Cognitive fatigue, humor, and physical activity: A field experiment testing whether humorous messages promote walking in cognitively fatigued individuals.

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Abstract

Despite the success of humorous messages in various health interventions, its role in promoting physical activity (PA) remains understudied. This study addresses this gap by investigating the effectiveness of humorous messages in a 2-week smartphone-based intervention aimed at promoting walking behavior, particularly amongst cognitively fatigued individuals. Female participants (n = 57; M_{age} = 32.00; SD = 4.385) received humorous, nonhumorous, or a mix of both messages (in the form of memes) via a study-specific application, with cognitive fatigue measured daily. Panel linear regression models revealed a significant positive interaction between cognitive fatigue and message type. Our results suggest that the resilience of humorous messages to cognitive fatigue and their potential as motivational tools position them as a more robust choice for promoting PA. Importantly, when cognitively fatigued individuals received humorous messages, their walking behaviors showed no significant change, in contrast to the detrimental impact of nonhumorous messages on exercise. Recognizing the differential effects of cognitive fatigue on message effectiveness and considering the potential of humorous messages as motivational tools offers a valuable perspective for tailoring interventions to individual states.

Keywords: cognitive fatigue; humor; physical activity (PA); field experiment; message design

Cognitive Fatigue, Humor, and Physical Activity: A Field Experiment Testing Whether Humorous Messages Promote Walking in Cognitively Fatigued Individuals

Physical inactivity is a worldwide health problem because it causes preventable diseases and shortens life expectancy (WHO, 2020). For this reason, several smartphone health interventions exist to increase physical activity (PA) behaviors, such as walking (Hardeman et al., 2019). These interventions often use cues or prompts as message notifications to motivate users to walk (Prestwich et al., 2010). These messages may or may not be based on existing literature (Middelweerd et al., 2014). However, an example of well-researched techniques often used in these messages are behavior change techniques, such as goal setting or social support (Michie et al., 2015). Another strategy with potentially persuasive powers to change behaviors is the implementation of humor in these exercise-promoting messages (Blanc & Brigaud, 2014). Humor makes it possible to step away from merely persuasive and educational purposes (Lister et al., 2015) and focus on the user's engagement with the platform and subsequently with the proposed behavior (Molina & Sundar, 2020).

Moreover, humor may overcome a frequently encountered barrier in regular PA engagement, namely cognitive fatigue (Marcora et al., 2009). Cognitive fatigue is known to impede engagement in exercising because it alters our perception of effort, making exercise seem more effortful than it is (Zering et al., 2017). The main hypothesis under examination in this study posits that humorous messages are more effective than nonhumorous messages in motivating individuals experiencing cognitive fatigue to engage in walking. This potential effectiveness is attributed to the ability of humorous messages to influence individuals' perceived cognitive fatigue (Clarkson et al., 2016; Djambaska et al., 2016). For instance, humor has been found to reduce reactance and increase message effectiveness in a variety of

studies (Jäger & Eisend, 2013; Moyer-Gusé et al., 2018; Nabi, 2016; Skalski et al., 2009). We aimed to examine whether humorous messages can effectively motivate individuals experiencing cognitive fatigue to walk. The study was conducted through a field experiment utilizing WearAware, a smartphone application designed explicitly for this purpose, which transmits messages and collects activity data from a wearable tracker.

Background

Physical Inactivity

The WHO defines PA as "any bodily movement produced by skeletal muscles that requires energy expenditure" (for an overview, see WHO, 2020). Furthermore, the WHO provides guidelines to define how much PA is needed for good health based on age . Adults aged between 18 and 64 years should engage in at least 150 min of moderate-intensity physical activities or at least 75 min of vigorous-intensity physical activities per week. Globally, one in four adults does not meet these recommendations and therefore is called insufficiently active (WHO, 2020).

In Belgium, approximately 60% of the total population is physically inactive at all ages, of whom 75% are women (Healthy Belgium, 2022). Further, a significant decline in PA is observed during the transition from emerging adulthood to adulthood (Arnett, 2007; Healthy Belgium, 2022). Before the age of 25, 37.4% of women are sufficiently active. In contrast, only 26.8% of women are sufficiently active between the ages of 25 and 34, and only 27.9% are sufficiently active between the ages of 35 and 44. These percentages are approximately 15% and 10% higher for men, respectively (Healthy Belgium, 2022).

Overall, it is important to build an exercise routine before reaching the age of 40, as our bodies naturally start to decline in middle age: Our muscles begin to lose mass and elasticity, which slows down our metabolism and makes it easier to gain weight (Aarts et al., 1997; Rich, 2020). In turn, weight gain increases the risks of heart disease, high blood

pressure, diabetes, and other health issues. Moreover, building an exercise routine is especially important for women, as higher levels of exercise before pregnancy (and in early pregnancy) are associated with significantly lower risks of developing gestational diabetes (Tobias et al., 2011). Furthermore, higher levels of PA reduce the chances of cervical cancer (Szender et al., 2016). Additionally, when transitioning into menopause, women with a regular exercise routine experience lower levels of stress, anxiety, and depression compared to insufficiently active women (Nelson et al., 2008).

Consequently, enhancing PA behaviors amongst inactive women aged between 25 and 40 is paramount. To help increase PA behaviors within this group, we designed and evaluated humorous and nonhumorous messages employing a field experiment using a research-based smartphone application.

Smartphone-Based Interventions

People increasingly rely on communication tools such as sports and health apps with accompanying wearable technologies to promote their health and well-being (Vandendriessche et al., 2020). Subsequently, a growing body of literature has recognized the effectiveness of smartphone-based PA interventions with or without wearables (Emberson et al., 2021; Gal et al., 2018; Schoeppe et al., 2016; Stephenson et al., 2017). However, studies have repeatedly highlighted high abandonment rates, explaining that the initial eagerness to use apps eventually plummets (Krebs & Duncan, 2015), even though 39% of users say that using health apps or wearables has helped them live a healthier and more active life (Vandendriessche et al., 2020). For this reason, Molina and Sundar (2020) argued that there is a need to implement communication strategies in the design of these apps to sustain user engagement, which in turn affects the promotion of behavior change. One way of achieving more sustained user engagement that leads to increased PA behaviors is to research, develop, and test evidence-based PA messages for these apps (Bergeron et al., 2019).

PA-Promoting Messages

In contrast to evaluating the overall effectiveness of health apps (Coughlin et al., 2016), messaging strategies in smartphone-based health interventions have received limited attention. This is surprising, as technological advancements create new targeting and content tailoring opportunities within PA messages. Targeted interventions focus on specific individuals or specific characteristics of individuals—for instance, inactive people—whereas tailoring involves adapting messages to each specific individual (Hawkins et al., 2008). Smartphones equipped with various sensors allow for improved tailored messages, addressing not only external (location: e.g., being at work can be a barrier to go for a walk) but also internal (emotional state) barriers for a specific individual (Hardeman et al., 2019; Nahum-Shani et al., 2018). Previous studies affirmed the effectiveness of targeted and tailored text messages, especially those considering demographics, such as age, gender, and education, as well as psychosocial variables such as cognitive, emotional, and social factors (Cerin et al., 2017; Head et al., 2013). In addition, PA messages tailored to the user instead of generic automated text reminders are more beneficial (Bidargaddi et al., 2018; Wang, 2015).

PA-Promoting Messages in Smartphone-Based Interventions

Considering the vital role of messages in PA interventions (Bergeron et al., 2019; Maher et al., 2017), there is a need for continued development and evaluation of targeted and tailored activity-promoting messages. Messages adapted to the visual smartphone environment and addressing external/internal barriers are essential (Symons et al., 2022; Lister et al., 2015). Moreover, recent research suggests that interventions should recognize that individuals experience barriers that make it hard for them to engage in physical activities (Lister et al., 2015). Therefore, developers have been called into action to tailor messages to these existing barriers (Lister et al., 2015). A means to achieve this is implementing nontraditional approaches, such as humor, to build appealing messages in an attempt to

empower and engage individuals instead of only being concerned with the more traditional (i.e., educative and persuasive) approaches.

Humor as a Health-Promoting Strategy

Humor, recognized as "fundamentally a communicative activity," has established positive effects (Mesmer-Magnus et al., 2012, p. 157). There is consensus that humor can make individuals feel better emotionally by bringing them from a negative state into a positive state (Djambaska et al., 2016.) As humor makes an audience laugh and promotes happiness, it enhances physical and psychological well-being. It creates a positive mood, which may increase the persuasive effects of messages (Herzog & Strevey, 2008). The overall positive effects of humor are well established in commercial advertising, where humor was found to attract individuals' attention, promote positive attitudes toward ads and their brands, enhance purchase intention, and improve recall of an ad (Eisend, 2011).

In the past 2 decades, humor has been increasingly used in health messaging, where it has been found to reduce reactance and increase message effectiveness (Jäger & Eisend, 2013; Moyer-Gusé et al., 2018; Nabi, 2016; Skalski et al., 2009). In addition, humorous health messages are processed with greater attention than nonhumorous health messages (Weinberger & Gulas, 1992). However, their persuasive power varies and poses potential downsides, such as trivialization (Griskevicius et al., 2010; Moyer-Gusé et al., 2011; Nabi et al., 2007).

Overall, a combination of studies shows that humor has been used to promote health-related variables for several issues, including (binge) drinking (Skalski et al., 2009), organ donation (Weber et al., 2006), vaccine hesitancy (Moyer-Gusé, 2018), sexual health (Collins, 2003), healthy eating (Bleakley et al., 2015; Brown, 2020), smoking (Abril et al., 2017; Granado-Font, 2018), cancer self-examination (Nabi, 2016), and mental illness (Wright,

2014), as well as speeding, drunk driving, texting, and driving (Jäger & Eisend, 2013) and sun protection (Mukherjee & Dube, 2012), with conditional effectiveness.

Humor in PA Interventions

Research on PA interventions using humor is relatively limited. While certain studies mentioned in Bottorff and colleagues' systematic review (2015) highlight the positive reception of humor in PA-promoting interventions for adult men, a comprehensive examination of humor's impact in these interventions is lacking. Additionally, Morton and colleagues (2015) focused on an application using evidence-based text messages for PA promotion among high-risk type two diabetes patients. Despite participants' suggestions for incorporating humor into feedback messages, the explicit exploration of humor's effectiveness in these interventions remains unaddressed (Symons, 2022). Given the positive outcomes reported in health-promoting literature on humor and the existing research gap concerning humor in PA interventions, the question arises as to whether humor can be used effectively within PA interventions.

Memes as a Humor Format

A particular type of message has been proven effective in health interventions, namely (self-created) humorous internet memes (Kostygina et al., 2020). Internet memes are multimodal texts, usually pictures that include verbal aspects with a playful spirit that is humoristic, parodistic, or satirical (Marino, 2015). According to Shifman (2012), an internet meme can consist of one to three attributes to make it humorous: playfulness, incongruity, and/or superiority. This study is focused on the playful aspect of internet memes, as we wanted the visuals to be attractive to a wide audience. Playfulness refers to a humorously crafted image in which the humor is appreciated for its own sake (Shifman, 2012). Hence, we focused on humorous cat memes. Due to their prominent features, cats can be easily anthropomorphized, iconized, and made to embody human feelings and behaviors in a

humoristic fashion accessible to a broad audience (Thibault & Marino, 2018). In addition, humorous cat memes have been effectively used in content design strategies (Kostygina et al., 2020) and health campaigns, such as the CAT-mageddon antismoking campaign (Alfonso, 2016). The latter study featured cat memes and generated the second-highest user engagement (preceded by a social influencer campaign).

Research on humor in PA interventions is limited (Bottorff et al., 2015; Morton et al., 2015), creating a gap in understanding its effectiveness. Our study is intended to fill this gap, focusing on humorous cat memes as an innovative, visually appealing approach within PA interventions. Based on this knowledge, we hypothesize the following:

> H_1: A humorous message (i.e., cat memes) encouraging PA behaviors (i.e., walking) will have a more positive effect on PA (as operationalized by more steps taken in 60 min after receiving a message) than a nonhumorous message encouraging PA activity (as operationalized by fewer steps taken in 60 min after receiving a message).

Additionally, surprise is a crucial component of humor (Alden et al., 2000), and anticipating a message as funny might lessen the surprise, diminishing the humor experience. Further, Yousef et al. (2021) demonstrated that a combination of positive and negative appeals, as opposed to relying solely on one type, is more effective in changing behavior compared to informational appeals. To explore these concepts, we investigated whether there was a distinction in outcomes when individuals receive exclusively humorous or nonhumor messages versus a mix of both:

> H_2: Consistently receiving the same type of messages (humorous or nonhumorous) will be less effective at encouraging PA (as operationalized by fewer steps taken in 60 min after receiving a message) than receiving an alternation of (humorous and nonhumorous) messages (as operationalized by more steps taken in 60 min after receiving a message).

Cognitive Fatigue

A frequently encountered barrier when individuals try to establish a regular exercise routine is fatigue (Zheng et al., 2010), encompassing a combination of physical and cognitive fatigue (Chalder et al., 1993). Physical fatigue, also known as peripheral fatigue, results from repeated muscle actions (Mizuno et al., 2011). Cognitive or central fatigue resembles "a failure to initiate and/or sustain tasks that require self-motivation and internal cues" (Leavitt & DeLuca, 2010, p. 6).

Cognitive fatigue mainly occurs after performing a mentally demanding task for a prolonged time (Herlambang et al., 2021). Because PA is an effortful activity requiring energy, it is often hard for fatigued individuals, particularly cognitively fatigued individuals, to initiate and maintain PA when energy is depleted (Sonnentag, 2018). Energetic resources are often depicted as a battery that can be depleted and, therefore, must be recharged (Anseel, 2021). The depletion of this battery manifests itself in feelings of exhaustion and cognitive tiredness (Zohar et al., 2003). Niermann and colleagues (2016) found that high levels of cognitive fatigue and low levels of vigor in the afternoon predicted a reduced likelihood of PA after work, using objective and subjective methods to measure PA, namely accelerometers and self-reported questions.

Cognitive fatigue results in lower levels of PA because of higher perceptions of effort (Zering et al., 2017; Marcora et al., 2009). Higher perceptions of effort lower exercise performance, and exertion perception influences intended exercise intensity and the willingness to invest in an exercise routine (Brown & Bray, 2019). For instance, Harris and Bray (2019) found that increased levels of cognitive fatigue led to lower benefits versus cost scores, decreasing participants' likelihood to engage in physical exercise. These findings suggest that individuals' physical performance is significantly impaired and that they deliberately plan to invest less effort in exercise when feeling cognitively fatigued (see also

the systematic review of Van Cutsem et al., 2017). Therefore, we suggest that cognitive fatigue negatively influences PA behaviors:

> H_3: Cognitive fatigue will negatively influence PA behaviors (as operationalized by fewer steps taken in 60 min after receiving a message).

Humorous Messages and Cognitive Fatigue

There are reasons to assume that humorous messages can be especially persuasive in motivating cognitively fatigued individuals. Humorous messages can elicit a positive mood (Djambaska et al., 2016), which is found to alter individuals' evaluations of their experienced cognitive fatigue (Clarkson et al., 2016), and, according to the meta-analysis of Cameron and colleagues (2015), positive mood interventions engender more favorable outcome expectancies concerning PA. Additionally, altering people's perceptions of cognitive fatigue by inducing a positive state counteracts the effects of cognitive fatigue and leads to replenishment (Thayer, 1987; Tice et al., 2007). For instance, Egan and Hirt (2015) found that when participants undertook a cognitively fatiguing task and were afterward induced to a positive state, their perceptions of cognitive fatigue were significantly lower than those of participants who were induced to a negative state. Moreover, the level of perceived cognitive fatigue of participants who experienced the positive state did not differ significantly from participants not exposed to a fatiguing cognitive task (control condition).

Additionally, when a user's cognitive capacity is reduced due to cognitive fatigue (Clarkson et al., 2016), they expend less effort in seeing, reading, and interpreting messages (Diamond et al., 2008). As a result, an easier, more surprising (and thus, humorous) message might be more effective in enhancing behaviors than a more serious or nonhumorous message (van Dantzig et al., 2018). The combination of the effectiveness of humorous messages in health interventions and the potential to alter individuals' evaluation of their experienced cognitive fatigue leads us to the following hypothesis:

H_4: The effects of humorous messages (i.e., cat memes) on PA behaviors (i.e., walking) will be moderated by cognitive fatigue so that humorous messages are more effective (as operationalized by more steps taken in 60 min after receiving a message) in fatigued women compared to nonfatigued women (i.e., the difference between humorous and nonhumorous messages will increase when cognitive fatigue increases).

Study Contributions

Focusing on the underexplored realm of humor in PA interventions, we investigated the effectiveness of humorous cat memes sent through a mobile phone application in promoting walking behaviors. Considering the significant barrier of cognitive fatigue in establishing a regular exercise routine, our study delves into its negative influence on PA behaviors. Exploring the interplay between humorous messages and cognitive fatigue, we investigated whether humorous messages can be particularly persuasive in motivating cognitively fatigued individuals. Our understanding of the dynamics among humor, cognitive fatigue, and PA behaviors will create opportunities for refining future intervention strategies. Overall, our study addresses critical gaps in the literature and contributes valuable insights to the design of effective and innovative PA-promoting interventions.

Methods

Participants

Female participants were recruited through social media. A social media influencer, @HealthyHabits.Clien (approximately 70,000 followers as of June 2021), who promotes a healthy lifestyle through intuitive eating, agreed to share a post in her Instagram story for free with the request to participate in this scientific study. It was communicated that five vouchers of €125 would be drawn among the participants who completed at least 80% of the study tasks to reach a higher number of participants. We decided to contact an influencer for two

reasons: First, she could quickly engage the right target audience, as her followers aligned with the demographic we were targeting; second, it was a cost-effective strategy. She merely communicated our need for participants in one story without requesting payment.

Interested individuals could swipe up and answer some questions via an online survey to determine their eligibility to participate in this study. Firstly, participants had to have Android as an operating system on their smartphones, as the research application—specifically developed for this study—only operated on Android. Android was chosen as the operating system because it is the most widely used in Belgium (StatCounter, 2024). Secondly, participants needed to be able to read, speak, and understand the Dutch language, as the application and stimulus materials were designed and pretested in Dutch. Thirdly, participants could not have participated in previous studies (pretests or pilot study; see below). Lastly, women had to be between 25 and 40 years old and inactive (as per WHO's definition of inactivity—see Background). The latter was assessed by three self-reported questions (Symons et al., 2022). Only women who answered that they exercised less than 150 min at moderate intensity, less than 75 min at a vigorous intensity, and sat for 50% of the time or more during working hours were selected. At the conclusion of this online questionnaire, individuals interested in participating further could provide their email addresses through a separate form to ensure their personal information remained distinct from their anonymous responses. It was made clear that future participation was voluntary.

In this way, the researchers were able to contact the qualified candidates: 421 eligible individuals who provided their e-mail addresses were randomly selected and contacted by e-mail to participate in the main study. When 63 individuals agreed to participate, the maximum number of available Fitbits was reached, and further invitations to participate were halted. During the study, two participants canceled their participation. After finalizing the data collection, four participants were omitted from the database due to a high proportion of

missing data. Ultimately, the sample consisted of 57 women from Flanders, the Dutch-speaking part of Belgium.

Research-Based Application: WearAware

WearAware is an Android-operated smartphone application developed for this study (see Appendix A, p. 48). Participants downloaded WearAware through the Play Store. After downloading the application, the participants entered the login screen. Researchers provided each participant an anonymous login ID randomly, and after filling in these details, the application asked to connect to the Fitbit tracker. As such, the steps taken according to the trackers could be linked to the assigned login ID instead of linking the data to the participants, ensuring anonymous participation.

Additionally, WearAware divided the participants randomly into three groups (without the interference of the researchers): one group consistently receiving humorous messages, another group consistently receiving nonhumorous messages, and the last group receiving a mix of humorous and nonhumorous messages. On the back end, researchers were able to observe that, for instance, ID 1 was assigned to Group B. The only thing participants could do within the WearAware application was to consult their steps if they wanted to. However, the WearAware application provided (a) prompts to self-report cognitive fatigue and (b) on-screen (humorous and/or nonhumorous) messages to encourage walking behaviors. As the WearAware application was connected to the activity trackers, the researchers were able to see the number of steps taken within a period of 1 hr before and 1 hr after each specific message at the back end of the application.

Self-Report Prompts

The WearAware application sent a notification to signal a prompt to report one's cognitive energy level. Upon the survey notification being delivered, participants were instructed to stop their current activity and complete this short questionnaire. Participants

were asked to answer the question on a scale that used a smiley face, similar to the mood-tracking application Daylio (2022), which represents a 5-point Likert scale from 1 (*no mental energy at all*) to 5 (*much mental energy*). Participants expressed confusion when reporting mental fatigue levels instead of energy levels in the pilot study (as detailed below), so energy levels were subsequently assessed; however, the items were reversely coded afterward. Participants were prompted with this question three times per day: during the morning (9:30 AM–10:30 AM), in the afternoon (1:30 PM–2:30 PM), and in the evening (5:30 PM–6:30 PM). These 1-hr timeframes were chosen to prevent expectancy effects (Schwerdtfeger et al., 2010). As previous research has shown that fatigue fluctuates with the time of day (Millar, 2017), this frequency was chosen to ensure adequate spacing throughout the day (Dunton et al., 2014). According to the systematic review by Degroote et al. (2020), most studies use a prompt frequency between two and ten prompts a day. As the WearAware application also sent three cues a day to engage in PA behaviors (Ben-Zeev et al., 2013), it was necessary to carefully select intervention points, considering the burden and the need for uncompromised quality of measurements (Nahum-Shani et al., 2018). When a participant could not answer the questions before a subsequent survey, the survey would disappear and remain unanswered. In addition, day of the week and past walking behaviors are important moderators for moderate-intensity PA behaviors, which we also controlled for in this study (Cerin et al., 2017).

PA Messages

As mentioned, WearAware sent messages to encourage individuals to walk. The content of the humorous messages consisted of cats stimulating individuals to walk. The nonhumorous messages consisted of the same texts as the humorous pictures. However, they depicted a neutral white sneaker instead of a cat (see Appendix B, p. 49). In the back end of the application, researchers could see if the messages were humorous or nonhumorous. These messages were also sent within predefined time frames before each survey: morning (7AM–

9AM), noon (11AM–1PM), and afternoon (3PM–5PM). The participants' steps taken before and after each message (within the time frame of 1 hr) were saved by the WearAware application and downloaded into a database after the study. The WearAware application was designed so that messages and prompts could not overlap. Messages and prompts that were ignored were stored as missing data.

Procedure: Preliminary Assessments

This study followed APA Ethical Guidelines for research with human subjects and received approval from the first author's University Ethics Committee for the Social Sciences and Humanities on the 14th of June 2021 (SHW_18_81).

Pretest I (Monday, March 8th, 2021–Monday, March 22nd, 2021)

The first pretest was intended to assess the stimulus materials (humorous messages). Respondents (n = 71, M_{Age} = 28; SD = 5.28; all females; all sedentary; all inactive) were recruited utilizing snowball sampling, starting with the researchers' personal networks. No incentive was given. Each respondent was randomly exposed to five humorous cat pictures (out of 52) and had to evaluate these pictures based on perceived humor on a 7-point Likert Scale (Nabi et al., 2007). One-sample t-tests showed that all 52 pictures scored, on average, higher than the neutral value of four on perceived humor (M = 4.20; SD = 0.88; $t(406)$ = 4.323; $p < .001$). The 28 highest scoring pictures were selected for the pilot study, providing four unique messages per day over the course of 1 week with no repetition (Kim & Cappella, 2019).

Pilot Study (Monday, March 29th, 2021–Sunday, April 4th, 2021)

The pilot study was intended to review and evaluate WearAware. Participants (n = 7, M_{Age} = 34; SD = 4.53; all females; all sedentary; all inactive; did not participate in the previous study) were recruited via posts in Facebook groups, and no incentive was given. The post was shared in location-based Facebook Groups (e.g., People living in

Antwerp/Limburg/West-Vlaanderen) to reach people from different regions. The post explained that we sought inactive and sedentary women aged between 25 and 40. Plausible participants also needed to confirm they belonged to this group beforehand in a survey (see Participants section). When entering the pilot study, participants were randomly divided into groups that received humorous messages or nonhumorous messages from WearAware. As we specifically wanted to examine the presence of differences based on the stimulus materials (by questioning the messages afterward), there was no mixed group in the pilot study.

After 1 week of using WearAware with Fitbit, participants were interviewed about their experiences. Based on this pilot study, the researchers decided that setting up all Fitbits in advance was necessary, as this was an obstacle for most participants. In addition, participants indicated that they started using the Fitbit application due to frequent notifications. Hence, it was decided to disable all functionalities and notifications during the definite study and consequently stress that Fitbit was only used as a measuring device. Further, the survey questions' answering format, the messages' time frames, and the number of messages were adapted for the definitive study following the participants' feedback. Lastly, participants in the humor group indicated that overall, the messages were funny, unlike the nonhumorous group, which did not indicate that the messages were funny. New messages were developed corresponding to participants' suggestions. All participants liked the application's design and stated that WearAware was user-friendly.

Pretest II (Friday, June 18th, 2021–Wednesday, June 30th, 2021)

The purpose of this second pretest was again to assess the stimulus materials, this time not only reviewing the materials but also understanding if the difference between the humorous and nonhumorous pictures was sufficient to accomplish the objective of the messages. Respondents (n = 149) who participated in this second pretest were all female and, on average, 37 years old (SD = 12.81). This sample was again reached by sharing a post in

several location-based Facebook groups, no incentive was given, and participants were not allowed to have participated in any of the previous studies. Most, but not all, people indicated they were sedentary and inactive. Each respondent was randomly exposed to six pictures out of 124 (initial and new pictures based on feedback from the pilot study); three humorous pictures depicted a cat and three nonhumorous pictures depicted a neutral white sports shoe. For the evaluation, respondents only received unrelated humorous and nonhumorous messages (i.e., six different messages). To assess if the stimulus materials satisfied the requirements, respondents were asked to rate how humorous, motivating, surprising, and cute all messages were (on a 5-point scale ranging from *not at all* to *a lot*). Surprise has been found to influence perceived humor positively (Alden et al., 2000), and cat images are often seen as cute (Dale et al., 2016; Myrick et al., 2021). To ensure the selected images did not score higher on cuteness than on humor, we added the perceived cuteness of the message as a control question. Twenty-one humorous pictures (three messages a day for 1 week with no repeated messages) that scored the highest on humor, motivation, surprise, and cuteness, and at the same time had the highest distinction on the same scores for the nonhumorous messages, were selected for the intervention. Messages that scored high on humor in the previous pretest were selected first (Kim & Cappella, 2019).

Procedure: Intervention (Monday, July 5th, 2021–Sunday, July 18th, 2021)

This field experiment lasted 2 full weeks (10 working days and 4 weekend days). the Fitbits were sent to the participants before the start of the first week. Upon the arrival of the Fitbits, which already contained the anonymous login data, participants were asked to complete an anonymous survey online to indicate their sex and year of birth, distributed via Qualtrics. At the start of the survey, they were asked to fill in their anonymous login ID to link this data to the WearAware data. It was communicated that the participants had to wear the Fitbit exclusively as a measuring device (all functionalities were disabled). During the

baseline week, participants could get used to wearing a Fitbit. During the intervention week of the study, participants were asked to install the self-made research application WearAware. After these two weeks of observation, participants were told they could use the Fitbits to their full potential (without disabling functionalities) or send them back to the researchers.

Measures

Cognitive Fatigue. Cognitive fatigue was measured by the question, "To what extent are you feeling mentally energetic?" As mentioned, items were reversely coded afterward. Following the systematic review of Degroote et al. (2020), validated fatigue scales cannot be used in real-time assessments. As such, we relied upon a one-item measurement, also used in previous ecological momentary assessment studies (Burke & Naylor, 2020; Hacker & Ferrans, 2007). The chosen item was based on a validated scale and pretested in the pilot study to ensure the validity and reliability of the fatigue measurement (Michielsen et al., 2002). In addition, mental or cognitive energy was explained in advance to the participants. However, similar information about the concept and the question could be obtained by pressing the information symbol while answering the question.

Time of Day, Steps Taken Within 60 Min Before the Message, and Steps Taken Within 60 Min After the Message (DV). The messages encouraging individuals to walk were sent within three time frames, later coded as morning = 0, noon = 1, and evening = 2. As this variable is not linear, two dummy variables (noon and afternoon) were necessary, using morning as an indicator. The participants' steps taken within 1 hr before and after each message were saved by the WearAware application and downloaded into a database after the study.

Message Type. Within the same database, it was recorded if the message that the participant received on a specific moment was humorous = 1 or nonhumorous = 0.

Consistency. As previously mentioned, participants were randomly divided into three groups. The consistency variable indicates whether participants consistently received the same type of message, either consistently humorous or nonhumorous (coded as 1) or a mix of humorous and nonhumorous (coded as 0).

Day of the Week and Average Steps During the Baseline Week. The first variable was based on the day of the week; Monday through Friday were coded as 0 and Saturday to Sunday as 1. The intermediate steps during the baseline week were calculated based on the data retrieved from Fitbit.

Results

Sample

Descriptive statistics were computed at an individual level. Participants (n = 57) were all female, on average 32 years (M_{age} = 32.00; SD = 4.385) old, with a minimum age of 25 and a maximum age of 40.

Intervention

To test our four hypotheses, four linear regression models were estimated (Table 1). The data were analyzed as panel data clustered among participants to account for the heterogeneity of the results stemming from individual differences between participants. In other words, each exposure to a message is not an independent observation; instead, participants serve as panels that contain all the exposures they received throughout the study. GLS-random effects models were performed with Stata 17 software. Using this method meant that no information was lost, as it would have been when aggregating PA points and survey answers of multiple participants into single data points.

[insert Table 1 (p. 51) near here]

Hypothesis 1: Model 1

Model 1 investigated the main effect of message type (humorous) and control variables: steps taken within 60 min before the message, the average steps taken in the baseline week, the time of the day (noon and afternoon/evening compared to morning), and the reception of messages during a week or weekend day (weekend). Model 1 tested whether a humorous message encouraging walking had a more positive effect on walking behaviors than a nonhumorous message. The model (χ^2 [6, N^1 = 55] = 97.56, $p < .000$) revealed that there was no main effect of message type (humorous messages) on walking behavior (i.e., steps taken within 60 min after the message; β = -53.04, SE = 42.88, t = -1.237, p = .216). As a result, the first hypothesis (that humorous messages have a more positive effect on walking behaviors than nonhumorous messages) was rejected. Steps taken within 60 min before the message (β = 0.29, SE = 0.04, t = 8.306, $p < .000$), the time of day (i.e., afternoon compared to morning; β = 103.54, SE = 50.52, t = 2.049, $p < .050$), and the day of the week (i.e., weekend days; β = 160.73, SE = 47.52, t = 3.383, $p < .000$) were significant predictors of walking behavior (steps taken within 60 min after the message). However, average steps taken in the baseline week (β = 0.00, SE = 0.01, t = 0.541, p = .589) and time of day (i.e., noon compared to morning; β = 31.27, SE = 47.00, t = 0.665, p = .506) were not. These results demonstrate that when the messages were received and if participants were already engaging in more active behaviors before receiving an encouraging message (or not) significantly influenced walking behaviors after receiving a message. Messages received later in the day (compared to the morning) and during the weekend positively influenced walking behaviors and steps that had already been taken within 60 min before receiving an encouraging message.

[1] N = number of groups (i.e., number of participants and not number of observations).

Hypothesis 2: Model 2

Model 2 tested the same predictors while exploring whether receiving humorous versus alternating humorous and nonhumorous messages changed behavior to test the second hypothesis that consistently receiving the same type of messages (humorous or nonhumorous) would be less effective on walking behaviors than receiving an alternation of (humorous and nonhumorous) messages. The consistency variable and an interaction term between message type and consistency were added to Model 1 to analyze this. An interaction term based on message type (humor = 1) and consistency (same type of messages = 1) was made to isolate consistently receiving humorous messages within the model. Model 2 shows (χ^2 [8, N = 55] = 99.29, p < .000), with a positive insignificant interaction, that humor's effect is not dependent on consistently receiving humorous or altering humorous and nonhumorous messages (β = 13.07, SE = 86.80, t = 0.151, p = .880). Therefore, the second hypothesis was rejected. In this way, the second model gives an extra dimension to Model 1. Moreover, humorous messages were not more effective than nonhumorous messages (β = -61.92, SE = 67.41, t = -0.919, p = .358).

Hypothesis 3: Model 3

Model 3 investigated the main effects of cognitive fatigue, examining if it negatively influences walking. The model (χ^2 [9, N = 55] = 88.24, p < .000) revealed that there was a nonsignificant (negative) main effect of cognitive fatigue on walking behavior (i.e., steps taken within 60 min after the message; β = -43.07, SE = 22.74, t = -1.894, p = .058), meaning that cognitive fatigue did not significantly influence walking behaviors. Therefore, the third hypothesis was rejected.

Hypothesis 4: Model 4

Model 4 tested the interaction effects between cognitive fatigue and message type. Based on message type (humor = 1) and cognitive fatigue (1 = low levels of cognitive fatigue,

5 = high levels of cognitive fatigue), an interaction term was made to examine the interaction between humorous messages and levels of perceived cognitive fatigue. Based on this interaction term, the model investigated if the effects of humorous messages on walking behaviors would be moderated by cognitive fatigue so that humorous messages were more effective in cognitively fatigued people. The model (χ^2 [10, N = 55) = 95.49 p < .000) showed a significant interaction term between cognitive fatigue and message type (β = 115.55, SE = 44.98, t = 2.569, p < .010). In order to establish whether this interaction was driven by humor increasing steps when cognitive fatigue increased (see Figure 1) or nonhumorous messages failing to increase them as mental fatigue increased (or both), we created two follow-up models.

[insert Figure 1 (p. 53) near here]

As such, we recreated the final model (DV = steps taken within 60 min after the message; predictors: steps taken within 60 min before the message, average steps baseline week, time of day [noon], time of the day [weekend], and cognitive fatigue) for humorous messages only, and after that, for nonhumorous messages only. Based on the first (humor) model (χ^2 [6, N = 40] = 72.74 p < .000), cognitive fatigue is not a significant predictor for humorous messages (β = -2.95, SE = 28.51, t = -0.104, p = .918); see Table 2. However, based on the second (nonhumor) model (χ^2 [6, N = 33] = 38.30 p < .000), cognitive fatigue is a significant predictor for nonhumorous messages (β = -105.92, SE = 37.02, t = -2.861, p < .000); see Table 3. These findings indicate that nonhumorous messages decrease in effectiveness when cognitive fatigue rises. In contrast, humorous messages did not change walking behaviors based on levels of cognitive fatigue. As such, humorous messages are not more effective in increasing steps when individuals feel cognitively fatigued; therefore, our last hypothesis is rejected.

[insert Table 2 (p. 52) near here]

[insert Table 3 (p. 52) near here]

Discussion

The positive effects of using humor in interventions have already been studied thoroughly in health communication, but empirical evidence in PA interventions is still lacking. For this reason, a field study was conducted to explore if humorous intervention messages would positively affect walking behaviors.

The first hypothesis of this study stated that a humorous message would have a more positive effect on PA than a nonhumorous message (H_1). According to Model 1 in the statistical analysis, we did not find an effect of the messages overall, and we rejected the first hypothesis. These findings show that, overall, quasirandomly sending messages and only differentiating messages between humorous or nonhumorous content might be insufficient to persuade individuals to walk (timing and appropriateness). Therefore, deeper tailoring of the messages remains necessary. This aligns with Wang's study (2015), which demonstrated that simply adding messages to self-monitoring systems is ineffective. As such, message designers need to consider individual characteristics, such as environmental and personal determinants, to tailor messages to users' specific needs at the specific moment a message is sent (Brug et al., 2012; Nahum-Shani et al., 2018). As such, researchers could consider tailoring the messages to specific subgroups of participants instead of sending rather generic humorous versus nonhumorous messages to a larger group. For instance, future studies can implement humorous messages specifically designed to highlight the mental health benefits for individuals who report feeling stressed right after work, sending these messages when they stop working or arrive at home after work (relevance to personal experience).

Additionally, no differences were found between consistently receiving the same type of messages (humorous or nonhumorous) and receiving an alternation of (humorous and nonhumorous) messages (H_2), thereby also causing us to reject the second hypothesis. These

results are in contrast with the results of Yousef et al. (2021), who found that a combination of appeals (a mix of positive and negative messages) in contrast to solely using informational appeals was most effective in promoting behavior change. A possible explanation as to why we did not find similar results may be that variations in messages might have resulted in inconsistent messaging, which can be confusing or frustrating for people seeking to maintain a regular exercise routine, as inconsistency, dissonance, and predictability play roles in behavior (Thaler & Sunstein, 2009). Users may find it challenging to know what to do or how to proceed as a result. Moreover, a person may not be effectively motivated or inspired to act if the various messages are irrelevant to their unique goals or needs, as motivational aspects and a mismatch with emotional flow can hinder engagement (Kreuter et al., 2013). As a result, messages may be disregarded or ignored, which lessens their total effectiveness. Instead of developing a single set of (humorous vs. nonhumorous) messages, future interventions could create a library of messages whereby each message can be tailored to individuals' specific needs and preferences. As such, message relevance would increase, even when messages are varied (individual preferences and relevance to personal experience).

Further, we hypothesized that feeling cognitively fatigued would negatively influence walking behaviors (H_3). Although feelings of cognitive fatigue resulted in fewer steps, this relation was not significant. This finding is contrary to previous studies, which have suggested that cognitive fatigue negatively influences PA behaviors, with individuals more explicitly engaging in lower levels of exercise duration, intention, and willingness to perform the behavior (Brown & Bray, 2019; Marcora et al., 2009; Martin Ginis & Bray, 2010; Van Cutsem et al., 2017). While past studies manipulated subjects to be cognitively fatigued before examining the relationship with exercise (e.g., Marcora et al., 2009), we aimed to capture cognitive fatigue on an everyday basis. Therefore, we can only conclude that the average cognitive fatigue experienced by the average participant in this field experiment was

not significant enough to influence walking behaviors. It is undisputed that cognitive fatigue negatively affects PA behaviors (Marcora et al., 2009; Brown & Bray, 2019; Martin Ginis & Bray, 2010; Van Cutsem et al., 2017), yet the level of cognitive fatigue reported by our participants was insufficient to influence walking behaviors on its own.

Lastly, based on the knowledge that humor might be more persuasive when people feel cognitively fatigued, we hypothesized that the effects of humorous messages on walking behaviors would be moderated by cognitive fatigue so that humorous messages would be more effective in fatigued people (H_4). After looking at the direct effects of cognitive fatigue on humorous and nonhumorous messages separately, we found that humorous messages were not effective regardless of the levels of cognitive fatigue but that the effectiveness of nonhumorous messages decreased when cognitive fatigue increased, prompting us to reject our last hypothesis. It is not the case that humorous messages become more effective when cognitive fatigue increases, but nonhumorous messages become less effective when cognitive fatigue increases, suggesting a complex interplay. Researchers should explore how cognitive fatigue, coping mechanisms, individual differences in humor appreciation, and dynamic message adaptation influence the effectiveness of humor and nonhumor under varying levels of cognitive fatigue. Additionally, investigating the psychophysiological responses and exploring the relevance and alignment of messages with cognitive states could provide insights into the nuanced relationship between cognitive fatigue, message tones, and behavior change.

In conclusion, these theoretical implications advocate for a personalized, tailored approach in designing interventions, moving beyond simplistic distinctions between humorous and nonhumorous messages. As such, future studies should explore how messages varying in emotional valence (positive, negative, neutral) and relevance to personal experiences impact PA behaviors in different demographic or psychological subgroups. The

study emphasizes the importance of message consistency, relevance to personal experiences, and the dynamic interplay between cognitive factors and message effectiveness in the realm of PA interventions. Future studies can examine how different levels of cognitive fatigue interact with emotional responses to messages and subsequent behavior change.

Limitations and Strengths

The current study is subject to certain limitations. For instance, this study consisted of an all-female sample (n = 57). The decision to study only females was made because many uncontrollable confounding variables characterize field experiments. Therefore, we chose to limit the presence of other confounding variables, such as gender and age. This was necessary because the small sample size was dictated by available resources—mainly the number of activity trackers. Furthermore, in terms of generalization, consider that participants in this field study were aware that their PA patterns were being recorded, meaning that they could have behaved differently due to this monitoring, which could have had an impact on the outcomes. Additionally, given that the study was conducted in a specific area with a specific participant group, the findings might not be applicable to other people or locations.

Despite these limitations, unlike lab settings, this field experiment provides valuable insights into designing and testing evidence-based messages in a real-life context, ensuring great ecological validity. Additionally, by using activity trackers and a research-based application to monitor steps, we were able to provide objective data on levels of PA, which is generally more accurate than self-reported information on PA. Further, the WearAware application randomly divided participants into groups, increasing the internal validity of the experiment. Lastly, one of the greatest strengths of this study compared to most controlled experiments is that we accurately measured actual behaviors (with the activity tracker and self-made application) and used these robust data to analyze the effect of the messages on walking behaviors.

Practical Implications

This study reiterates the importance of further targeting and tailoring messages in health interventions (Conroy et al., 2019; Nahum-Shani et al., 2018). It highlights that finding the right moment to send an activity-promoting message remains crucial—considering when to send a message, how individuals feel, and what barriers they might experience (Nahum-Shani et al., 2015). Our study shows that nonhumorous messaging may lessen the effectiveness of PA interventions, especially for people who are cognitively fatigued. Therefore, PA interventions should take cognitive fatigue into consideration, as it can seriously influence how effective intervention messages are. Given more specific tailoring, it can still be interesting to implement humor in existing applications and wearables, such as Fitbit. Messages that each respond to an individual's needs can make a difference in tailored health interventions. As such, these results open the doors to more innovative strategies of health promotion.

Conclusions

Overall, the positive effects of using humor in interventions have already been studied thoroughly in health communication, but empirical evidence in PA interventions was lacking. In this study, we examined how humor could be used in a smartphone-based intervention to encourage walking, which is a crucial component of regular PA. Thus, this study examined how cognitive fatigue impacted the effectiveness of humorous and nonhumorous messages in encouraging walking. The results indicate that these message types are affected differently by cognitive fatigue, with humorous messages being unaffected by cognitive fatigue, in contrast to nonhumorous messages that lose effectiveness as cognitive fatigue increases. This emphasizes how crucial it is to take the effects of cognitive fatigue into account when developing interventions to encourage PA.

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References

Aarts, H., Paulussen, T., & Schaalma, H. (1997). Physical exercise habit: On the conceptualization and formation of habitual health behaviours. *Health Education Research, 12*(3), 363-374. https://doi.org/10.1093/her/12.3.363

Abril, E. P., Szczypka, G., & Emery, S. L. (2017). LMFAO! Humor as a response to fear: Decomposing fear control within the extended parallel process model. *Journal of Broadcasting & Electronic Media, 61*(1), 126-143. https://doi.org/10.1080/08838151.2016.1273921

Alden, D. L., Mukherjee, A., & Hoyer, W. D. (2000). The effects of incongruity, surprise, and positive moderators on perceived humor in television advertising. *Journal of Advertising, 29*(2), 1-15. https://doi.org/10.1080/00913367.2000.10673605

Alden, D. L., Mukherjee, A., & Hoyer, W. D. (2000). Extending a contrast resolution model of humor in television advertising: The role of surprise. *Humor-International Journal of Humor Research, 13*(2), 193-217. https://doi.org/10.1515/humr.2000.13.2.193

Alfonso, F. (2016, February 19). *#CATmageddon: A bold and new approach in anti-smoking campaigns*. https://oneill.law.georgetown.edu/5470-2/

Anseel, F. (2021, March 30). Hoe blijft u weerbaar in 2021*? De Tijd.* https://www.tijd.be/opinie/column/hoe-blijft-u-weerbaar-in-2021/10275399.html

Arnett, J. J. (2007). Emerging adulthood: What is it, and what is it good for? *Child Development Perspectives*, 1(2), 68-73. https://doi.org/10.1111/j.1750-8606.2007.00016.x

Ben-Zeev, D., Kaiser, S. M., Brenner, C. J., Begale, M., Duffecy, J., & Mohr, D. C. (2013, December). Development and usability testing of FOCUS: A smartphone system for self-management of schizophrenia. *Psychiatric Rehabilitation Journal, 36*(4), 289-296. https://doi.org/10.1037/prj0000019

Bergeron, C. D., Tanner, A. H., Friedman, D. B., Zheng, Y., Schrock, C. S., Bornstein, D. B., Segar, M., & Swift, N. (2019). Physical activity communication: A scoping review of the literature. *Health Promotion Practice, 20*(3), 344-353. https://doi.org/10.1177/1524839919834272

Bidargaddi, N., Almirall, D., Murphy, S., Nahum-Shani, I., Kovalcik, M., Pituch, T., Maaieh, H., & Strecher, V. (2018). To prompt or not to prompt? A microrandomized trial of time-varying push notifications to increase proximal engagement with a mobile health app. *JMIR MHealth and UHealth, 6*(11), e10123. https://doi.org/10.2196/10123

Blanc, N., & Brigaud, E. (2014). Humor in print health advertisements: Enhanced attention, privileged recognition, and persuasiveness of preventive messages. *Health Communication, 29*(7), 669-677. https://doi.org/10.1080/10410236.2013.769832

Bleakley, A., Jordan, A. B., Hennessy, M., Glanz, K., Strasser, A., & Vaala, S. (2015). Do emotional appeals in public service advertisements influence adolescents' intention to reduce consumption of sugar-sweetened beverages? *Journal of Health Communication, 20*(8), 938-948. https://doi.org/10.1080/10810730.2015.1018593

Bottorff, J. L., Seaton, C. L., Johnson, S. T., Caperchione, C. M., Oliffe, J. L., More, K., Jaffer-Hirji, H., & Tillotson, S. M. (2015). An updated review of interventions that include promotion of physical activity for adult men. *Sports Medicine, 45*, 775-800. https://doi.org/10.1007/s40279-014-0286-3

Brown, D. M. Y., & Bray, S. R. (2019). Effects of mental fatigue on exercise intentions and behavior. *Annals of Behavioral Medicine, 53*(5), 405-414. https://doi.org/10.1093/abm/kay052

Brug, J., van Assema, P., & Lechner, L. (2012). *Gezondheidsvoorlichting en gedragsverandering: Een planmatige aanpak* (8th ed.). Koninklijke Van Gorcum.

Burke, L. A., & Naylor, G. (2020). Daily-life fatigue in mild to moderate hearing impairment: An ecological momentary assessment study. *Ear and Hearing, 41*(6), 1518–1532. https://doi.org/10.1097/AUD.0000000000000888

Cameron, D. S., Bertenshaw, E. J., & Sheeran, P. (2015). The impact of positive affect on health cognitions and behaviours: A meta-analysis of the experimental evidence. *Health Psychology Review, 9*(3), 345-365. https://doi.org/10.1080/17437199.2014.923164

Cerin, E., Mitáš, J., Cain, K. L., Conway, T. L., Adams, M. A., Schofield, G., Sarmiento, O. L., Reis, R. S., Schipperijn, J., & Davey, R. (2017). Do associations between objectively-assessed physical activity and neighbourhood environment attributes vary by time of the day and day of the week? *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 1-16. https://doi.org/10.1186/s12966-017-0493-z

Chalder, T., Berelowitz, G., Pawlikowska, T., Watts, L., Wessely, S., Wright, D., & Wallace, E. P. (1993). Development of a fatigue scale. *Journal of Psychosomatic Research, 37*(2), 147-153. https://doi.org/10.1016/0022-3999(93)90081-p

Clarkson, J. J., Otto, A. S., Hassey, R., & Hirt, E. R. (2016). Perceived mental fatigue and self-control. In E. R. Hirt, J. J. Clarkson, & L. Jia (Eds.), *Self-regulation and Ego Control* (pp. 185–202). Elsevier Academic Press. https://doi.org/10.1016/B978-0-12-801850-7.00010-X

Conroy, D. E., Hojjatinia, S., Lagoa, C. M., Yang, C.-H., Lanza, S. T., & Smyth, J. M. (2019). Personalized models of physical activity responses to text message micro-interventions: A proof-of-concept application of control systems engineering methods. *Psychology of Sport and Exercise, 41,* 172-180. https://doi.org/10.1016/j.psychsport.2018.06.011

Coughlin, S. S., Whitehead, M., Sheats, J. Q., Mastromonico, J., & Smith, S. (2016). A review of smartphone applications for promoting physical activity. *Jacobs Journal of Community Medicine, 2*(1). https://www.ncbi.nlm.nih.gov/pubmed/27034992

Dale, J. P., Goggin, J., Leyda, J., McIntyre, A. P., & Negra, D. (2016). *The aesthetics and affects of cuteness*. Routledge.

Daylio. (2022). *Daylio mood tracker* [Mobile application software]. https://daylio.net

Degroote, L., DeSmet, A., De Bourdeaudhuij, I., Van Dyck, D., & Crombez, G. (2020). Content validity and methodological considerations in ecological momentary assessment studies on PA and sedentary behaviour: A systematic review. *International Journal of Behavioral Nutrition and PA, 17*(1), 1-13. https://doi.org/10.1186/s12966-020-00932-9

Diamond, B. J., Johnson, S. K., Kaufman, M., & Graves, L. (2008). Relationships between information processing, depression, fatigue and cognition in multiple sclerosis. *Archives of Clinical Neuropsychology, 23*(2), 189-199. https://doi.org/10.1016/j.acn.2007.10.002

Djambaska, A., Petrovska, I., & Bundalevska, E. (2016). Is humor advertising always effective? Parameters for effective use of humor in advertising. *Journal of Management Research, 8*(1), 1-19. https://doi.org/ 10.5296/jmr.v8i1.8419

Dunton, G. F., Huh, J., Leventhal, A. M., Riggs, N., Hedeker, D., Spruijt-Metz, D., & Pentz, M. A. (2014, March). Momentary assessment of affect, physical feeling states, and physical activity in children. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association, 33*(3), 255-263. https://doi.org/10.1037/a0032640

Egan, P. M., & Hirt, E. R. (2015). Flipping the switch: Power, social dominance, and expectancies of mental energy change. *Personality and Social Psychology Bulletin, 41*(3), 336-350. https://doi.org/ 10.1177/0146167214565054

Eisend, M. (2011). How humor in advertising works: A meta-analytic test of alternative models. *Marketing Letters, 22*(2), 115-132. https://doi.org/10.1007/s11002-010-9116-z

Emberson, M. A., Lalande, A., Wang, D., McDonough, D. J., Liu, W., & Gao, Z. (2021). Effectiveness of smartphone-based physical activity interventions on individuals' health

outcomes: A systematic review. *BioMed Research International*, *2021*(1), 6296896. https://doi.org/10.1155/2021/6296896

Gal, R., May, A.M., van Overmeeren, E.J. (2018). The effect of physical activity interventions comprising wearables and smartphone applications on physical activity: A systematic review and meta-analysis. Sports Med – Open, *4*(42), 1-15. https://doi.org/10.1186/s40798-018-0157-9

Granado-Font, E., Ferré-Grau, C., Rey-Reñones, C., Pons-Vigués, M., Pujol Ribera, E., Berenguera, A., Barrera-Uriarte, M. L., Basora, J., Valverde-Trillo, A., Duch, J., & Flores-Mateo, G. (2018). Coping strategies and social support in a mobile phone chat app designed to support smoking cessation: Qualitative analysis. *JMIR mHealth and uHealth*, *6*(12), e11071. https://doi.org/10.2196/11071

Griskevicius, V., Shiota, M. N., & Neufeld, S. L. (2010). Influence of different positive emotions on persuasion processing: A functional evolutionary approach. *Emotion, 10*(2), 190-206. https://doi.org/10.1037/a0018421

Hacker, E. D., & Ferrans, C. E. (2007). Ecological momentary assessment of fatigue in patients receiving intensive cancer therapy. *Journal of Pain and Symptom Management, 33*(3), 267-275. https://doi.org/10.1016/j.jpainsymman.2006.08.007

Hardeman, W., Houghton, J., Lane, K., Jones, A., & Naughton, F. (2019). A systematic review of just-in-time adaptive interventions (JITAIs) to promote PA. *International Journal of Behavioral Nutrition and Physical Activity, 16*(1), 31. https://doi.org/10.1186/s12966-019-0792-7

Harris, S., & Bray, S. R. (2019). Effects of mental fatigue on exercise decision-making. *Psychology of Sport and Exercise, 44*, 1-8. https://doi.org/10.1016/j.psychsport.2019.04.005

Hawkins, R. P., Kreuter, M., Resnicow, K., Fishbein, M., & Dijkstra, A. (2008). Understanding tailoring in communicating about health. *Health education research*, *23*(3), 454–466. https://doi.org/10.1093/her/cyn004

Healthy Belgium. (2022, February*). Physical activity in adults*. Retrieved June 25, 2022, from https://www.healthybelgium.be/en/health-status/determinants-of-health/physical-activity#references

Head, K. J., Noar, S. M., Iannarino, N. T., & Harrington, N. G. (2013). Efficacy of text messaging-based interventions for health promotion: A meta-analysis. *Social Science & Medicine, 97*, 41-48. https://doi.org/10.1016/j.socscimed.2013.08.003

Herlambang, M. B., Cnossen, F., & Taatgen, N. A. (2021). The effects of intrinsic motivation on mental fatigue. *PloS One, 16*(1), e0243754. https://doi.org/10.1371/journal.pone.0243754

Herzog, T. R., & Strevey, S. J. (2008). Contact With Nature, Sense of Humor, and Psychological Wellbeing. *Environment and Behavior, 40*(6), 747-776. https://doi.org/10.1177/0013916507308524

Jäger, T., & Eisend, M. (2013). Effects of fear-arousing and humorous appeals in social marketing advertising: The moderating role of prior attitude toward the advertised behavior. *Journal of Current Issues & Research in Advertising, 34*(1), 125-134. https://doi.org/10.1080/10641734.2013.754718

Kim, M., & Cappella, J. N. (2019). An efficient message evaluation protocol: Two empirical analyses on positional effects and optimal sample size. *Journal of Health Communication*, 24(10), 761–769. https://doi.org/10.1080/10810730.2019.1668090

Kostygina, G., Tran, H., Binns, S., Szczypka, G., Emery, S., Vallone, D., & Hair, E. (2020). Boosting health campaign reach and engagement through the use of social media

influencers and memes. *Social Media & Society, 6*(2). https://doi.org/10.1177/2056305120912475

Krebs, P., & Duncan, D. T. (2015). Health app use among US mobile phone owners: A national survey. *JMIR mHealth and uHealth*, 3(4), 107-119. https://doi.org/10.2196/mhealth.4924

Kreuter, M. W., Farrell, D. W., Olevitch, L. R., & Brennan, L. K. (2013). *Tailoring health messages: Customizing communication with computer technology*. Routledge.

Leavitt, V. M., & DeLuca, J. (2010). Central fatigue: Issues related to cognition, mood and behavior, and psychiatric diagnoses. *PM & R: The Journal of Injury, Function, and Rehabilitation*, *2*(5), 332–337. https://doi.org/10.1016/j.pmrj.2010.03.027

Lister, C., Royne, M., Payne, H. E., Cannon, B., Hanson, C., & Barnes, M. (2015). The laugh model: Reframing and rebranding public health through social media. *American Journal of Public Health, 105*(11), 2245-2251. https://doi.org/10.2105/AJPH.2015.302669

Maher, C., Ryan, J., Ambrosi, C., & Edney, S. (2017). Users' experiences of wearable activity trackers: A cross-sectional study. *BMC Public Health, 17*(1), 880. https://doi.org/10.1186/s12889-017-4888-1

Marcora, S. M., Staiano, W., & Manning, V. (2009). Mental fatigue impairs physical performance in humans. *Journal of Applied Physiology (1985), 106*(3), 857-864. https://doi.org/10.1152/japplphysiol.91324.2008

Marino, G. (2015). Semiotics of spreadability: A systematic approach to Internet memes and virality. *Institutional Research Information System, 1*(1), 43-66. https://dx.doi.org/10.18680/hss.2015.0004

Martin Ginis, K. A., & Bray, S. R. (2010). Application of the limited strength model of self-regulation to understanding exercise effort, planning and adherence. *Psychology and Health, 25*(10), 1147-1160. https://doi.org/10.1080/08870440903111696

Mesmer-Magnus, J., Glew, D. J., & Viswesvaran, C. (2012). A meta-analysis of positive humor in the workplace. *Journal of Managerial Psychology, 27*(2), 155–190. https://doi.org/10.1108/02683941211199554

Michie, S., Wood, C. E., Johnston, M., Abraham, C., Francis, J. J., & Hardeman, W. (2015). Behaviour change techniques: The development and evaluation of a taxonomic method for reporting and describing behaviour change interventions (a suite of five studies involving consensus methods, randomised controlled trials and analysis of qualitative data). *Health Technology Assessment, 19*(99), 1-188. https://doi.org/10.3310/hta19990

Michielsen, HJ., De Vries, J., Van Heck, GL. (2002).Psychometric qualities of a brief self-rated fatigue measure: The Fatigue Assessment Scale (FAS). *Journal of Psychosomatic Research*, *54,* 345–52.

Middelweerd, A., Mollee, J. S., van der Wal, C. N., Brug, J., & Te Velde, S. J. (2014). Apps to promote PA among adults: A review and content analysis. *International Journal of Behavioral Nutrition and Physical Activity, 11*(1), 97. https://doi.org/10.1186/s12966-014-0097-9

Millar, B. M. (2017). Clocking self-regulation: Why time of day matters for health psychology. *Health Psychology Review, 11*(4), 345-357. https://doi.org/10.1080/17437199.2017.1316673

Mizuno, K., Tanaka, M., Yamaguti, K., Kajimoto, O., Kuratsune, H., & Watanabe, Y. (2011). Mental fatigue caused by prolonged cognitive load associated with sympathetic hyperactivity. *Behavioral and Brain Functions, 7*(1), 17. https://doi.org/10.1186/1744-9081-7-17

Molina, M. D., & Sundar, S. S. (2020). Can Mobile Apps Motivate Fitness Tracking? A Study of Technological Affordances and Workout Behaviors. *Health Communication, 35*(1), 65-74. https://doi.org/10.1080/10410236.2018.1536961

Morton, K., Sutton, S., Hardeman, W., Troughton, J., Yates, T., Griffin, S., Davies, M., Khunti, K., & Eborall, H. (2015). A text-messaging and pedometer program to promote physical activity in people at high risk of type 2 diabetes: The development of the PROPELS follow-on support program. *JMIR mHealth and uHealth*, *3*(4), e5026. https://doi.org/10.2196/mhealth.5026

Moyer-Gusé, E., Mahood, C., & Brookes, S. (2011). Entertainment-Education in the context of humor: Effects on safer sex intentions and risk perceptions. *Health Communication*, *26*(8), 765-774. https://doi.org/10.1080/10410236.2011.566832

Moyer-Gusé, E., Robinson, M. J., & Mcknight, J. (2018). The role of humor in messaging about the MMR vaccine. *Journal of Health Communication*, *23*(6), 514-522. https://doi.org/10.1080/10810730.2018.1473533

Mukherjee, A., & Dubé, L. (2012). Mixing emotions: The use of humor in fear advertising. *Journal of Consumer Behaviour, 11*(2), 147-161. https://doi.org/10.1002/cb.389

Myrick, J. G., Nabi, R. L., & Eng, N. J. (2021). Consuming memes during the COVID pandemic: Effects of memes and meme type on COVID-related stress and coping efficacy. *Psychology of Popular Media, 11*(3), 316-323. https://doi.org/10.1037/ppm0000371

Nabi, M. G., Ahangar, A., Akhtar, H., Akbar, A., & Mustafa, S. A. (2016). Awareness and knowledge of breast cancer risk factors, symptoms and screening among females in a hospital in North India. *Journal of Evolution of Medical and Dental Sciences, 5*(32), 1719-1724. https://doi.org/10.14260/jemds/2016/406

Nabi, R. L., Moyer-Guse, E., & Byrne, S. (2007). All joking aside: A serious investigation into the persuasive effect of funny social issue messages. *Communication Monographs, 74*(1), 29-54. https://doi.org/10.1080/03637750701196896

Nahum-Shani, I., Hekler, E. B., & Spruijt-Metz, D. (2015). Building health behavior models to guide the development of just-in-time adaptive interventions: A pragmatic framework. *Health psychology: Official Journal of the Division of Health Psychology, American Psychological Association*, *34S*(0), 1209–1219. https://doi.org/10.1037/hea0000306

Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2018). Just-in-time adaptive interventions (JITAIs) in mobile health: Key components and design principles for ongoing health behavior support. *Annals of Behavioral Medicine, 52*(6), 446–462. https://doi.org/10.1007/s12160-016-9830-8

Nelson, D. B., Sammel, M. D., Freeman, E. W., Lin, H., Gracia, C. R., & Schmitz, K. H. (2008). Effect of physical activity on menopausal symptoms among urban women. *Medicine and Science in Sports and Exercise, 40*(1), 50-58. https://doi.org/10.1249/mss.0b013e318159d1e4

Niermann, C. Y., Herrmann, C., von Haaren, B., van Kann, D., & Woll, A. (2016). Affect and subsequent physical activity: An ambulatory assessment study examining the affect-activity association in a real-life context. *Front Psychology, 7,* 677. https://doi.org/10.3389/fpsyg.2016.00677

Prestwich, A., Perugini, M., & Hurling, R. (2010). Can implementation intentions and text messages promote brisk walking? A randomized trial. *Health Psychology, 29*(1), 40-49. https://doi.org/10.1037/a0016993

Rich, R. J. (2020, September). *Sport and exercise at every age: Path to Improved Health.* Retrieved July 26, 2021, from https://familydoctor.org/sports-and-exercise-at-every-age/

Schoeppe, S., Alley, S., Van Lippevelde, W., & Duncan, M. J. (2016). Efficacy of interventions that use apps to improve diet, physical activity, and sedentary behaviour: A

systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 13*(127), 1-26. https://doi.org/10.1186/s12966-016-0454-y

Schwerdtfeger, A., Eberhardt, R., Chmitorz, A., & Schaller, E. (2010). Momentary affect predicts bodily movement in daily life: An ambulatory monitoring study. *Journal of Sport and Exercise Psychology*, *32*(5), 674-693. https://doi.org/10.1123/jsep.32.5.674

Shifman, L. (2012). An anatomy of a YouTube meme. *New Media & Society, 14*(2), 187-203. https://doi.org/10.1177/1461444811412160

Skalski, P., Tamborini, R., Glazer, E., & Smith, S. (2009). Effects of humor on presence and recall of persuasive messages. *Communication Quarterly, 57*(2), 136-153. https://doi.org/10.1080/01463370902881619

Sonnentag, S. (2018). The recovery paradox: Portraying the complex interplay between job stressors, lack of recovery, and poor well-being. *Research in Organizational Behavior: An Annual Series of Analytical Essays and Critical Reviews, 38(*38), 169-185. https://doi.org/10.1016/j.riob.2018.11.002

StatCounter. (2024, September). *Mobile operating system market share in Belgium*. Retrieved October 24, 2024, from https://gs.statcounter.com/os-market-share/mobile/belgium

Stephenson, A., McDonough, S. M., & Murphy, M. H. (2017). Using computer, mobile, and wearable technology-enhanced interventions to reduce sedentary behaviour: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity, 14*(105), 1-17. https://doi.org/10.1186/s12966-017-0561-4

Symons, M., Vandebosch, H., Cutello, C. A., & Poels, K. (2022). Message reminders encouraging brisk walking by considering the dynamic factor of cognitive fatigue. *European Journal of Health Communication, 3*(3), 41-68. https://doi.org/10.47368/ejhc.2022.303

Szender, J. B., Cannioto, R., Gulati, N. R., Schmitt, K. L., Friel, G., Minlikeeva, A., Platek, A., Gower, E. H., Nagy, R., Khachatryan, E., Mayor, P. C., Kasza, K. A., Lele, S. B., Odunsi, K., & Moysich, K. B. (2016). Impact of physical inactivity on risk of developing cancer of the uterine cervix: A case-control study. *Journal of Lower Genital Tract Disease, 20*(3), 230-233. https://doi.org/10.1097/LGT.0000000000000210

Thaler, R. H., & Sunstein, C. R. (2009). *Nudge: Improving decisions about health, wealth, and happiness*. Penguin.

Thayer, R. E. (1987). Energy, tiredness, and tension effects of a sugar snack versus moderate exercise. *Journal of Personality and Social Psychology, 52*(1), 119-125. https://doi.org/10.1037//0022-3514.52.1.119

Thibault, M., & Marino, G. (2018). Who run the world? Cats: Cat lovers, cat memes, and cat languages across the web. *International Journal for the Semiotics of Law - Revue internationale de Sémiotique juridique, 31*(3), 473-490.

Tice, D. M., Baumeister, R. F., Shmueli, D., & Muraven, M. (2007). Restoring the self: Positive affect helps improve self-regulation following ego depletion. *Journal of Experimental Social Psychology, 43*(3), 379-384. https://doi.org/10.1016/j.jesp.2006.05.007

Tobias, D. K., Zhang, C. L., van Dam, R. M., Bowers, K., & Hu, F. B. (2011). Physical activity before and during pregnancy and risk of gestational diabetes mellitus: A meta-analysis. *Diabetes Care, 34*(1), 223-229. https://doi.org/10.2337/dc10-1368

Van Cutsem, J., Marcora, S., De Pauw, K., Bailey, S., Meeusen, R., & Roelands, B. (2017, August). The effects of mental fatigue on physical performance: A systematic review. *Sports Medicine, 47*(8), 1569-1588. https://doi.org/10.1007/s40279-016-0672-0

Van Dantzig, S., Bulut, M., Krans, M., van der Lans, A., & de Ruyter, B. (2018). Enhancing physical activity through context-aware coaching. In *PervasiveHealth '18: Proceedings*

of the 12th EAI International Conference on Pervasive Computing Technologies for Healthcare (pp. 187-190). https://doi.org/10.1145/3240925.3240928

Vandendriessche, K., Steenberghs, E., Matheve, A., Georges, A., & De Marez, L. (2020 December 20). *Digimeter.* Imac. https://www.imec.be/sites/default/files/inline-files/DIGIMETER2020.pdf

Wang, J. B., Cadmus-Bertram, L. A., Natarajan, L., White, M. M., Madanat, H., Nichols, J. F., Ayala, G. X., & Pierce, J. P. (2015). Wearable sensor/device (Fitbit One) and SMS text-messaging prompts to increase physical activity in overweight and obese adults: A randomized controlled trial. *Telemedicine and e-Health, 21*(10), 782-792. https://doi.org/10.1089/tmj.2014.0176

Weber, K., Martin, M. M., Members of COMM 401, & Corrigan, M. (2006). Creating persuasive messages advocating organ donation. *Communication Quarterly*, *54*(1), 67-87. https://doi.org/10.1080/01463370500270413

Weinberger, M. G., & Gulas, C. S. (1992). The impact of humor in advertising: A review. *Journal of Advertising*, *21*(4), 35-59. https://doi.org/10.1080/00913367.1992.10673384

WHO. (2010). *Global Recommendations on PA for Health.* Retrieved March 10, 2021, from https://www.who.int/publications/i/item/9789241599979

WHO. (2020). *What is PA?* Retrieved July 26, 2021, from https://www.who.int/news-room/fact-sheets/detail/physical-activity

Wright, S., Twardzicki, M., Gomez, F., & Henderson, C. (2014). Evaluation of a comedy intervention to improve coping and help-seeking for mental health problems in a women's prison. *International review of psychiatry, 26*(4), 423-429. https://doi.org/10.3109/09540261.2014.924096

Yousef, M., Dietrich, T., & Torrisi, G. (2021). Positive, negative or both? Assessing emotional appeals effectiveness in anti-drink driving advertisements. *Social Marketing Quarterly, 27*(3), 195-212. https://doi.org/10.1177/152450042110250

Zheng, J., You, L. M., Lou, T. Q., Chen, N. C., Lai, D. Y., Liang, Y. Y., Li, Y. N., Gu, Y. M., Lv, S. F., & Zhai, C. Q. (2010). Development and psychometric evaluation of the dialysis patient-perceived exercise benefits and barriers scale. *International Journal of Nursing Studies*, *47*(2), 166-180. https://doi.org/10.1016/j.ijnurstu.2009.05.023

Zering, J. C., Brown, D. M. Y., Graham, J. D., & Bray, S. R. (2017). Cognitive control exertion leads to reductions in peak power output and as well as increased perceived exertion on a graded exercise test to exhaustion. *Journal of Sports Sciences, 35*(18), 1799-1807. https://doi.org/10.1080/02640414.2016.1237777

Zohar, D., Tzischinski, O., & Epstein, R. (2003). Effects of energy availability on immediate and delayed emotional reactions to work events. *Journal of Applied Psychology, 88*(6), 1082-1093. https://doi.org/10.1037/0021-9010.88.6.1082

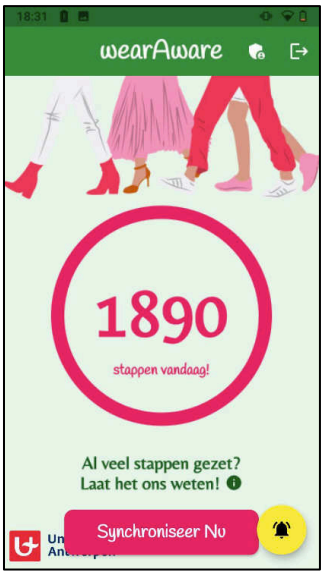
Appendices

Appendix A: Research-Based WearAware Application

Appendix A Alt Text: Below you can see an example of what the WearAware application looks like when participants use it on their phones. On the left you can see the start screen, next to it an in-app notification. Below the start screen you can see an example of a PA message, to its right you can see an example of a survey question.

Start Screen

In-App Notification



Message

Survey Question

Appendix B: Example Stimulus Materials

Appendix B Alt Text: below you can see examples of the stimulus materials used in this study. On the left you can see the humorous cat memes, on the right you can find their non-humorous counterpart.

Humorous	Nonhumorous
	
	
	
	

Tables

Table 1. Linear Regression of the impact of message type and cognitive fatigue on steps

Table 1 Alt Text: The table below presents four linear regression models. Each model represents a hypothesis that is tested. For each model, the dependent variable is "steps taken within 60 minutes after the message". Predictors are presented in the left column (e.g., message type and cognitive fatigue). The values in each cell represent the unstandardized beta coefficients.

DV: Steps taken within 60 minutes after the message	**H_1 - Model 1**	**H_2 - Model 2**	**H_3 - Model 3**	**H_4 - Model 4**
	Unstandardized beta coefficients			
Message Type (humor)	-53.04	-61.92	-70.68	**-377.59**
	(42.88)	(67.41)	(68.75)	**(137.72)****
Steps taken within 60 minutes before the message	**0.29**	**0.30**	**0.27**	**0.27**
	(0.04)***	**(0.04)*****	**(0.04)*****	**(0.04)*****
Average Steps Baseline Week	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)
Time of the day (noon)	31.27	31.78	51.22	51.95 (47.31)
	(47.00)	(47.16)	(47.49)	
Time of the day (afternoon)	**103.54**	**103.45**	94.40	94.81 (53.73)
	(50.52)**	**(50.66)***	(53.93)	
Day of the week (weekend)	**160.73**	**160.96**	**162.26**	**162.26**
	(47.52)**	**(47.62)****	**(49.68)****	**(49.50)****
Consistency (consistently humorous or nonhumorous)		26.98	-10.66	-3.52 (63.30)
		(63.63)	(63.47)	
Consistency X Message Type		13.07	50.29	39.88 (86.89)
		(86.80)	(87.11)	
Cognitive fatigue (survey)			-43.07	**-104.02**
			(22.70)	**(32.80)****
Cognitive Fatigue X Message Type				**115.55**
				(44.98)**
Constant	**229.44**	**317.81**	**317.81**	**494.17**
	(71.13)***	**(97.03)*****	**(97.03)*****	**(118.57)*****
R^2	**0.1051*****	**0.1057*****	**0.1051*****	**0.1129*****
Wald Chi^2	**97.56*****	**99.29*****	**88.24*****	**95.49*****

*$p < 0.050$, **$p < 0.010$ ***$p < 0.001$*

Table 2. Linear Regression of the impact of humorous messages and cognitive fatigue on steps

Table 2 Alt Text: The table below presents a recreation of Table 1 with "steps taken within 60 minutes after the message" as dependent variable and "steps taken within 60 minutes before the message", "average steps baseline week", "time of the day (noon)", "time of the day (weekend)", and "cognitive fatigue" as predictors, but for **humorous messages** only. Predictors are presented in the left column. The values in each cell represent the unstandardized beta coefficients.

DV: Steps taken within 60 minutes after the message	**Model humor**
	Unstandardized beta coefficients
Steps taken within 60 minutes before the message	**0.28 (0.04)*** **
Average Steps Baseline Week	0.01 (0.01)
Time of the day (noon)	107.77 (57.22)
Time of the day (afternoon)	**176.36 (66.93)** **
Day of the week (weekend)	106.57 (60.65)
Cognitive fatigue (survey)	-2.95 (28.51)
Constant	122.63 (103.43)
R^2	**0.1461*** **
Wald Chi^2	**72.74*** **

**p < 0.050, **p < 0.010 ***p < 0.001*

Table 3. Linear Regression of the impact of nonhumorous messages and cognitive fatigue on steps

Table 3 Alt Text: The table below presents a recreation of Table 1 with "steps taken within 60 minutes after the message" as dependent variable and "steps taken within 60 minutes before the message", "average steps baseline week", "time of the day (noon)", "time of the day (weekend)", and "cognitive fatigue" as predictors, but for **nonhumorous messages** only. Predictors are presented in the left column. The values in each cell represent the unstandardized beta coefficients.

DV: Steps taken within 60 minutes after the message	**Model nonhumor**
	Unstandardized beta coefficients
Steps taken within 60 minutes before the message	**0.21 (0.07)*** **
Average Steps Baseline Week	-0.00 (0.02)
Time of the day (noon)	-26.91 (78.29)
Time of the day (afternoon)	24.97 (83.83)
Day of the week (weekend)	**286.73 (79.26)*** **
Cognitive fatigue (survey)	**-105.92 (37.02)*** **
Constant	**598.51 (168.21)*** **
R^2	**0.1095*** **
Wald Chi^2	**38.30*** **

**p < 0.050, **p < 0.010 ***p < 0.001*

Figures

Figure 1. Scatterplot: Interaction Message Type X Cognitive Fatigue (Full range and Zoomed)

Figure 1 Alt Text: below you can see two scatterplots: one in full range and one zoomed. The left one represents the zoomed-in model. A scatterplot is a graphical representation of data points in a two-dimensional space. Each point represents the values of levels of cognitive fatigue (x-axis) and the steps taken within 60 minutes after the message (y-axis). This representation this is made twice each time: on the left for nonhumorous messages and on the right for humorous messages.