011). We used measures of inhibitory functions that were both product specific and more general.

Product specific inhibition: Participants completed a recognition memory task for the previously seen relevant and irrelevant information amongst new relevant and irrelevant distractor information. The recognition memory was measured using reaction time (RT) as well as correct responses. In the control condition, participants saw 14 items (one previously seen relevant item and one new relevant item per replicate) in random order. In the dilution condition, participants saw 28 items (one previously seen irrelevant item and one new irrelevant item per replicate). A stronger inhibition of irrelevant information among leisure RPA individuals should lead to higher error rates and RT latencies for the irrelevant items.

As a second measure, we asked participants to self-report which of the relevant and irrelevant attributes they had considered. Participants in the dilution condition saw the same attributes as in the product judgment task and selected which attributes they had considered when judging each product (ranging from zero to four attributes per replicate). Participants in the control condition did not perform this task since they had only seen relevant attributes.

General inhibitory functions: three measures were included to measure general inhibitory functions: (1) an online version of the Stroop Color-Word Interference test (Stroop, 1935) in which we measured correct responses and RT for 24 congruent and 24 incongruent items; (2) an intertemporal choices task with eight items that involved trading off smaller, immediate monetary payoffs (e.g., receiving \$15 tomorrow) versus larger, future monetary payoffs (e.g., receiving \$35 in 10 days from now); and (3) a self-control scenarios task that involved three choices between immediately gratifying options (e.g., eating a tasty microwaveable snack, buying a shoe on sale) versus options that would be more gratifying in the future (e.g., eating a healthy fruit, saving a target amount of money) (Tuk, Zhang, & Sweldens, 2015). The

procedures are presented in figure 4 (please see SOM, study 2 for more information about the procedure). Finally, participants completed several demographic questions (gender, age, income, and education levels).

Figure 4*Key Measures Elicited in Study 2*

Results and Discussion

Participants: Three hundred and two participants recruited via MTurk completed study 2. Thirteen failed an attention check and were excluded. The final sample comprised 289 participants (demographics in table 2). Physical activity responses were processed and truncated according to the IPAQ guidelines for data processing and analysis (Hagströmer, Oja, & Sjöström, 2006).

Order manipulation: The order did not influence the judgments or interact with the type of information and RPA. Hence, we collapsed the data across the order factor. This rules out demand, fatigue, and hypothesis guessing effects.

Independent variable—RPA: The RPA classification criterion was the same as in study 1. Participants were categorized as being regularly physically active for leisure ($n = 97$) and at work ($n = 76$). Overall, 50% of participants indicated to be sedentary (no RPA for leisure or at work, $n = 145$, see table 4).

Table 4

RPA Groups for Work and Leisure in Study 2

		Leisure RPA		
		No	Yes	Total
Occupational RPA	No	145	68	213
	Yes	47	29	76
	Total	192	97	289

Dependent variable—product judgments: We used a direct replication of the product judgment task from study 1 (between-subjects: type of information, within-subjects: seven replicates) to elicit the product judgments as our dependent variable.

We submitted the product rating to a 2 (type of information: control, dilution) x 2 (leisure RPA: yes, no) x 2 (work RPA: yes, no) between-subjects ANOVA. As predicted, again, occupational RPA did not impact the judgments, irrespective of the type of information and the level of leisure RPA (three-way interaction: $p = .605$, two-way interaction with type of information: $p = .147$, two-way interaction with leisure RPA: $p = .588$, main effect: $p = .577$). Since none of the terms involving occupational RPA yielded significant results, we are not reporting any follow-up analysis for this factor.

Next, we look at the leisure RPA factor (see table 5 for means and standard deviations). There was a significant interaction between the type of information and leisure RPA ($F(1, 281) = 4.45, p = .036, \eta^2 = 0.015$). Post-hoc comparisons of the leisure RPA factor across the dilution condition controlling for multiple comparisons using the Bonferroni alpha-level correction, showed the following. Leisure RPA individuals did not dilute their judgments ($p = .999$), while other participants showed a significant dilution effect ($p < .001$). Further, the rating of leisure RPA individuals in the control condition was significantly higher than the rating of other participants in the dilution condition ($p = .002$). No other contrasts were significant. Finally, the ANOVA showed no main effect of leisure RPA ($p = .370$) and the dilution condition had a significant main effect on the judgments ($p < .001, \eta^2 = 0.049$).

In short, individuals who engage in leisure RPA did not dilute their judgments.

Individuals who are active at work or sedentary showed a dilution effect. Table 5 shows the test statistics for each condition in studies 1 – 3.

Table 5

Average Product Ratings and Test Statistics Across Conditions in Study 1 - 3

		No Leisure RPA	Leisure RPA	
Study 1 N = 281	Control	M = 75.60 SD = 10.26	M = 73.22 SD = 10.97	Interaction: F(1, 273) = 3.63, p = .057
	Dilution	M = 69.82 SD = 12.65	M = 72.53 SD = 9.31	
Study 2 N = 289	Control	M = 78.81 SD = 9.16	M = 77.92 SD = 10.59	Interaction: F(1, 281) = 4.45, p = .036
	Dilution	M = 71.57 SD = 11.17	M = 76.12 SD = 10.39	
Study 3 N = 120	Control	M = 71.52 SD = 11.31	M = 70.79 SD = 10.65	Interaction: F(1, 116) = 7.82, p = .006
	Dilution	M = 54.06 SD = 15.78	M = 66.31 SD = 12.71	

Controls: There were no gender and age differences between leisure RPA and other participants ($p = .168$ and $p = .146$, respectively). Adding both control variables did not impact the significant interaction between the type of information and leisure RPA ($p = .016$, $\eta^2 = 0.020$). As before, leisure RPA participants were more likely to be in higher income ($p < .001$, $d = 0.55$) and education level brackets ($p < .001$, $d = 0.72$) but neither influenced the product judgments ($p = .123$ and $p = .690$). Importantly, the significant interaction effect between the

type of information and leisure RPA persisted after controlling for income and education ($p = .030$, $\eta^2 = 0.016$).

We added personality traits as covariates (leisure RPA individuals scored significantly higher on conscientiousness ($p = .032$, $d = 0.26$) and emotional stability ($p = .034$, $d = 0.26$)), but the significant interaction between the type of information and leisure RPA remained significant ($p = .018$, $\eta^2 = 0.019$). Finally, there was no difference for leisure RPA participants in terms of their divergent thinking score ($p = .787$). In short, the demographics (gender, age, income, education), personality traits, and divergent thinking did not impact the results.

Inhibition measures: None of the measures related to inhibitory functions (recognition of product information, Stroop test RT and accuracy, intertemporal choices, self-control scenarios) showed any significant differences for leisure RPA individuals, apart from one (see SOM study 2 for specific results). The self-reported number of attributes considered showed a difference: while leisure RPA individuals did not consider a different number of irrelevant information ($M_{NoRPA} = 3.56$, $M_{RPA} = 3.04$, $t(142) = 0.79$, $p = .429$), critically, they considered more relevant information ($M_{RPA} = 6.83$, $M_{NoRPA} = 6.57$; $t(141.12) = 1.85$, $p = .018$, $d = 0.32$). This indicates that leisure RPA individuals considered the relevant information more and were therefore less likely to dilute their judgments.

Further robustness checks: Table 6 compares different linear regression models using alternative predictors. The baseline model 1—using the dilution dummy, leisure RPA dummy, as well as their interaction to predict the judgments—indicated a significant interaction effect. This interaction remained significant when adding demographics (Model 2).

Table 6*Regression Analysis for Study 2 Comparing Leisure RPA and Inhibition as Predictors*

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
Dilution condition	-7.24*** (1.49)	-6.76*** (1.48)	-1.21 (6.07)	-5.34 (6.12)	-2.30 (6.12)	-6.24 (6.10)
Leisure RPA	-0.88 (1.79)	0.23 (1.81)			-1.09 (1.81)	-0.02 (1.82)
Dilution x Leisure RPA	5.44* (2.57)	5.51* (2.56)			5.44* (2.62)	5.61* (2.60)
Inhibition ^a			0.72 (3.23)	-2.93 (3.36)	0.58 (3.22)	-3.01 (3.32)
Dilution x Inhibition			-2.94 (4.08)	0.29 (4.14)	-3.37 (4.07)	-0.31 (4.10)
<i>Demographics</i>						
Age		0.93** (0.05)		0.20** (0.05)		0.20** (0.05)
Female		0.93 (1.22)		0.39 (1.24)		0.72 (1.23)
Education (> 2-year college)		-1.58 (1.27)		-1.19 (1.28)		-1.82 (1.29)
Salary (> \$25k)		-1.47 (1.36)		-0.78 (1.37)		-1.22 (1.38)
Adj. R^2	.075	.116	.059	.094	0.071	0.114

Standard errors reported in parentheses. $p < .001$ ***; $p < .01$ **; $p < .05$ *;^a = Reaction time in incongruent trials in the Stroop test.

We tested an alternative Model 3 using inhibitory control as a predictor since better inhibitory skills (vs. leisure RPA) may reduce the dilution effect. We used the RT on incongruent trials in the Stroop task.⁷ The results showed no association between inhibitory control and the judgments. Models 4, 5 and 6 with different controls show the same pattern, attesting to the robustness of the finding.

Study 2 replicates the findings of study 1. The results were also robust to order effects, and the inclusion of various control variables including demographics, personality traits, creativity/divergent thinking skills, and measures of inhibition and self-control (e.g., intertemporal choices, eating behavior, saving money). As in study 1, occupational RPA was not associated with an attenuated dilution effect. Additionally, rather than inhibiting the irrelevant, leisure RPA individuals appear to be better at appropriately considering the relevant information. Thus, our findings are more consistent with an attribute weighting account rather than an inhibitory mechanism.

Study 3: A Field Study at the Gym

For study 3 we collaborated with a gym and tested individuals on-site after their exercise. This study setting confers several benefits. First, it reduces over-reporting of physical activity (via self-reports). Second, to improve generalizability, we diversified to a UK sample and chose a gym whose members had varying socioeconomic backgrounds.

⁷ The response accuracy for incongruent trials, intertemporal choice score, and self-control score showed equivalent results.

Third, it also allows us to investigate the effect of a single bout of exercise (SBE) among regularly physically active versus not regularly active individuals. While all participants had exercised before completing the survey, only about half of them were physically active for leisure on a regular basis. Hence, we investigated an SBE among regularly active versus not regularly active individuals. Based on the findings that acute exercise mainly facilitates processing speed but not accuracy in cognitive performance (McMorris et al., 2016), we expected the product judgments in the latter group to be unaffected by an SBE. Please note that there is also evidence that acute exercise can have detrimental effects for cognition among sedentary or unfit individuals (McMorris & Corbett, 2016).

Fourth, we wanted to investigate another potential alternative account. A measure of regulatory focus was included as it can moderate the dilution effect (Malaviya & Sternthal, 2009). We also measured whether participants viewed leisure RPA with a promotion-oriented lens (Joireman, Shaffer, Balliet, & Strathman, 2012). Finally, we investigated inhibitory mechanisms (recall, self-reported attribute consideration) similar to study 2.

Methodology

We set up a testing station in the hallway connecting the exercise facilities with the gym reception so that people leaving the gym would walk by. Gym-goers were approached and asked to participate. As an incentive, they were given a snack or energy drink after completing the study. The same product judgment task as in the previous two studies was used. The other measures are discussed next.

Regulatory focus: Following the product judgment task, participants completed a measure of regulatory focus—the commonly employed friendship strategies (Bhargave, Chakravarti, & Guha, 2015). Participants were asked to choose three out of six strategies for maintaining friendships. Three of them were promotion-oriented (“*be generous and willing to give of myself*”) and three of them were prevention-oriented strategies (“*stay in touch and avoid losing contact with my friends*”). Regulatory focus orientation was operationalized as the number of promotion-oriented strategies chosen, resulting in a score from zero to three.

Product information considered: Like in study 2, participants in the dilution condition then indicated which product attributes they had considered in the previously completed product judgment task. This self-report measure was included to consolidate the finding that leisure RPA is associated with considering a higher number of relevant attributes, as opposed to a lower number of irrelevant attributes. Unlike study 2, given the gym setting, participants were presented with only one of the product descriptions to keep the overall time frame short. Participants were asked to select which of the four attributes they had considered when judging the product. We observed whether participants selected the relevant attribute (yes, no) and how many irrelevant attributes they selected (from zero to three).

Recall task: All participants then completed a recall task for one randomly selected product. Participants were asked to remember what kind of product they had been looking for in the previous product judgment task (e.g., “*You were looking for a stereo system that is _____. Please remember what kind of stereo system you were looking for*”). Participants gave their answer in a text box. Due to the shorter time frame, this question was asked for one randomly chosen replicate.

RPA and exercise: Participants completed the IPAQ and specific questions about the just completed exercise session. We asked how long they had been exercising and what kind of exercise they had been doing as well as the level of exertion using the Borg Perceived Exertion scale (Borg & Løllgen, 2001).

As an additional measure of regulatory focus, participants completed two questions about their exercise motivation (Higgins, Roney, Crowe, & Hymes, 1994). Participants indicated their agreement to a promotion-oriented exercise item (Ideal self: *“I exercise to be the person I would ideally like to be”*) and a prevention-oriented exercise item (Ought self: *“I exercise because I feel I should”*; 1 = disagree to 9 = agree) on separate screens and in counter-balanced order. Finally, participants completed demographic questions regarding their age, gender, and education.

Results and Discussion

Participants: One hundred twenty gym-goers participated (Table 2 provides demographics). The sample size was determined by the availability of gym-goers during the time period granted by the gym for data collection. Leisure and occupational RPA individuals were identified based on the same classification system as previously (see table 7). Thus, while all participants were exercising on the particular day, only 49% were classified as regularly physically active for leisure according to their IPAQ responses. This allowed us to investigate an SBE among regularly active versus not regularly active individuals.

Table 7*RPA Groups for Work or Leisure in Study 3*

		Leisure RPA		
		No	Yes	Total
Occupational RPA	No	49	35	84
	Yes	12	24	36
	Total	61	59	120

Dependent variable—product judgments: As predicted, and similar to the previous results, occupational RPA had no effect, so we do not present further analyses for this factor. A 2 (type of information: control, dilution) x 2 (RPA: yes, no) between-subjects ANOVA yielded a significant interaction effect ($F(1, 116) = 7.82, p = .006, \eta^2 = 0.06$).

Post-hoc comparisons of the leisure RPA factor across the dilution condition controlling for multiple comparisons using Bonferroni alpha-level correction, showed the following. Participants who were not regularly physically active significantly diluted their judgments, irrespective of the fact that they had just exercised ($p < .001$). Leisure RPA individuals showed no significant dilution effect ($p = .999$). There was no product rating difference in the control condition between the RPA groups ($p = .999$). In the dilution condition, ratings of leisure RPA individuals were significantly higher ($p = .004$). Ratings of leisure RPA individuals in the control condition were significantly higher than those of no-RPA individuals in the dilution condition ($p < .001$). No other contrasts were significant. Finally, the ANOVA showed a main effect of RPA ($p = .014, \eta^2 = 0.05$) and the dilution condition on the judgments ($p < .001, \eta^2 = 0.16$). Please see table 5 for means and standard deviations in each group.

Product information considered: While 92% of the RPA individuals selected the relevant attribute, 78% of the no-RPA individuals did ($\chi^2(1) = 1.85, p = .173$). These results are directionally consistent with those of study 1, albeit statistically non-significant. Note, due to time constraints in a gym setting we elicited responses for only one replicate (vs. 7 replicates in study 1), which might explain the difference. For the irrelevant attributes, there was no difference between leisure RPA and no-RPA individuals ($p = .333$).

Controls: There were no significant differences in memory for the product information ($p = .358$), regulatory focus ($p = .202$), and the exercise motivation variables (promotion orientation: $p = .334$, prevention orientation: $p = .735$) when comparing leisure RPA versus no-RPA individuals, thus refuting these constructs as alternative accounts. None of the demographics impacted the results. In addition, we found no differences regarding the SBE parameters (duration, exertion, type of exercise performed) when comparing leisure RPA versus no-RPA individuals.

Study 3 replicates the findings of the previous studies. Individuals who engage in RPA for leisure (vs. regularly active workers) are less susceptible to the dilution effect, among a sample of socially diverse gym-goers. A SBE did not reduce the dilution effect in participants who are not regularly physically active. The results further refute demographics and regulatory focus as alternate accounts.

Study 4: Seasoned Runners' Performance in the Dilution Task

Study 4 adds to the previous studies in the following ways. First, we wanted to examine seasoned runners' product judgments for generalizability. Second, we wanted to investigate the dilution effect using a within-subjects design (Glover, 1997; Hoffman & Patton, 1997; Peters & Rothbart, 2000), which allows the calculation of a dilution score. Such a score measures the *extent* to which an individual dilutes her judgments. Our prediction was that the more frequently a person engaged in physical activity, the lower their dilution score would be.

Study 4 was conducted in collaboration with parkrun UK—a physical activity organization with over 1 million running members, which organizes weekly five kilometer runs in different locations. Volunteers time each participant's run, thus providing objective measures of RPA. After each run, participants' results are posted online. The study was advertised through parkrun's newsletter (the sample size was determined by the number of interested runners that signed up). Runners received a \$7 gift voucher for completing a five-minute survey.

A key difference from the previous studies is that participants completed a within-subjects version of the dilution paradigm. Specifically, participants were asked to rate the control versions of three product replicates with only supportive information, and the dilution version of three different replicates with supportive plus irrelevant product information. The difference between the control and dilution version ratings constituted an individual's "dilution score".

After participants rated six products, they completed questions regarding their parkrun motivation, and their current mood. Participants answered one general mood item ("*How are you feeling right now?*" Seven-point scale from 'very bad' to 'very good'). Next, participants

completed 13 items from the POMS. The score for each subscale (depression, vigor, anger and fatigue) was computed as the average of the respective items. This was followed by two questions about participants' motivations to participate in parkrun (on separate screens, in random order). Like in study 3, these questions were framed to tap into participants' regulatory focus (Higgins, Roney, Crowe, & Hymes, 1994) (*I do parkrun to be the person I would ideally like to be; I do parkrun because I feel I should*; 1 = disagree to 9 = agree).

Each participant's data was matched with their respective parkrun online profile. We collected participants' total number of runs completed, their average time, and their personal best and worst performance. Participants' running frequency was computed by dividing the total number of runs completed by the number of possible runs since their first run. We also collected participants' gender and age group.

Results and Discussion

Two hundred seventy-four participants completed the online survey. Out of those, we were unable to locate the individual parkrun websites for six participants. The final sample consisted of 268 runners (demographics in table 2). We computed an individual dilution score as a measure of the extent to which each person lowered their product judgments when seeing irrelevant information compared to relevant product information only. The average of the three dilution products was subtracted from the average of the three control products. Higher values on this score represent a stronger dilution effect.

We performed linear regression analysis to investigate whether the dilution score was associated with participants' running frequency, because this indicates how *regularly* people had

participated in parkrun. We predicted the dilution score using the running frequency, controlling for age and gender. As an aside, in this particular case (unlike studies 1 and 2), the use of “frequency” of runs alone is an appropriate independent variable as the intensity of the physical activity (i.e., a 5K run) is held roughly constant across runners.

Results showed a significant negative association between the dilution score and the running frequency ($\beta = -10.93$, $SE = 3.32$, $t(267) = -2.53$, $p = .012$).⁸ The more regularly a person had run, the less they diluted their judgments. Further, we included participants’ motivation (ideal-self, ought-self), mood, vigor, anger, and fatigue scores to the regression model. However, none of these variables were associated with the dilution score nor did they impact the significant association between running frequency and the dilution score (see table 8).

⁸ We also controlled for the total engagement in runs but this did not impact the result. The association between running frequency and the dilution score remained significant ($p=.020$). SOM study 4 contains a correlation matrix of all variables.

Table 8*Regression Analysis for the Dilution Score in Study 4*

	Model 1	Model 2	Model 3
	β (SE)	β (SE)	β (SE)
Running Frequency	-10.93* (4.32)	-10.91* (4.37)	-10.61* (4.42)
Age	0.86* (0.43)	0.93* (0.44)	0.83 (0.46)
Female	-2.21 (2.09)	-1.90 (2.13)	-1.67 (2.15)
Ideal Self		-0.61 (0.49)	-0.65 (0.50)
Ought Self		0.20 (0.51)	0.21 (0.52)
Mood			-0.10 (1.32)
Fatigue			0.43 (1.45)
Vigor			0.48 (1.51)
Depression			-4.51 (3.19)
Anger			0.87 (3.33)
Adj. R^2	.019	.046	.057

Standard errors reported in parentheses.

 $p < .001$ ***; $p < .01$ **; $p < .05$ *

Study 5: Evidence Beyond the Dilution Effect—Desirability-Feasibility Tradeoffs

In study 5, to increase domain generalizability, we investigated a different paradigm which also requires decision makers to integrate two types of information. To that end, we investigated a scenario that involves options described on a mix of desirability-feasibility attributes (Liberman & Trope, 1998). The desirability of a product or activity describes the value of the desired end state, such as the quality of a product or the payoff amount in a lottery. Feasibility concerns the ease or difficulty of reaching this desired end state (Liu, 2008), like a product's price or the probability of winning in a lottery. A wide range of studies have investigated desirability-feasibility trade-offs in different contexts such as gambling (Sagristano, Trope, & Liberman, 2002), gift giving (Baskin, Wakslak, Trope, & Novemsky, 2014), rebate redemption (Cohen, Belyavsky, & Silk, 2008), and assortment size preferences (Goodman & Malkoc, 2012).

In many studies, feasibility attributes are of less concern to decision makers than desirability attributes (Escalas & Luce, 2004; Sagristano et al., 2002; Sevincer & Oettingen, 2013; Vallacher & Wegner, 1987; Wegner, Vallacher, Kiersted, & Dizadji, 1986). In the consumer domain, Thompson et al. (2005) showed that people tend to give too much weight to the capability of products (i.e., desirability) and neglect usability information (i.e., feasibility), and choose overly complex, feature-rich products leading to reduced satisfaction and negative user experience. In a similar vein, Cohen et al. (2008) contend that consumers focus more on end states that products fulfil and underweight the steps to reach the goal, which often occurs in the contexts of rebate redemptions and consumer electronics (e.g., signing an expensive smartphone contract without being able to pay the monthly fees).

We label this phenomenon “feasibility neglect”, as neglecting feasibility considerations unduly can result in negative experiences. The primary aim of study 5 was to investigate if leisure RPA individuals are less susceptible to such a “feasibility neglect”. Note, from a normative perspective, it is not necessarily better to place more emphasis on feasibility. If the desirability attribute is more important than the feasibility attribute, then it should receive a greater weight. However, we look at contexts where not neglecting the feasibility attribute is typically important for the outcome.

Methodology

Participants were recruited via MTurk for a payment of \$1.20. We aimed to recruit roughly 50 participants per group and condition, based on the sample size of Liberman and Trope (1998) whose stimuli we used.

Order manipulation: Participants either completed the demographics and physical activity section first, followed by the decision tasks, or vice versa. Thus, importantly, half of the participants saw the independent variable first and the dependent variable later, and vice versa. Taken together, this allows us to examine demand, fatigue, and hypothesis guessing effects.

Dependent variable: The desirability feasibility trade-off was adapted from Liberman and Trope (1998). Participants imagined that a friend was offering them concert tickets which varied in terms of feasibility (i.e., price) and desirability (i.e., liking of the band). Participants were randomly assigned to one of two between-subjects conditions (HDLF condition: high desirability / low feasibility; LDHF condition: low desirability / high feasibility). In the HDLF condition the concert tickets were for a band that the participant liked very much, but the tickets were also

more expensive than expected, \$30. In the LDHF condition, the concert tickets were for a new band that the participant was not very familiar with and was not sure he/she would like the kind of music the band was playing. But since the tickets were part of a special deal, they only cost \$8 each instead of their usual price of \$30. Participants evaluated how likely it was that they would buy the tickets (0 = highly unlikely, 100 = highly likely).

Independent variable—RPA: Participants completed an adapted version of the IPAQ (Hagströmer et al., 2006). We did not measure occupational RPA as it was not associated with the product judgments in the previous studies.

Controls: We measured construal level as it has been shown to affect desirability-feasibility tradeoffs (Liberman & Trope, 1998). Specifically, participants completed thirteen items from the Behavior Identification Form (BIF; Vallacher & Wegner, 1989). The BIF asks subjects to choose between a concrete description (e.g., “putting a key in the lock”) and an abstract description (“securing the house”) of different everyday behaviors. The low-level, concrete construal describes the action of a behavior (e.g., the means and details of a behavior). The high-level, abstract construal emphasizes the goal of a behavior or why a certain behavior takes place (e.g., the motives and meaning). The scores were summed up to create an index ranging from zero to 13. A higher score represents a more abstract level of construal mindset. Finally, questions on personality (TIPI; Gosling et al., 2003) and demographics (age, gender, income) were elicited.

Results and Discussion

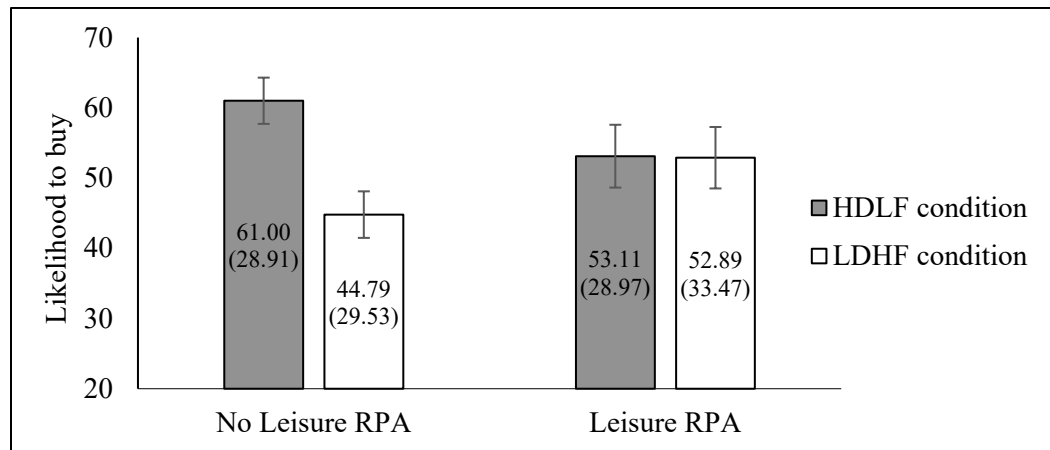
Participants: The final sample consisted of 257 participants (demographics in table 2). The physical activity responses were analyzed as previously (36% leisure RPA, $n = 92$).

Dependent variable—desirability feasibility trade-off: The likelihood of buying the concert tickets was submitted to a 2 (leisure RPA: yes, no) x 2 (type of ticket: HDLF, LDHF) between-subjects ANOVA. The results yielded a significant interaction between leisure RPA and the type of ticket ($F(1, 253) = 4.24, p = .041, \eta^2 = 0.016$). Please see figure 5 for means and standard deviations. Post-hoc comparisons (controlling for multiple comparisons with Bonferroni alpha-level correction) of the leisure RPA factor across condition showed the following. In line with “feasibility neglect”, inactive participants rated the HDLF (vs. LDHF) option significantly higher ($p = .004$). However, for leisure RPA individuals, there was no significant difference ($p = .999$). There were no other significant contrasts. The ANOVA also showed a significant main effect of the type of ticket, $F(1, 253) = 4.38, p = .037, \eta^2 = 0.017$. Ratings were higher for the HDLF than for the LDHF option ($M_{\text{HDLF}} = 57.06$ vs. $M_{\text{LDHF}} = 48.89$), indicating that overall, the HDLF tickets were more attractive, and participants placed more emphasis on desirability. There was no main effect of leisure RPA ($p = .969$).

Controls: The leisure RPA group consisted of slightly more males ($\chi^2(1) = 3.63, p = .057$) and had higher education and income level ($p = .006, d = 0.35$, and $p < .001, d = 0.48$, respectively). Further, leisure RPA individuals tended to be more extraverted ($p = .053, d = 0.25$) and open to new experiences ($p = .066, d = 0.24$). Finally, leisure RPA participants had a marginally higher BIF score ($M_{\text{RPA}} = 8.82, M_{\text{No_RPA}} = 7.84, t(255) = -1.96, p = .051$). Controlling for these variables in an ANCOVA model did not alter the key findings.

Figure 5

Rating of Desirability Feasibility Options for Leisure RPA versus Other Individuals



Study 5 provides evidence that individuals who do not engage in leisure RPA had a relatively stronger preference for a product characterized by high desirability and low feasibility (vs. one characterized by low desirability and high feasibility), thus demonstrating “feasibility neglect”. However, leisure RPA individuals exhibited similar ratings for both products, which indicates they may be less susceptible to feasibility neglect. Importantly, these results could not be explained by demand/order effects, differences in personality traits, demographics (age, gender, income, and education), and construal level mindset.

General Discussion

This research documents a novel benefit of engaging in leisure RPA. The results show that individuals who are regularly physically active for leisure are less susceptible to the dilution bias (and feasibility neglect) compared to their less active and occupational RPA counterparts,

despite controlling for a number of individual-level and situational variables. Leisure RPA individuals showed less bias in two different attribute weighting paradigms, thus attesting to the domain generalizability. However, it is important to reiterate that these differences do not extend to any and all kinds of decisions. Being regularly physically active appears to confer no universal benefits on various other tasks where the outcome does not depend on the appropriate weighing of relevant and irrelevant attribute information (e.g., Stroop task, intertemporal discounting, self-control tasks, product attribute recall, reaction times, etc.). Thus, we note that leisure RPA is not to be mistaken as a panacea. Given that we examined individual-level measures of RPA, we took care to investigate a whole host of plausible alternative accounts, as we discuss next.

Robustness Checks and Ruling Out Alternative Accounts

Diverse demographics, replicates, scales, and order: Leisure RPA was associated with similar decision patterns in diverse samples (US and UK, MTurkers, gym goers, seasoned runners, and people from socially diverse backgrounds of varying age, and socioeconomic status; table 2) and across seven different replicates of products/services, thus attesting to its wide applicability. Additionally, we found the same results using three different physical activity measures (GPAQ, IPAQ, run frequency), and both self-reports (studies 1-3, 5) and objective measures (study 4 where independent observers recorded runs) of RPA. To refute the possibility of demand effects, fatigue or hypothesis guessing we varied the order of the tasks, including the relative order of the independent and dependent variable, but the results were unaffected.

Individual differences: We controlled for demographics (gender, age, income and educational level), reasoning ability (RAT, NST), personality traits (BFI-SV, TIPI), mood

(POMS), regulatory focus and construal level (BIF). While some differences emerged for the regularly physically active participants, the key results with regard to the decision making tasks remained. We can therefore refute these explanations as alternate accounts. However, other alternative explanations should be explored. For example, while we measured educational level and reasoning ability, we did not measure general intelligence. As intelligence can be associated with the use of “less-is-more” decision heuristics such as Take-The-Best (TTB; Bröder, 2000, 2003; Gigerenzer, Hoffrage, & Kleinbölting, 1991), which in turn may attenuate the dilution effect, future research should investigate this and other alternative explanations.

Leisure versus occupational RPA: Only *leisure* as opposed to occupational RPA was associated with a reduced dilution effect. Thus, the findings cannot be attributed to physical effort alone but rather to motivational and cognitive differences. This implies that the mindset of physical activity matters for the outcome. Future research could investigate how workers’ perception of occupational physically activity can be changed (e.g., with action and coping plans) to lead to similar benefits as leisure RPA. For example in the health domain, Crum and Langer (2007) showed that room attendants whose work was framed as ‘good physical exercise’ showed improved health outcomes (i.e., weight, blood pressure, body fat, waist-to-hip ratio and BMI) compared to a control group which performed the same work without an exercise framing.

Indicative Process Explanations

Two additional findings are noteworthy. First, the key finding—regularly physically active individuals being less susceptible to the dilution effect—was not driven by an *improved inhibition of irrelevant information*. Analysis of participants’ memory for the irrelevant

information (accuracy and RT) did not support the argument for better inhibition. Further, a common measure of inhibitory functions (Stroop test), as well as measures of delay of gratification and self-control (intertemporal choices, self-control scenarios from domains like saving money) did not support this idea. These findings indicate that there are no generalized differences in terms of inhibition.

Conversely, the reduced dilution effect among the regularly physically active seems to be driven by a *stronger consideration of the goal-relevant information*. For irrelevant information, in contrast, there was no difference. Overall, these results suggest regularly physically active individuals might be better at appropriately weighing the relevant (vs. ignoring the irrelevant).

We must acknowledge that this was tested only indirectly (i.e., inferred from memory tests and self-reported attribute considerations). It was not possible to distinguish between alternative processes based on the design of the dilution paradigm, and we did not collect process tracing evidence, such as eye-tracking. Instead of following a deliberative weighting process, participants could have used “simple heuristics” (Gigerenzer, Hertwig, & Pachur, 2011). As such, the TTB heuristic would be an excellent alternative candidate to explain our results (Bröder, 2000; Gigerenzer et al., 1991). As alluded to earlier, regularly physically active individuals with higher socio-economic background (and potentially higher IQ) might have been more likely to use the TTB heuristic to form product judgments (Bröder, 2003). Instead of considering all available cues and weighting them more appropriately, RPA individuals might have considered only a single cue with the highest validity (i.e., the relevant attribute), thus leading to an attenuated dilution effect. Future studies could disentangle such alternative decision processes with process tracing methodology.

RPA versus Other Activities and Lifestyle Factors

While we make a case for leisure RPA, the reader might wonder about other activities. For example, could playing the violin regularly, lead to similar outcomes? At the outset, we acknowledge that other activities—especially if they chronically activate similar cognitive and motivational principles—should lead to similar outcomes. Indeed, a wide variety of lifestyle variables have been shown to lead to beneficial effects in other, seemingly unrelated decision making areas (Smayda, Worthy, & Chandrasekaran, 2017; Sun, Yao, Wei, & Yu, 2015). However, we chose to concentrate on leisure RPA because of several reasons.

First, physical activity is an activity that is frequently engaged in by a wide range of the population, not one that is a “specialist” activity or a niche skill or hobby. Thus, “access” to physical activity is not limited by specialized interests (e.g., new language, meditation) or required resources (e.g., expensive violin lessons).

Second, RPA is important for governments, not-for-profits, and public policy entities because the socio-economic implications of physical activity are extremely significant. Insufficient physical activity is the fourth leading modifiable behavioral risk factor behind smoking, high blood pressure, and obesity, and is responsible for approximately 3,200,000 deaths per year worldwide (WHO, 2010). Globally, physical inactivity related deaths cost \$13.7 billion in productivity losses (Ding et al., 2016). Our investigation of decision making benefits further underscores the policy impacts of RPA.

Third, our theorizing puts forward a mechanism that cannot be blanketly applied to any activity. Not all activities—like hobbies and enjoyable pastimes (e.g., solving crosswords), flow activities (e.g., fishing), or habitual activities (e.g., reading the news)—are likely to activate the

same set of planning cognitions (Pfeffer & Strobach, 2021) *in combination* with the embodiment of choices in the physical activity (Raab, 2020). We argue that RPA is distinct from other learning or cognitive training activities exactly because the cognitive skills are not independent of the motor performance but can actually be enhanced by it (Heisz et al., 2017; Kontra et al., 2015; Liu et al., 2017).

Further Avenues for Future Research

There are several interesting avenues of future research. While we ruled out a wide range of alternative accounts, we did not manipulate RPA experimentally and cannot eliminate all possible confounding factors. Note though, the focus of our studies is on chronic and sustained RPA (context-independent) as a lifestyle variable. Simply manipulating physical activity in a single bout is therefore problematic. As we find in study 3, a SBE seems not to confer benefits with regards to the dilution paradigm. We let participants engage in their ‘preferential’ exercise instead of standardizing the SBE (duration, intensity, type etc.) to represent real-life exercise behavior more accurately—although future work could control for fine-grained exercise parameters and modalities (e.g., aerobics vs. weight training).

In the case of occupational RPA, conducting an RCT might even be impossible. Still, since RCTs are the gold standard, future studies should use a longitudinal RCT and assign inactive individuals to an RPA intervention group or a waiting-list control group to establish causality.

Self-reported physical activity can be subjective and prone to bias because of people’s memory limitations and social desirability responses. Future studies could employ more

objective real-life measures of physical activity, for example via accelerometry and mobile tracking, which take into account dynamic within-subject fluctuations of physiological physical activity measures in everyday life (Reichert et al., 2020), to quantify the relationship between physical activity and decision making more precisely.

Future studies could also investigate temporal effects, moderators, and boundary conditions. For example, does too much physical activity lead to poorer decisions? Do different types of leisure physical activity (e.g., aerobics vs. weights) have differential effects on decision making? Finally, it would be interesting to see whether individuals who engage in RPA make better decisions in other domains where particular information should be ignored or not overly influence judgments, such as in hiring, or legal decisions. Altogether, there are many exciting directions for future research that could be pursued.

References

- Ahlskog, J. E., Geda, Y. E., Graff-Radford, N. R., & Petersen, R. C. (2011). Physical exercise as a preventive or disease-modifying treatment of dementia and brain aging. *Mayo Clinic Proceedings, 86*(9), 876-884.
- Barenberg, J., Berse, T., & Dutke, S. (2011). Executive functions in learning processes: Do they benefit from physical activity? *Educational Research Review, 6*(3), 208-222.
- Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn?: A taxonomy for far transfer. *Psychological Bulletin, 128*(4), 612.
- Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology, 59*, 617-645.

- Barz, M., Parschau, L., Warner, L. M., Lange, D., Fleig, L., Knoll, N., & Schwarzer, R. (2014). Planning and preparatory actions facilitate physical activity maintenance. *Psychology of Sport and Exercise, 15*(5), 516-520.
- Baskin, E., Wakslak, C. J., Trope, Y., & Novemsky, N. (2014). Why Feasibility Matters More to Gift Receivers than to Givers: A Construal-Level Approach to Gift Giving. *Journal of Consumer Research, 41*(1), 169-182.
- Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., Martin, B. W., . . . Sarmiento, O. L. (2012). Correlates of physical activity: Why are some people physically active and others not? *The Lancet, 380*(9838), 258-271.
- Beilock, S. L., Lyons, I. M., Mattarella-Micke, A., Nusbaum, H. C., & Small, S. L. (2008). Sports experience changes the neural processing of action language. *Proceedings of the National Academy of Sciences, 105*(36), 13269.
- Berchicci, M., Pontifex, M. B., Drollette, E. S., Pesce, C., Hillman, C. H., & Di Russo, F. (2015). From cognitive motor preparation to visual processing: the benefits of childhood fitness to brain health. *Neuroscience, 298*, 211-219.
- Best, J. R. (2010). Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise. *Developmental Review, 30*(4), 331-351.
- Bhargave, R., Chakravarti, A., & Guha, A. (2015). Two-stage decisions increase preference for hedonic options. *Organizational Behavior and Human Decision Processes, 130*, 123-135.
- Borg, G., & Löllgen, H. (2001). Borg's perceived exertion and pain scales. *Deutsche Zeitschrift für Sportmedizin, 52*(9), 252.

- Bröder, A. (2000). Assessing the empirical validity of the "Take-the-best" heuristic as a model of human probabilistic inference. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 26(5), 1332.
- Bröder, A. (2003). Decision making with the "adaptive toolbox": influence of environmental structure, intelligence, and working memory load. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 29(4), 611.
- Bull, F. C. (2009). Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *Journal of Physical Activity & Health*, 6(6), 790.
- Burzynska, A. Z., Ganster, D. C., Fanning, J., Salerno, E. A., Gothe, N. P., Voss, M. W., . . . Kramer, A. F. (2020). Occupational physical stress is negatively associated with hippocampal volume and memory in older adults. *Frontiers in Human Neuroscience*.
- Chaddock, L., Erickson, K. I., Prakash, R. S., Kim, J. S., Voss, M. W., VanPatter, M., . . . Hillman, C. H. (2010). A neuroimaging investigation of the association between aerobic fitness, hippocampal volume, and memory performance in preadolescent children. *Brain Research*, 1358, 172-183.
- Chaddock-Heyman, L., Erickson, K. I., Voss, M., Knecht, A., Pontifex, M. B., Castelli, D., . . . Kramer, A. (2013). The effects of physical activity on functional MRI activation associated with cognitive control in children: a randomized controlled intervention. *Frontiers in Human Neuroscience*, 7, 72.
- Chan, J. S. Y., Liu, G., Liang, D., Deng, K., Wu, J., & Yan, J. H. (2019). Special issue—therapeutic benefits of physical activity for mood: a systematic review on the effects of exercise intensity, duration, and modality. *The Journal of Psychology*, 153(1), 102-125.

- Chang, Y.-K., Tsai, Y.-J., Chen, T.-T., & Hung, T.-M. (2013). The impacts of coordinative exercise on executive function in kindergarten children: an ERP study. *Experimental Brain Research, 225*(2), 187-196.
- Coenen, P., Huysmans, M. A., Holtermann, A., Krause, N., Van Mechelen, W., Straker, L. M., & Van Der Beek, A. J. (2018). Do highly physically active workers die early? A systematic review with meta-analysis of data from 193 696 participants. *British Journal of Sports Medicine, 52*(20), 1320-1326.
- Cohen, J. B., Belyavsky, J., & Silk, T. (2008). Using visualization to alter the balance between desirability and feasibility during choice. *Journal of Consumer Psychology, 18*(4), 270-275.
- Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., . . . Sallis, J. F. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise, 35*(8), 1381-1395.
- Crum, A. J., & Langer, E. J. (2007). Mind-Set Matters: Exercise and the Placebo Effect. *Psychological Science, 18*(2), 165-171.
- Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N. E., . . . Naglieri, J. A. (2011). Exercise Improves Executive Function and Achievement and Alters Brain Activation in Overweight Children: A Randomized, Controlled Trial. *Health Psychology, 30*(1), 91-98.
- DeVries, G., Terwel, B. W., & Ellemers, N. (2014). Spare the details, share the relevance: The dilution effect in communications about carbon dioxide capture and storage. *Journal of Environmental Psychology, 38*(C), 116-123.

- Dietrich, A., & Audiffren, M. (2011). The reticular-activating hypofrontality (RAH) model of acute exercise. *Neuroscience and Biobehavioral Reviews*, 35(6), 1305-1325.
- Ding, D., Lawson, K. D., Kolbe-Alexander, T. L., Finkelstein, E. A., Katzmarzyk, P. T., Van Mechelen, W., . . . Lancet Physical Activity Series 2 Executive, C. (2016). The economic burden of physical inactivity: a global analysis of major non-communicable diseases. *The Lancet*, 388(10051), 1311-1324.
- Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D. (1976). *Manual for kit of factor-referenced cognitive tests*. Princeton, NJ: Educational Testing Service.
- Escalas, J. E., & Luce, M. F. (2004). Understanding the effects of process-focused versus outcome-focused thought in response to advertising. *Journal of Consumer Research*, 31(2), 274-285.
- Etnier, J. L., Shih, C. H., & Piepmeier, A. T. (2016). The history of research on chronic physical activity and cognitive performance. *Exercise-Cognition Interaction: Neuroscience Perspectives*, 29-42.
- Fenzl, N., Bartsch, K., & Koenigstorfer, J. (2014). Labeling Exercise Fat-Burning Increases Post-Exercise Food Consumption in Self-Imposed Exercisers. *Advances in Consumer Research*, 42, 471.
- Gigerenzer, G. (2007). *Gut feelings: The intelligence of the unconscious*: Penguin.
- Gigerenzer, G., Hoffrage, U., & Kleinbölting, H. (1991). Probabilistic mental models: a Brunswikian theory of confidence. *Psychological Review*, 98(4), 506.
- Gigerenzer, G. E., Hertwig, R. E., & Pachur, T. E. (2011). *Heuristics: The foundations of adaptive behavior*: Oxford University Press.

- Glenberg, A. M. (1997). Mental models, space, and embodied cognition. In *Creative thought: An investigation of conceptual structures and processes*. (pp. 495-522). Washington, DC, US: American Psychological Association.
- Glover, S. M. (1997). The influence of time pressure and accountability on auditors' processing of nondiagnostic information. *Journal of Accounting Research*, *35*(2), 213-226.
- Goodman, J. K., & Malkoc, S. A. (2012). Choosing Here and Now versus There and Later: The Moderating Role of Psychological Distance on Assortment Size Preferences. *Journal of Consumer Research*, *39*(4), 751-768.
- Gosling, S. D., Rentfrow, P. J., & Swann, W. B. (2003). A very brief measure of the Big-Five personality domains. *Journal of Research in Personality*, *37*(6), 504-528.
- Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature*, *423*(6939), 534-537.
- Guilford, J. P. (1967). Creativity - Yesterday, Today, and Tomorrow. *Journal of Creative Behavior*, *1*(1), 3-14.
- Hagströmer, M., Oja, P., & Sjörström, M. (2006). The International Physical Activity Questionnaire (IPAQ): A study of concurrent and construct validity. *Public Health Nutrition*, *9*(6), 755-762.
- Hansen, C. J., Stevens, L. C., & Richard Coast, J. (2001). Exercise duration and mood state: How much is enough to feel better? *Health Psychology*, *20*(4), 267-275.
- Heisz, J. J., Clark, I. B., Bonin, K., Paolucci, E. M., Michalski, B., Becker, S., & Fahnestock, M. (2017). The effects of physical exercise and cognitive training on memory and neurotrophic factors. *Journal of Cognitive Neuroscience*, *29*(11), 1895-1907.

- Herting, M. M., & Nagel, B. J. (2012). Aerobic fitness relates to learning on a virtual Morris Water Task and hippocampal volume in adolescents. *Behavioural Brain Research*, *233*(2), 517-525.
- Higgins, E. T., Roney, C. J. R., Crowe, E., & Hymes, C. (1994). Ideal Versus Ought Predilections for Approach and Avoidance - Distinct Self-Regulatory Systems. *Journal of Personality and Social Psychology*, *66*(2), 276-286.
- Hillman, Erickson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heart: exercise effects on brain and cognition. *Nature Reviews Neuroscience*, *9*(1), 58-65. doi:10.1038/nrn2298
- Hillman, C. H., Buck, S. M., Themanson, J. R., Pontifex, M. B., & Castelli, D. M. (2009). Aerobic fitness and cognitive development: Event-related brain potential and task performance indices of executive control in preadolescent children. *Developmental Psychology*, *45*(1), 114.
- Hillman, C. H., Pontifex, M. B., Castelli, D. M., Khan, N. A., Raine, L. B., Scudder, M. R., . . . Kamijo, K. (2014). Effects of the FITKids randomized controlled trial on executive control and brain function. *Pediatrics*, *134*(4), e1063-e1071.
- Hoffman, V. B., & Patton, J. M. (1997). Accountability, the dilution effect, and conservatism in auditors' fraud judgments. *Journal of Accounting Research*, *35*(2), 227-237.
- Holtermann, A., Hansen, J. V., Burr, H., Søgaard, K., & Sjøgaard, G. (2012). The health paradox of occupational and leisure-time physical activity. *British Journal of Sports Medicine*, *46*(4), 291-295.
- Holtermann, A., Krause, N., van der Beek, A. J., & Straker, L. (2018). The physical activity paradox: six reasons why occupational physical activity (OPA) does not confer the

cardiovascular health benefits that leisure time physical activity does. *British Journal of Sports Medicine*, 52(3), 149.

Hopkins, M. E., Davis, F. C., Vantighem, M. R., Whalen, P. J., & Bucci, D. J. (2012).

Differential Effects of Acute and Regular Physical Exercise on Cognition and Affect. *Neuroscience*, 215, 59-68.

Hotaling, J. M., Cohen, A. L., Shiffrin, R. M., & Bussemeyer, J. R. (2015). The dilution effect and information integration in perceptual decision making. *PloS One*, 10(9), e0138481.

Hüttermann, S., Memmert, D., & Simons, D. J. (2014). The size and shape of the attentional “spotlight” varies with differences in sports expertise. *Journal of Experimental Psychology: Applied*, 20(2), 147.

Isen, A. M., & Daubman, K. A. (1984). The influence of affect on categorization. *Journal of Personality and Social Psychology*, 47(6), 1206.

Jaeggi, S. M., Buschkuhl, M., Jonides, J., & Perrig, W. J. (2008). Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences*, 105(19), 6829-6833.

Joireman, J., Shaffer, M. J., Balliet, D., & Strathman, A. (2012). Promotion Orientation Explains Why Future-Oriented People Exercise and Eat Healthy: Evidence From the Two-Factor Consideration of Future Consequences-14 Scale. *Personality and Social Psychology Bulletin*, 38(10), 1272-1287.

Kamijo, K., Pontifex, M. B., O’Leary, K. C., Scudder, M. R., Wu, C. T., Castelli, D. M., & Hillman, C. H. (2011). The effects of an afterschool physical activity program on working memory in preadolescent children. *Developmental Science*, 14(5), 1046-1058.

- Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive Sciences*, *14*(7), 317-324.
- Kontra, C., Lyons, D. J., Fischer, S. M., & Beilock, S. L. (2015). Physical experience enhances science learning. *Psychological Science*, *26*(6), 737-749.
- Krafft, C. E., Schwarz, N. F., Chi, L., Weinberger, A. L., Schaeffer, D. J., Pierce, J. E., . . . Tomporowski, P. D. (2014). An 8-month randomized controlled exercise trial alters brain activation during cognitive tasks in overweight children. *Obesity*, *22*(1), 232-242.
- Lathia, N., Sandstrom, G. M., Mascolo, C., & Rentfrow, P. J. (2017). Happier People Live More Active Lives: Using Smartphones to Link Happiness and Physical Activity. *PLoS One*, *12*(1), e0160589.
- Lee, T. M. C., Wong, M. L., Lau, B. W.-M., Chia-Di Lee, J., Yau, S.-Y., & So, K.-F. (2014). Aerobic exercise interacts with neurotrophic factors to predict cognitive functioning in adolescents. *Psychoneuroendocrinology*, *39*, 214-224.
- Liberman, N., & Trope, Y. (1998). The role of feasibility and desirability considerations in near and distant future decisions: A test of temporal construal theory. *Journal of Personality and Social Psychology*, *75*(1), 5-18.
- Liu, F., Sulpizio, S., Kornpetpanee, S., & Job, R. (2017). It takes biking to learn: Physical activity improves learning a second language. *PLoS One*, *12*(5), e0177624.
- Liu, W. (2008). Focusing on Desirability: The Effect of Decision Interruption and Suspension on Preferences. *Journal of Consumer Research*, *35*(4), 640-652.

- Malaviya, P., & Sternthal, B. (2009). Parity Product Features Can Enhance or Dilute Brand Evaluation: The Influence of Goal Orientation and Presentation Format. *Journal of Consumer Research*, 36(1), 112-121.
- Masley, S., Roetzheim, R., & Gualtieri, T. (2009). Aerobic exercise enhances cognitive flexibility. *Journal of Clinical Psychology in Medical Settings*, 16(2), 186-193.
- McMorris, T. (2016). Exercise–cognition interaction: State of the art and future research. In T. McMorris (Ed.), *Exercise-cognition interaction: neuroscience perspectives* (p. 459–481). Elsevier Academic Press.
- McMorris, T., & Corbett, J. (2016). Effects of athletic fitness on the exercise–cognition interaction. In T. McMorris (Ed.), *Exercise-cognition interaction: neuroscience perspectives* (pp. 227-250). Elsevier Academic Press.
- McMorris, T., & Graydon, J. (1997). The effect of exercise on cognitive performance in soccer-specific tests. *Journal of Sports Sciences*, 15(5), 459-468.
- McMorris, T., Turner, A., Hale, B. J., & Sproule, J. (2016). Beyond the catecholamines hypothesis for an acute exercise–cognition interaction: A neurochemical perspective. In T. McMorris (Ed.), *Exercise-cognition interaction: neuroscience perspectives* (p. 65–103). Elsevier Academic Press.
- Mednick, S. A. (1968). The Remote Associates Test. *The Journal of Creative Behavior*, 2(3), 213-214.
- Mehta, R., Hoegg, J., & Chakravarti, A. (2011). Knowing too much: Expertise-induced false recall effects in product comparison. *Journal of Consumer Research*, 38(3), 535-554.

- Mellström, C., & Johannesson, M. (2008). Crowding out in blood donation: was Titmuss right? *Journal of the European Economic Association*, 6(4), 845-863.
- Meyvis, T., & Janiszewski, C. (2002). Consumers' Beliefs about Product Benefits: The Effect of Obviously Irrelevant Product Information. *Journal of Consumer Research*, 28(4), 618-635.
- Moore, S. C., Lee, I. M., Weiderpass, E., Campbell, P. T., Sampson, J. N., Kitahara, C. M., . . . Patel, A. V. (2016). Association of leisure-time physical activity with risk of 26 types of cancer in 1.44 million adults. *The Journal of the American Medical Association Internal Medicine*, 176(6), 816-825.
- Moreau, D., Morrison, A. B., & Conway, A. R. A. (2015). An ecological approach to cognitive enhancement: complex motor training. *Acta Psychologica*, 157, 44-55.
- Morris, J. N., & Raffle, P. A. B. (1954). Coronary Heart Disease in Transport Workers. A Progress Report. *British Journal of Industrial Medicine*, 11(4), 260.
- Nisbett, R. E., Zukier, H., & Lemley, R. E. (1981). The dilution effect: Nondiagnostic information weakens the implications of diagnostic information. *Cognitive Psychology*, 13(2), 248-277.
- Northey, J. M., Cherbuin, N., Pumpa, K. L., Smee, D. J., & Rattray, B. (2017). Exercise interventions for cognitive function in adults older than 50: a systematic review with meta-analysis. *British Journal of Sports Medicine*.
- Oppezzo, M., & Schwartz, D. L. (2014). Give your ideas some legs: The positive effect of walking on creative thinking. *Journal of Experimental Psychology: Learning Memory and Cognition*, 40(4), 1142-1152.

- Peters, E., & Rothbart, M. (2000). Typicality can create, eliminate, and reverse the dilution effect. *Personality and Social Psychology Bulletin*, 26(2), 177-187.
- Pfeffer, I., & Strobach, T. (2020). Influence of a Planning Intervention on Physical Activity Behavior: the Moderating Role of Intentions and Executive Functions in a Randomized Controlled Trial. *International Journal of Behavioral Medicine*, 27(5), 506-519.
- Pontifex, M. B., Raine, L. B., Johnson, C. R., Chaddock, L., Voss, M. W., Cohen, N. J., . . . Hillman, C. H. (2011). Cardiorespiratory fitness and the flexible modulation of cognitive control in preadolescent children. *Journal of Cognitive Neuroscience*, 23(6), 1332-1345.
- Raab, M. (2020). *Judgment, Decision-Making, and Embodied Choices*: Academic Press.
- Raab, M., & Johnson, J. G. (2007). Expertise-based differences in search and option-generation strategies. *Journal of Experimental Psychology: Applied*, 13(3), 158.
- Raichlen, D. A., Bharadwaj, P. K., Fitzhugh, M. C., Haws, K. A., Torre, G. A., Trouard, T. P., & Alexander, G. E. (2016). Differences in resting state functional connectivity between young adult endurance athletes and healthy controls. *Frontiers in Human Neuroscience*, 10(2016), 610.
- Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in Personality*, 41(1), 203-212.
- Reichert, M., Giurgiu, M., Koch, E. D., Wieland, L. M., Lautenbach, S., Neubauer, A. B., . . . Liao, Y. (2020). Ambulatory assessment for physical activity research: State of the science, best practices and future directions. *Psychology of Sport and Exercise*, 50, 101742.

- Rhodes, R. E., & Smith, N. E. I. (2006). Personality correlates of physical activity: A review and meta-analysis. *British Journal of Sports Medicine, 40*(12), 958-965.
- Rovio, S., Kåreholt, I., Viitanen, M., Winblad, B., Tuomilehto, J., Soininen, H., . . . Kivipelto, M. (2007). Work-related physical activity and the risk of dementia and Alzheimer's disease. *International Journal of Geriatric Psychiatry, 22*(9), 874-882.
- Ruff, C. C., Ugazio, G., & Fehr, E. (2013). Changing social norm compliance with noninvasive brain stimulation. *Science, 342*(6157), 482-484.
- Sagrignano, M. D., Trope, Y., & Liberman, N. (2002). Time-dependent gambling: Odds now, money later. *Journal of Experimental Psychology: General, 131*(3), 364-376.
- Sapolsky, R. (2014). What drives us to do the right thing. *The Wall Street Journal, 2*.
- Sevincer, A. T., & Oettingen, G. (2013). Alcohol intake leads people to focus on desirability rather than feasibility. *Motivation and Emotion, 37*(1), 165-176.
- Shacham, S. (1983). A Shortened Version of the Profile of Mood States. *Journal of Personality Assessment, 47*(3), 305-306.
- Simonson, I., Nowlis, S. M., & Simonson, Y. (1993). The effect of irrelevant preference arguments on consumer choice. *Journal of Consumer Psychology, 2*(3), 287-306.
- Smayda, K. E., Worthy, D. A., & Chandrasekaran, B. (2017). Better late than never (or early): Music training in late childhood is associated with enhanced decision-making. *Psychology of Music, 46*(5), 734-748.
- Smith, H. D., Stasson, M. F., & Hawkes, W. G. (1998). Dilution in legal decision making: Effect of non-diagnostic information in relation to amount of diagnostic evidence. *Current Psychology, 17*(4), 333-345.

- Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2005). Bridging the intention-behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychology & Health, 20*(2), 143-160.
- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*(6), 643-662.
- Stroth, S., Kubesch, S., Dieterle, K., Ruchsow, M., Heim, R., & Kiefer, M. (2009). Physical fitness, but not acute exercise modulates event-related potential indices for executive control in healthy adolescents. *Brain Research, 1269*, 114-124.
- Sun, S., Yao, Z., Wei, J., & Yu, R. (2015). Calm and smart? A selective review of meditation effects on decision making. *Frontiers in Psychology, 6*, 1059.
- Tetlock, P. E., & Boettger, R. (1989). Accountability: A social magnifier of the dilution effect. *Journal of Personality and Social Psychology, 57*(3), 388.
- Thompson, D. V., Hamilton, R. W., & Rust, R. T. (2005). Feature fatigue: When product capabilities become too much of a good thing. *Journal of Marketing Research, 42*(4), 431-442.
- Tuk, M. A., Zhang, K., & Sweldens, S. (2015). The Propagation of Self-Control: Self-Control in One Domain Simultaneously Improves Self-Control in Other Domains. *Journal of Experimental Psychology: General, 144*(3), 639-654.
- Vallacher, R. R., & Wegner, D. M. (1987). What Do People Think They're Doing - Action Identification and Human-Behavior. *Psychological Review, 94*(1), 3-15.
- Vallacher, R. R., & Wegner, D. M. (1989). Levels of Personal Agency - Individual Variation in Action Identification. *Journal of Personality and Social Psychology, 57*(4), 660-671.

- Vallerand, R. J. (2007). Intrinsic and extrinsic motivation in sport and physical activity: A review and a look at the future. In G. Tenenbaum & R. C. Eklund (Eds.), *Handbook of Sport Psychology* (p. 59–83). John Wiley & Sons, Inc..
- Warburton, D. E. R., & Bredin, S. S. D. (2017). Health benefits of physical activity: a systematic review of current systematic reviews. *Current Opinion in Cardiology*, 32(5), 541-556.
- Wegner, D. M., Vallacher, R. R., Kiersted, G. W., & Dizadji, D. (1986). Action Identification in the Emergence of Social-Behavior. *Social Cognition*, 4(1), 18-38.
- Werle, C., Wansink, B., & Payne, C. (2015). Is it fun or exercise? The framing of physical activity biases subsequent snacking. *Marketing Letters*, 26(4), 691-702.
- Wiltermuth, S. S. (2011). Too Much Information: The Perils of Nondiagnostic Information in Negotiations. *Journal of Applied Psychology*, 96(1), 192-202.
- World Health Organization (2010). *Global Recommendations on Physical Activity for Health*. Retrieved from https://www.who.int/dietphysicalactivity/factsheet_recommendations/en/
- World Health Organization (2020). *WHO guidelines on physical activity and sedentary behaviour: at a glance*. Retrieved from: <https://www.who.int/publications/i/item/9789240014886>