Good Vibrations: Consumer Responses to Technology-Mediated Haptic Feedback

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Individuals often experience incidental device-delivered haptic feedback (e.g., vibrational alerts accompanying messages on mobile phones and wearables), yet almost no research has examined the psychological and behavioral implications of technology-mediated touch on consumers. Drawing from theories in social psychology and computer science, we explore how device-delivered haptic feedback may have the capability to augment consumer responses to certain consumer-directed communications. Across four studies, we find that haptic alerts accompanying messages can improve consumer performance on related tasks and demonstrate that this effect is driven by an increased sense of social presence in what can otherwise feel like an impersonal technological exchange. These findings provide applied value for mobile marketers and gadget designers, and carry important implications for consumer compliance in health and fitness domains.

Keywords: haptics, user-device interaction, mediated communication, social presence, wearables, Internet-of-Things

An increasing proportion of consumer-directed communication is mediated through technological devices individuals hold (e.g., mobile phones) or wear (e.g., smartwatches). Interestingly, the fact that these devices are in direct contact with users' hands or skin means that, for the first time, these communications can appeal to a consumers' sense of touch. Indeed, the vast majority of mobile phones and wearables are equipped with haptic feedback actuators (tactile technology that applies forces, vibrations, or motions to the skin), and as a result, brands have begun experimenting with haptic technology in their mobile communication efforts. For example, in mobile ads for Stoli vodka, users can feel their phone vibrate when a woman shakes a cocktail (Johnson 2015). Gadget designers appear similarly keen to employ the power of touch: the clip-on Lumo Sensor buzzes when its wearer begins to slouch (Peppet 2014), the HAPIfork buzzes if the user is eating too quickly (Green 2018), and the Fitbit wristband vibrates when the wearer hits a fitness goal (Vanhemert 2015). However, while these applications are novel, the delivery of haptic feedback itself is nothing new: social etiquette obliges many of us to place our mobile devices on "silent" mode, and vibrotactile alerts have long accompanied the receipt of text messages, incoming phone calls, and other communications content. In fact, vibrotactile stimulation is so omnipresent that people even report feeling "phantom vibrations"—that is, vibrating sensations that do not actually exist (Drouin, Miller, and Kaiser 2012).

Despite the prevalence of such device-delivered haptic feedback, very little research has examined consumer responses to it. Some work has focused on attentional and accuracy-based outcomes of haptic feedback. For example,

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keyboards that produce vibrotactile feedback upon fingertip contact have been shown to lead to improved typing accuracy (Brewster, Chohan, and Brown 2007); and vibrotactile cues were found to be very effective when used to manage attention and to support tasks, such as visual search, navigation, driving, target acquisition, and piloting (Prewett et al. 2012). However, we argue that it is valuable to consider what additional psychological and behavioral consequences might stem from such sensations. Some scholars in computer science suggest that technology-mediated sensations (e.g., haptic feedback delivered through technological devices) can symbolize interpersonal touch under very specific conditions (e.g., if users are explicitly told that the sensations represent the touch of another person; Haans and IJsselsteijn 2006), and research in social psychology has shown that incidental interpersonal touch can substantially shape people's behavior and judgments in various ways (Gallace and Spence 2010). Yet, surprisingly, no research has explored how incidental haptic feedback accompanying device communications (e.g., vibrational alerts accompanying message notifications on mobile phones and wearables) might influence consumer responses to it.

In the current research, we address this gap by exploring how device-delivered haptic feedback accompanying communications can influence consequential consumer judgments and downstream outcomes. Drawing from theories in social psychology, communications, and computer science, we suggest that in addition to providing the utilitarian function of alerting consumers, haptic feedback accompanying messages might also play an additional role: generating a sense of "social presence" (Short, Christie, and Williams 1976) in what might otherwise feel like an impersonal technological exchange. Across four studies, we investigate how haptic feedback accompanying messages can influence consumer reactions to the communication exchange and impact downstream behaviors such as task performance. These findings contribute to the literature on consumer-product interactions by uncovering an important antecedent of consumer responsiveness to technological engagement, and add insight to the social psychology literature by documenting how and when technology-mediated haptic feedback may serve as a rough surrogate for incidental interpersonal touch. Such work is especially timely given recent calls for digital marketing research that keeps pace with rapidly expanding device types (Yadav and Pavlou 2014) and that explores consumer-centric responses to mobile marketing communications (Lamberton and Stephen 2016; Stephen 2016).

THEORETICAL FRAMEWORK

Consumer Reponses to Touch

When considering how haptics influence consumer behavior, it is common to think about how consumers use their sense of touch to acquire information about a product (e.g., touching a sweater to assess its texture; Morales 2009; Peck 2010). While this type of informational touch can have a considerable influence on consumer assessments, even incidental, noninformational haptic sensations have been shown to influence consumer attitudes, typically in a subconscious manner (Krishna 2012; Peck 2010; Peck and Wiggins 2006). For example, haptic sensations that arise from touching a product have been shown to influence tangential judgments (e.g., touching something soft can help reduce people's feelings of uncertainty in unrelated domains; Van Horen and Mussweiler 2014). Further, the mere ability to touch is valuable to consumers, and has been shown to induce feelings of psychological ownership (first demonstrated by Peck and Shu 2009; and replicated by Brasel and Gips 2014 using touchscreen interfaces).

The power of haptics may partially stem from the fact that it represents "our most proximal sense" (Montagu and Matson 1979). That is, in contrast to visual, auditory, and olfactory cues, which might be perceived while a product is at a distance, tactile exchanges always occur within one's peripersonal space (i.e., the space in which one can touch and manipulate objects; Holmes and Spence 2004), and typically involve immediate contact with one's body (Jones and Lederman 2006; Peck 2010). As a result, many argue that haptic cues have an idiosyncratic capacity to evoke a sense of closeness and human connection (Montagu and Matson 1979), especially given that people tend to automatically associate spatial proximity with psychological closeness (Trope and Liberman 2010). Recent research has confirmed that sensations from modalities requiring proximity (touch and taste) activate a greater sense of psychological closeness than sensations from modalities that do not require such proximity (e.g., hearing, sight; Elder et al. 2017).

Accordingly, haptic sensations play an influential role in the context of interpersonal communications. People use touch to express feelings of intimacy and tenderness, or to provide encouragement and emotional support (Jones and Yarbrough 1985). Whether a handshake, a pat on the back, or a nudge for attention, physical contact can convey a liveliness and intimacy that is at times more powerful than language (Jones and Yarbrough 1985). Even a brief, incidental touch from a person (e.g., an inconspicuous touch on the palm) has been shown to positively influence people's social behavior in both interpersonal and consumer settings. Studies have shown that incidental interpersonal touch can improve attitudes toward services, strengthen bonds between people, and even increase compliance with requests ("the Midas touch," Crusco and Wetzel 1984; Guéguen 2004), regardless of whether the tactile contact itself is explicitly acknowledged. In one classic study, Fisher et al. (1976) asked library clerks to return library cards to students and to either briefly place their hands onto the students' palms or not touch them at all. Students' evaluation of the library was more favorable if the library clerk "accidentally" touched them, although most of them did not remember being touched. More recently, Levav and Argo (2010) showed that minimal interpersonal contact (brief touch on the shoulder) altered participants' financial risk-taking behavior by increasing their sense of security. In sum, incidental interpersonal touch can trigger positive attitudes toward the source of touch, increase compliance, and motivate various related outcomes (although individual differences in responsiveness to interpersonal touch do exist, as per the comfort-with-interpersonal-touch scale, Webb and Peck 2015).

Technology-Mediated Touch

The aforementioned literature demonstrates several instances in which brief interpersonal touch can influence consumer judgments, even when the latter judgments are completely unrelated to the source of the touch. Given that touch is such a crucial component in interpersonal interactions, many have questioned how this might translate to interpersonal exchanges mediated through technology, which typically transpire over a distance and prevent immediate haptic contact between people.

Some scholars in computer science suggest that haptic feedback technology (tactile technology that applies forces, vibrations, or motions to the skin) can enable users to "virtually" touch one another over a distance, in what has been coined "mediated social touch" (Haans and IJsselsteijn 2006). Though haptic feedback technology in its current form does not provide the same physical sensation as a human's touch (e.g., electromechanical stimulation does not feel the same as the touch from another person's hand), most scholars in the field agree that haptic feedback can still symbolize the touch of another person, and argue that the literature on interpersonal touch offers a good framework for exploring applications and potential benefits of mediated social interactions (Brave, Nass, and Sirinian 2001; Rovers and van Essen 2004).

For example, in one recent study, Haans, de Bruijn, and IJsselsteijn (2014) replicated the "Midas touch" effect in the context of mediated communication: participants who received vibrotactile sensations from an armband that they were told represented the touch of a confederate were consequently more compliant and more willing to reciprocate than those who were not "virtually touched." Overall, this body of research collectively supports the ability of mediated social touch to personalize remote interactions in ways that words and visuals ostensibly cannot (Gallace and Spence 2010).

However, most of the beneficial effects of mediated social touch have been documented in contexts where the social nature of the haptic feedback is explicit (i.e., telling participants those sensations represent the touch of another person). Surprisingly, however, no research has examined whether incidental haptic feedback (e.g., haptic alerts accompanying device notifications, without explicitly describing the sensations as the touch of another person) might drive effects akin to those of incidental interpersonal touch. This is compelling to investigate given the prevalence of such haptic feedback (as described in this article's introduction) and the numerous behavioral responses that have been shown to stem from incidental interpersonal touch. To explore how incidental haptic feedback accompanying device communications might influence consumer behavior, we next turn to literature on social presence in mediated communication.

The Role of Social Presence in Mediated Communication

One mechanism that might explain the effects of technology-mediated touch on user responses is the increased sense of "social presence" that haptics provide. *Social presence* signals "access to another intelligence" in technology-mediated interactions (Biocca 1997) and is sometimes described as the degree to which the other is perceived to be a real person (Gunawardena and Zittle 1997), acting with agency and "intention" (Biocca, Harms, and Burgoon 2003). This description may be "deceptively intuitive" (Biocca et al. 2003), as social presence should not be confused with mere *copresence*. While copresence refers to a user's awareness or feeling that others are cosituated within an individual's interpersonal environment (Goffman 1959; Swinth and Blascovich 2002), the simple presence of another body or representation does not fully capture the intentionality implied in social presence. Biocca et al. (2003) illustrate this difference with the example of a corpse, which may be physically present, but is certainly not socially active. Thus, while these two terms are sometimes used interchangeably, most scholars agree that whereas copresence is a necessary prerequisite for social presence (Biocca et al. 2003), the latter represents a more complex construct (Nowak and Biocca 2003; Palmer 1995; Vanden Abeele, Roe, and Mario Pandelaere 2007).

Importantly, the attribution of social presence has been shown to positively affect user attitudes toward telecommunication exchanges, as it implies that there is a certain level of agency and intent behind the communication (Sallnäs, Sjöström, and Rassmus-Gröhn 2000; Skalski and Tamborini 2007). Studies have accordingly demonstrated that increased feelings of social presence can motivate participant engagement (e.g., increased student participation in online courses; Picciano 2002) and improve performance on related tasks (e.g., solving a jigsaw puzzle with a remote other; Giannopoulos et al. 2008). Conversely, remote communications lacking in social presence are perceived as impersonal, and as a consequence participants tend to behave in a less compliant manner (e.g., are less likely to share information with others; Leh 2001).

Notably, technologies vary in their ability to invoke social presence (Nowak and Biocca 2003), and, thus, social presence is often a direct function of the communication medium itself (Short et al. 1976). Given that touch is inherently associated with proximity and psychological closeness (Elder et al. 2017), many scholars have argued that mediated social touch is especially suited to increasing a sense of social presence in technology-enabled exchanges. For example, Giannopoulos et al. (2008) found that participants' ratings of social presence significantly increased when they were able to feel their remote partner's nudges (through an electronic thimble providing force feedback every time the partner pressed it). The ability of explicit mediated social touch to generate social presence in shared virtual environments has been documented in several other studies (e.g., Basdogan et al. 2000; Sallnäs 2010; Sallnäs et al. 2000). In the current research, we extend the literature above to suggest that even nonexplicit forms of haptic feedback (e.g., message notifications) may increase feelings of social presence in communicative exchanges, which should accordingly improve user attitudes toward the communication and performance on related concurrent tasks.

Overview of the Current Research

Given that, so far, limited research has examined consumer responses to incidental haptic feedback, we chose to center our investigation on its most common operationalization: vibrotactile feedback. Vibrotactile feedback is the standard form of haptic feedback used in the mediated social touch literature (Brave et al. 2001; Gallace and Spence 2010; Rovers and van Essen 2004). It is also the most pervasive form of haptic feedback in the marketplace and the dominant haptic alert accompanying message notifications (Haans and IJsselsteijn 2006), making it especially important to understand how this particular operationalization might affect consumer responses. Further, given that vibrotactile stimulation is a relatively crude form of haptic feedback (we discuss emerging, more sophisticated forms in the general discussion), it arguably represents a conservative test of technology-mediated touch effects.

While vibrotactile feedback might accompany messages in various contexts, we chose to primarily focus our exploration in the domain of consumer health and physical fitness. This emphasis was fueled by a number of practical and theoretical considerations. First, physical activity represents an externally valid context to investigate device-mediated communications given the skyrocketing adoption of health and fitness apps and wearable fitness trackers in the marketplace (Lamkin 2016; Orr 2016), which often act as a personal trainer and/or nutrition coach by tracking users' performance and sending guiding messages to encourage persistence and improve performance (Harris-Fry 2019; Leong 2016). In our studies, we similarly send encouraging messages to participants, but manipulate whether these messages are accompanied by haptic feedback or not, and then assess participants' resulting performance.

Our focus on the consumer health and physical fitness domain is also motivated by literature on social support. Although social support can come from various sources (e.g., a parent, friend, teacher, coach; Tardy 1985), positive subjective assessments of relationship quality (i.e., the extent to which relationships are perceived to be responsive and positively affective) have been shown to enhance feelings of social support (Reis and Collins 2000). This is relevant to our hypothesizing, given that we suggest that adding haptic feedback to encouraging messages should improve performance by increasing the sense of social presence. Importantly, social support has been shown to motivate individuals and improve outcomes in varying domains (see Veiel and Baumann 1992 for a review), but in particular for those tasks that require a certain level of persistence and resilience (Luthar, Cicchetti, and Becker 2000). The literature has already demonstrated the positive effects of social support on physical performance and exercise (for a meta-analysis, see Carron, Hausenblas, and Mack 1996), making it particularly compelling to explore whether social presence activated through technology-mediated incidental touch might have a similar positive influence on performance.

We conducted a series of studies to provide empirical support for our theorizing. In study 1, we examine the impact of adding haptic feedback to text messages sent to mobile smartphones. We find that when haptic feedback accompanies encouraging messages, individuals perform better on an objectively measured fitness task. A post-test confirms that such effects are not driven by increased attention, greater perceived intensity of the alerts, or greater experienced arousal. In study 2, we replicate this effect using alternative haptic-delivery devices (smartwatches) and rule out additional process explanations based on mood or multimodal activation. Study 3 extends our investigation to the field via a mobile application downloaded onto participants' own smartphones, and provides preliminary evidence for the mediational role of social presence, conceptualized as the degree to which the sender is perceived to be a real person acting with agency and "intention." Lastly, study 4 establishes more definitive support for social presence as the underlying mechanism. As a result, we add to research on consumer-product interactions by uncovering an important antecedent of consumer responsiveness to technological engagement and lend insight to the social psychology and communications literatures by documenting how and when technology-mediated haptic feedback may elicit outcomes akin to those found for interpersonal touch. We describe the details of our empirical work next.

STUDY 1: THE POSITIVE EFFECT OF HAPTIC FEEDBACK ON TASK PERFORMANCE

The purpose of study 1 was to provide initial evidence that the mere addition of haptic feedback to messages can improve performance on a related task. Participants were asked to partake in a physical challenge (taking as many steps as they could in a brief time span) while holding a mobile smartphone that received encouraging text messages. We expected that those participants who received messages accompanied by haptic feedback (e.g., a vibration) would perform better than those who received the same messages without haptic feedback.

Method

One hundred twenty-three members of a community-based subject pool (59% female, $M_{\text{age}} = 28.29$, SD = 12.03; we report detailed gender and age by condition for all studies in the web appendix) participated in our laboratory study in exchange for monetary compensation. This study took the form of a two-level (message alert: control vs. haptic) between-subjects design. Upon entering the lab, participants were seated at private cubicles and given mobile smartphones (Samsung Galaxy S6). These phones were preset to emit one of two notification alerts according to our two experimental conditions: a standard beep (control condition) or a standard beep accompanied by a standard vibration (haptic condition). In both conditions, messages appeared on the face of the phone as they were received, without any action required from the wearer.

Importantly, these phones come equipped with pedometers that measure the number of steps taken by the wearer. Immediately before handing the phones to participants, the experimenter reset the pedometers to zero. Participants were told that they would receive messages on the phone while attempting a physical challenge (described below). Participants were instructed not to use the phone for any other purpose aside from reading the text messages as they received them.

Participants then read a description of the physical challenge, which was to accumulate as many steps as they could in a period of 4 minutes (see appendix A for exact instructions). From a separate room, the experimenter proceeded to text the participants at 1 minute intervals. An initial message instructed participants to begin the exercise, and the four subsequent messages encouraged them in performing the physical task (e.g., "You're doing great! Keep it up"; see appendix B for the texting script, which was identical for all participants). Once the 4 minutes were over, participants were told to raise their hand so the experimenter could collect their phone and register their step count. To ensure there were no differences across conditions in the number of text messages noticed or received, participants were asked to indicate how many text messages they received. Participants reported their gender and age, were thanked for their participation, and collected their monetary compensation.

Results and Discussion

Message Receipt. Participants reported receiving an average of 3.78 out of the four messages sent, and importantly, there were no differences in the number of messages received across message alert conditions in this study ($M_{\text{Control}} = 3.77$, $M_{\text{Haptic}} = 3.79$; $p = .90$) or in any of our remaining studies (all ps $>.40$). This confirms that any differences in resulting performance were not being driven by a differential propensity to notice or read the text messages based on the message alert condition.

Task Performance. Twelve participants reported having a physical condition preventing them from some movement, potentially resulting from high upper age limit of our sample (70 years). These participants were excluded from the remaining analysis, resulting in a final sample of 111 participants (we report the results with the full sample in the web appendix). As predicted, ANOVA results confirmed a significant effect of message alert on the number of steps achieved by participants in the predicted direction: participants in the haptic alert condition performed better on the task (achieved more steps) than those in the control condition ($M_{\text{Control}} = 448.88$ vs. $M_{\text{Haptic}} = 523.91$; $F(1, 109) = 4.03$, $p = .05$, $\eta_p^2 = .04$). Thus, overall this study provided preliminary support for the positive effect of haptic feedback on task performance.

Post-Test. As mentioned, there were no differences in the number of messages received across message alert conditions in this study or in any of our remaining studies. However, to further ensure that the effects of haptic feedback were not being driven by increased attention, greater perceived intensity of the alerts, or greater experienced arousal, we ran a post-test with 84 additional members of the same community-based subject pool (55% female, $M_{\text{age}} = 26.64$, SD = 9.59; see detailed procedure and measures in the web appendix). Results confirmed there were no differences in attention ($M_{\text{Control}} = 5.68$ vs. $M_{\text{Haptic}} = 6.06$; $F(1, 82) = 1.62$, $p = .21$), intensity ($M_{\text{Control}} = 3.80$ vs. $M_{\text{Haptic}} = 4.13$; $F(1, 82) = 1.01$, $p = .32$), or experienced arousal ($M_{\text{Control}} = 3.84$ vs. $M_{\text{Haptic}} = 3.91$; $F(1, 82) = .45$, $p = .45$) across conditions.

STUDY 2: TESTING ALTERNATIVE PROCESS EXPLANATIONS

Study 2 served several purposes. First, we wished to replicate the effect we found in study 1 using an alternative haptic-delivery device (a smartwatch). Second, we added a third experimental condition (text messages accompanied by only haptic feedback and no auditory feedback), allowing us to determine whether the effects in our experimental condition in study 1 were being driven by the addition of haptic feedback specifically, or as a consequence of increased attention stemming from sensory activation in multiple modalities (auditory plus haptic).

We expected that messages accompanied by haptic feedback would improve performance as compared the same messages accompanied by only auditory feedback. This prediction was motivated by research showing that haptics represent a more proximal and psychologically close modality than audition (Elder et al. 2017; Holmes and Spence 2004; Montagu and Matson 1979). As a consequence, haptic feedback should feel more psychologically proximal than feedback from modalities that do not typically require such close proximity (i.e., audition). Further, haptic channels have been shown to be especially suited to increase feelings of social presence, which we theorize is the mechanism driving improved performance (Basdogan et al.2000; Sallnäs et al. 2000). Thus, overall, by generating greater feelings of social presence, messages accompanied by haptic feedback should be more persuasive in driving behavior and should affect performance more than those same messages paired with auditory feedback.

In addition, some research findings suggest that haptic feedback might influence a user's mood and arousal levels (Eid and Al Osman 2016; Tsetserukou 2010), though such findings have been mixed. As an example, research has documented both arousing (Seifi and MacLean 2013) as well as calming (Sefidgar et al. 2016) effects that can arise from vibrotactile stimulation. Given that mood and arousal levels have been shown to influence individuals' cognition and performance (exhibiting either inhibitory or facilitating effects; Isen, Daubman, and Nowicki 1987; Mano 1992), study 2 also assesses participants' mood and arousal in order to determine whether they might in any way explain the processes through which haptic feedback improves task performance.

Method

One hundred one undergraduate students (66% female, $M_{\text{age}} = 21.28$, SD = 3.12) participated in this laboratory study in exchange for monetary compensation. The study took the form of a three-level (message alert: auditory vs. haptic vs. auditory + haptic) between-subjects design. Upon entering the lab, each participant was seated at a private cubicle and given a Pebble smartwatch to wear. A smartwatch is a computerized wristwatch with functionality beyond timekeeping, including communication functions and activity-tracking features (Rawassizadeh, Price, and Petre 2014). These watches come equipped with pedometers that measure the number of steps taken by the wearer. To receive text messages, a smartwatch must be synced to a mobile phone, which relays the messages to the screen of the watch automatically (in this study, these synced phones were hidden behind each workstation, so that participants interacted only with the smartwatch). Immediately before handing the smartwatches to participants, the experimenter reset the pedometers to zero. Incoming message notifications were preset to either beep, vibrate, or both beep and vibrate, according to our three experimental conditions. In all three conditions, messages appeared on the face of the watch as they were received, without any action required from the wearer. The remainder of the procedure was identical to study 1, with the addition of measures to capture participants' mood (on seven-point Likert items: good, cheerful, unhappy (reverse-coded), bored (reverse-coded); $\alpha = .73$) and level of arousal (on six nine-point semantic differential pairs from Mehrabian and Russell, 1974: relaxed-stimulated, dull-jittery, unaroused-aroused, excited-calm (reverse-coded), wide awake-sleepy (reverse-coded), frenzied-sluggish (reverse-coded); $\alpha = .77$).

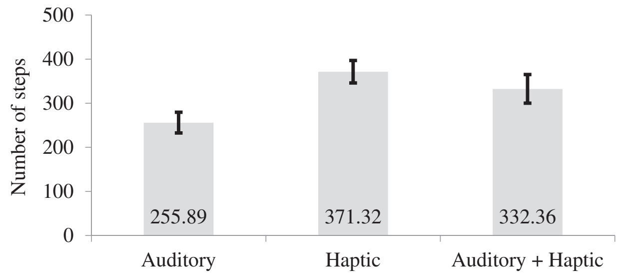
Results and Discussion

Task Performance. Fourteen participants were not able to receive any text messages (due to connectivity errors with their watches), and one participant deleted his pedometer data before the experimenter was able to record it. Accordingly, there were 86 observations available for analysis. ANOVA results again confirmed a significant main effect of message alert on the number of steps achieved by participants ($M_{\text{Auditory}} = 255.89$ vs. $M_{\text{Haptic}} = 371.32$ vs. $M_{\text{Auditory+Haptic}} = 332.36$; $F(2, 83) = 4.56$, $p = .01$, $\eta_p^2 = .10$); see figure 1). An examination of planned contrasts demonstrated that as in study 1, those in the auditory + haptic condition performed better on the task (achieved more steps) than those in the auditory condition ($M_{\text{Auditory}} = 255.89$, $M_{\text{Auditory+Haptic}} = 332.36$; $F(1, 83) = 3.73$, $p = .06$, $\eta_p^2 = .04$). Further, participants who received the text message accompanied by only haptic feedback also performed better than those who received the text alerts accompanied by auditory feedback ($M_{\text{Auditory}} = 255.89$, $M_{\text{Haptic}} = 371.32$; $F(1, 83) = 8.92$, $p < .01$, $\eta_p^2 = .10$). This confirms that the increase in performance did not merely stem from the activation of multiple sensory modalities. Lastly, there was no significant difference in performance between those in the haptic condition and those in the auditory + haptic condition ($M_{\text{Haptic}} = 371.32$, $M_{\text{Auditory+Haptic}} = 332.36$; $F(1, 83) = 1.04$, $p = .31$, $\eta_p^2 = .01$), confirming that differences in performance were not due to the presence or absence of auditory output.

Mood and Arousal. ANOVA results did not produce a significant main effect of message alert on reported mood ($F(2, 83) = .55$, $p = .55$) or arousal ($F(2, 83) = .15$, $p = .86$). Further, when we controlled for the effects of mood

FIGURE 1

STUDY 2: THE EFFECT OF MESSAGE ALERT ON TASK PERFORMANCE



and arousal, the effect of message alert type on task performance remained significant ($F(2, 81) = 4.34$, $p = .02$, $\eta_p^2 = .09$). Lastly, regression results confirm that neither mood ($t(85) = -.48$, $p = .64$) nor arousal ($t(85) = .79$, $p = .43$) had a significant effect on task performance. Together, these results suggest that the improved performance was not driven by any changes in mood or arousal that might stem from the receipt of haptic feedback. We continue to measure both mood and arousal in our remaining studies, and they are consistently unaffected by the alert manipulation and unable to explain effects on the dependent variable of interest (details available in the web appendix).

Together, our first two studies document the positive effect of haptic feedback from two different devices (mobile smartphones and smartwatches) on users' performance on an objectively tracked physical task. Further, we rule out process explanations based on mood, arousal, or multimodal sensory activation.

STUDY 3: INCREASING EXTERNAL VALIDITY AND EXPLORING THE UNDERLYING MECHANISM

Study 3 was a field study that served several purposes. Firstly, by developing a mobile application that participants could download onto their own smartphones from wherever they were remotely located, we were able to send messages in a context of greater external validity and over a longer time period (a 9 hour duration). Secondly, we took this opportunity to encourage participants on a host of wellness-related tasks, including messages pertaining to both physical (e.g., exercise) and nonphysical (e.g., healthy eating) activities. Lastly, given our theorizing that haptic feedback should improve performance due to increased feelings of social presence, we collected a preliminary measure to assess feelings of social presence and test its mediational role.

Method

For this study, the authors worked with a Silicon Valley–based software developer to create two versions of an "Activity Reminders" mobile app, based on a two-level (message alert: auditory vs. haptic) between-subjects design. The functionality of the app from the user's perspective was simple, as it merely served as an interface through which they could receive and read messages within the app. Upon receiving a message, users would get a push notification on their devices to let them know they received it. Then, upon opening the app, users would receive the message paired with either a standard auditory beep (control condition) or a standard vibration (haptic condition). Thus, regardless of the participants' general phone settings (i.e., what type of alert they had programmed for general push notifications), we were able to fully control for whether or not the messages themselves were accompanied by haptic feedback or not within the Activity Reminders app.

Participants in this field study were recruited via an online panel provider (Qualtrics) in exchange for monetary compensation, and participant involvement in the study spanned a three-day period (data collection was run in multiple iterations to achieve a large enough sample size). On the first day, participants were prescreened based on the following criteria given to the panel provider: 1) must currently reside in the Eastern US time zone (allowing us to control the time of day the messages were sent); and 2) must be able to complete the study on an Android device (due to the app's software compatibility). Qualifying participants were then presented with a set of instructions explaining the study procedure (see appendix C) and a link to download a randomly assigned version of the Activity Reminders app onto their smartphones. Finally, they were asked to enter a numeric code from within the app in order to verify their download.

On the second day, the experimenter proceeded to send participants a series of messages through the app. A total of nine messages were sent, separated by 1 hour intervals. The messages were designed to "remind" users to engage in overall healthy activities and behavior (based on general guidelines from the US Department of Health and Human Services 2008, 2015). The content of these messages recommended both physical movement (e.g., "Being active is important- try to do some exercise today!") and nonphysical activities (e.g., "Try to eat more fruits and vegetables today!"); see appendix D for the script of all messages. If the app was open at the time the message was received, users would immediately see the message pop up (see appendix E for a screenshot of the app interface) paired with either auditory or haptic feedback, according to condition. If the app was not open at the time the message was received, participants would receive a push notification letting them know a message was waiting for them.

Then, upon opening the app, they would receive the message paired with the designated alert.

On the third day, participants received a link to complete a final survey. First, they responded to a series of items meant to subjectively assess their relative performance on the recommended activities the day before (all on seven-point Likert scales: "In general, I was more active yesterday than usual," "I wrote down everything I ate yesterday," "I ate more fruits and vegetables yesterday than I usually do," "I avoided eating sugary drinks and snacks yesterday," "I performed some deep breathing yesterday," "I did light stretches yesterday," and "I got plenty of sleep last night"). In addition, they responded to four items designed to more quantitatively capture their performance ("Approximately how many minutes of exercise did you do yesterday?" "Approximately how many minutes did you stretch yesterday?" "Approximately how many glasses of water did you drink yesterday?" and "Approximately how many hours of sleep did you get last night?"). Afterward, participants were asked to assess the coach's social presence. Literature on social presence suggests that the construct can be conceptualized as the degree to which a sender is perceived to be a "real person" with "intention" in mediated communication (Gunawardena and Zittle 1997). Based on this operationalization, participants responded to two social presence items (on seven-point Likert scales: "A person was sending me these messages," and "The coach seemed to have a mind of his/her own," $r = .54$, $p < .001$; note that in our next study we use a more comprehensive measure of social presence in order to provide further support to our proposed process). Participants then indicated their mood, arousal, gender, and age. Lastly, participants were asked to indicate whether they did indeed read the messages throughout the day or if they read all of the messages at once.

Results and Discussion

Participation. While 323 participants downloaded the Activity Reminders app onto their device on day one, 137 participants (79% female, $M_{age} = 40.09$, $SD = 11.81$) completed the entire study across the three days. This attrition rate (58%) is comparable to attrition rates reported in similarly designed smartphone-based experiments (e.g., 63.74% in Howells, Ivtzan, and Eiroa-Orosa 2016).

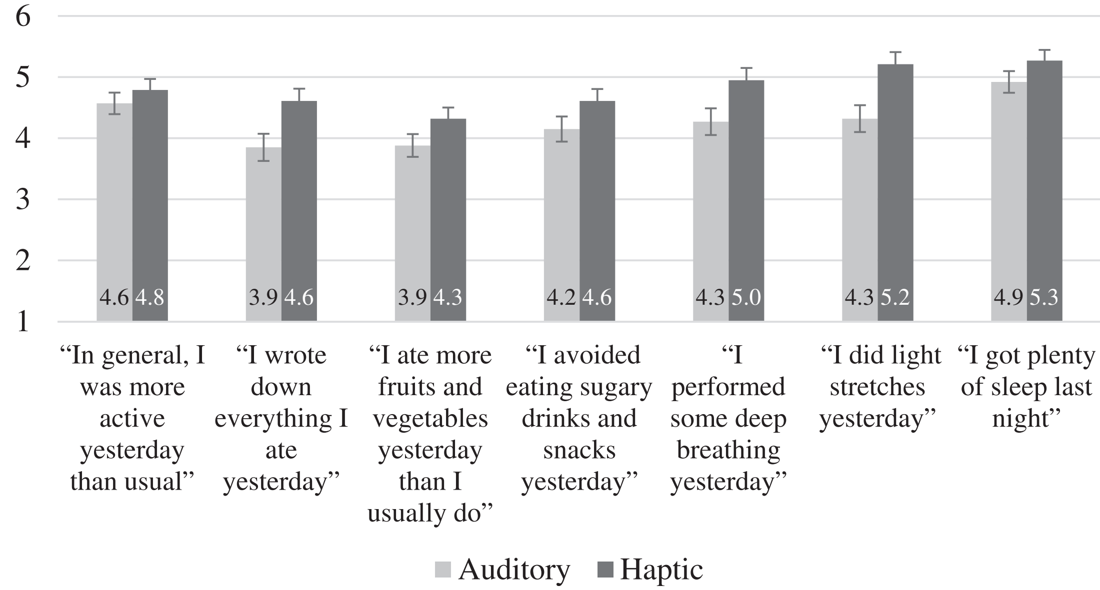
Task Performance. Eleven participants reported reading all the messages at one time, meaning they did not have the opportunity to act upon the recommendations or have repeated exposure to the alert manipulation. Accordingly, these participants were excluded from further analysis, resulting in a final sample of 126 participants (results with the full sample are in the web appendix). To test the effect of our alert manipulation on participants' subjectively assessed performance, we ran a repeated-measures ANOVA with activity as a within-subjects variable and message alert as the between-subjects factor. Consistent with findings in studies 1 and 2, results revealed a significant effect of message alert on performance, in that participants reported performing better on the tasks when the activity reminders were accompanied by haptic feedback ($F(1, 124) = 4.64$, $p = .03$, $\eta_p^2 = .04$; see figure 2). Notably, this effect did not differ across activities ($F = .77$, $p = .38$), suggesting that haptic feedback did not differentially influence performance on physical versus nonphysical activities.

We then assessed participants' responses to the quantitative performance measures (minutes of exercise, minutes of stretching, glasses of water, and hours of sleep). Three statistical outliers (one participant who indicated sleeping 300 hours, one participant who indicated sleeping 20 hours, and one participant who indicated drinking 32 glasses of water) were removed from further analysis (although the results including these three participants continue to be significant, $p = .05$). We log-transformed each measure, as they were all right-skewed (Howell 2007). A repeated-measures ANOVA with activity as a within-subjects variable and message alert as the between-subjects factor again revealed a significant effect of the message alert manipulation on performance, in that participants reported performing better on the tasks when the activity reminders were accompanied by haptic feedback ($M_{Exercise} = 40.88$, $M_{Stretching} = 9.39$, $M_{Water} = 6.48$, $M_{Sleep} = 7.30$; we report untransformed means for interpretation purposes) than when they were not ($M_{Exercise} = 34.75$, $M_{Stretching} = 6.86$, $M_{Water} = 5.03$, $M_{Sleep} = 6.81$; $F(1, 121) = 4.21$, $p = .04$, $\eta_p^2 = .03$). Again, this effect did not differ across activities (IF(1, 121) = .08, $p = .78$). While one natural limitation of these measures is that they rely on participants' self-reported activities and assume both honest and accurate reporting, we have no reason to believe inaccurate reporting would differ across our two experimental conditions, and these findings are bolstered by the objective performance measures in studies 1, 2, and 4.

Social Presence. ANOVA results revealed a marginally significant effect of message alert on the composite measure of social presence, with those participants in the haptic (vs. control) condition reporting a higher degree of social presence ($M_{Control} = 2.62$ vs. $M_{Haptic} = 2.96$; $F(1, 124) = 2.87$, $p = .09$, $\eta_p^2 = .02$). To determine the extent to which increased social presence explained the main effect of haptic feedback on performance, we applied a bootstrapping procedure using the lme4 package (Bates et al. 2015) for R (R Core Team 2013). In this test, we used a single aggregated measure of performance ($\alpha = .77$), controlling for the different types of activities by including them as fixed effects, and accounted for the natural clustering of the measures within individuals (repeated measure) by including a random effect. The test for the indirect effect of haptic feedback on performance through social

FIGURE 2

STUDY 3: THE EFFECT OF MESSAGE ALERT ON SUBJECTIVE TASK PERFORMANCE



presence was significant, with a 10,000 bootstrap, 95% confidence interval excluding zero (indirect effect = .1133; CI [.0582, .1783]).

We ran the same analysis with each mediator item separately as a robustness check. The pattern of results for both is in the expected direction (for "A person was sending me these messages": $M_{\text{Control}} = 2.53$ vs. $M_{\text{Haptic}} = 2.80$; $F(1, 124) = 1.74$, $p = .19$; and for "The coach seemed to have a mind of his/her own": $M_{\text{Control}} = 2.72$ vs. $M_{\text{Haptic}} = 3.06$; $F(1, 124) = 2.71$, $p = .10$), although a one-way ANOVAs using each item measuring social presence as a standalone dependent variable did not reach significance. Most importantly, when we reran the mediation analysis using each item as a standalone mediator, both analyses showed a significant indirect effect (for "A person was sending me these messages": indirect effect = .1001; 95% CI [.0409, .1707]; and for "The coach seemed to have a mind of his/her own": indirect effect = .0677; 95% CI [.0248, .1219]).

This provides preliminary evidence that the overall increase in performance due to the inclusion of haptic feedback is being driven by an increased sense of social presence in the exchanges. Notably, while our measure of social presence in this study stems from the literature (Gunawardena and Zittle 1997) and is consistent with the notion that communications implying agency, intent, or "access to another intelligence" should improve downstream outcomes (Biocca et al. 2003; Sallnäs et al. 2000; Skalski and Tamborini 2007), we use an improved, more comprehensive measure of social presence in our next study.

STUDY 4: ESTABLISHING PROCESS EVIDENCE

The main purpose of study 4 was to provide more definitive support for social presence as the underlying mechanism explaining the positive effect of haptic feedback on task performance.

Method

One hundred sixteen participants (52% female, $M_{\text{age}} = 28.12$, SD = 12.57) participated in our laboratory study in exchange for either monetary compensation or course credit. ANOVA results demonstrated that compensation method had a significant effect on our dependent variable of interest (task performance; $M_{\text{Paid}} = 483.49$ vs. $M_{\text{CourseCredit}} = 331.25$; $F(1, 114) = 25.84$, $p < .001$, $\eta_p^2 = .20$), which is consistent with previous literature demonstrating that paid participants exhibit greater motivation and effort than participants getting course credit (Brase, Fiddick, and Harries 2006; Nicholls et al. 2015). However, compensation method did not significantly interact with our independent variable (message alerts) in affecting task performance ($F(1, 114) = .39$, $p = .54$). Thus, we collapsed the data and included compensation method as a covariate in our analysis.

This study took the form of a two-level (message alert: auditory vs. auditory + haptic) between-subjects design. Upon entering the lab, each participant was seated at a private cubicle and given a mobile smartphone (Samsung

Galaxy S6). These phones were preset to emit one of two notification alerts according to our two experimental conditions. The remainder of the procedure was identical to study 1, with the addition of an enhanced measure of social presence, consistent with the notion that it should represent agency, intent, or "access to another intelligence" (Biocca et al. 2003; Sallnäs et al. 2000; Skalski and Tamborini 2007). Specifically, social presence was measured on four seven-point Likert scale items: "The coach seemed to have a mind of his/her own," "The coach seemed to be a person," "The coach had personality," and "The coach acted intentionally"; $\alpha = .74$). All participants reported their mood, arousal, gender, and age and were thanked for their participation, and those participating for monetary compensation collected their payment.

Results and Discussion

Task Performance. Nine participants reported having a physical condition preventing them from some movement. These participants were excluded from the remaining analysis, resulting in a final sample of 107 participants. As predicted and mirroring the results of previous studies, ANOVA results confirmed a significant effect of message alert on the number of steps achieved by participants in the predicted direction: participants in the auditory + haptic condition performed better on the task (achieved more steps) than those in the auditory condition ($M_{\text{Auditory}} = 400.57$ vs. $M_{\text{Auditory+Haptic}} = 456.63$; $F(1, 104) = 5.56$, $p = .03$, $\eta_p^2 = .05$).

Social Presence. An identical ANOVA with social presence as the dependent variable revealed a significant positive effect of haptic feedback ($M_{\text{Auditory}} = 2.64$ vs. $M_{\text{Auditory+Haptic}} = 3.03$; $F(1, 104) = 4.27$, $p = .04$, $\eta_p^2 = .04$). As in study 3, to determine the extent to which increased social presence explained the main effect of haptic feedback on performance, we applied a standard bootstrap procedure (model 4; Hayes 2013). Specifying a confidence interval of 95% with 10,000 bootstrap resamples, we found that the indirect effect of message alert type on task performance through social presence was significant, with a confidence interval excluding zero (indirect effect = 9.53; 95% CI [.4008, 28.90]). This adds confirmatory evidence that the overall increase in performance due to the inclusion of haptic feedback is being driven by an increased sense of social presence, conceptualized as the perception of agency and intention coming from the sender in the communication exchanges.

GENERAL DISCUSSION

Research in social psychology and consumer behavior has documented positive attitudinal outcomes that result from incidental interpersonal touch, but limited research had explored how incidental technology-mediated touch might impact consumer behavior and judgment. We address this gap by exploring how one particular form of technology-administered haptic feedback (vibrotactile message alerts) can influence consumer responses in consequential domains. Across four studies, we systematically demonstrate that haptic feedback accompanying message content can positively influence consumer attitudes toward the interaction, and impact consequential downstream behaviors such as their performance on health and fitness tasks. Studies 1 and 2 together demonstrate that adding haptic feedback to text messages on both mobile devices and smartwatches can improve consumer performance on related physical tasks. Importantly, these studies rule out process explanations based on attention, intensity, arousal, mood, or multimodal activation. Study 3 takes our investigation to the field, extends the investigation to various wellness-related behaviors, and provides preliminary evidence for the mediational role of social presence as a sense of access to someone else's intelligence acting with intention. Study 4 uses a more comprehensive measure of social presence to more definitively support its role as an underlying mechanism. Overall, we develop a multidisciplinary theoretical framework encompassing computer science, communication, and psychology to demonstrate that haptic alerts, by providing a physical cue of "social presence," can motivate effort and improve performance.

This research contributes to the literature on consumer-product interactions by uncovering an important antecedent of consumer responsiveness to technological engagement and adds insight to the social psychology literature by documenting how and when technology-mediated haptic feedback may elicit outcomes akin to those found for interpersonal touch. While the marketing literature has examined the efficacy of mobile marketing efforts from a firm's perspective, there is a dearth of research exploring consumer-centric responses to mobile marketing communications (Lamberton and Stephen 2016; Stephen 2016). Our research addresses this gap by investigating consumer reactions to communications mediated through mobile devices. In addition, by extending our empirical work to smartwatches, we address recent calls for consumer research that keeps pace with both rapidly expanding device types and novel interaction modes (Stephen 2016; Yadav and Pavlou 2014).

Further, while previous consumer behavior research has demonstrated consequential responses to the haptic properties of products touched by consumers (with the product acting as a passive agent), this work examines consumer responses to haptic exchanges "initiated" by the product itself (with the product acting as an active agent). Importantly, we support a process based on the idea that consumers are especially likely to attribute social presence to exchanges that trigger their sense of touch, since touch represents both a spatial and psychologically proximal modality.

Adding to the theoretical contributions, this research provides valuable insights for both industry and public policy. Worldwide mobile advertising expenditure is projected to surpass \$187 billion by 2020 (accounting for more than 30% of all advertising expenditure; Williams 2018), and the emerging category of smartwatch advertising is expected to reach \$69 million by 2019 (Kharif 2015; Samuely 2015). Brand managers can choose to add haptic feedback to communications on such devices, and our research would suggest that doing so might be an easy way to positively influence consumers' responses to the messages and improve attitudes toward the sender. Similar logic can be applied to within-app brand communications (more than 90% of the top 100 global brands have launched at least one branded app; Meola 2016). Haptic feedback can be programmed into an app's functionality during the software development phase (as we did in study 3) and might be a way to both improve consumer engagement with the app itself and strengthen consumer connections with the company or brand.

In terms of implications for public policy, our empirical studies demonstrated that haptic feedback can bolster the effectiveness of messages geared toward improving users' performance in physical fitness and health-related tasks. Examining antecedents to increased physical activity and good nutrition is paramount, given that medical experts and public health officials have strongly encouraged healthy eating along with increased physical movement as a way to combat the pervasive obesity epidemic (Hu 2008). Our findings are particularly interesting given the steep rise in consumer use of health and fitness apps and wearable fitness trackers (Lamkin 2016), which often act as a personal trainer and/or nutrition coach by tracking users' performance and sending motivational messages to encourage persistence (Harris-Fry 2019; Leong 2016). Our results suggest that developers of these health and fitness applications should consider potentially incorporating haptic feedback into such motivational communication attempts.

Our understanding of technology-mediated haptic effects is at a very early stage of development, and there are many interesting avenues to expand work in this research stream. For example, in this article we focused on haptic feedback that accompanies positively valenced content (e.g., encouraging messages). However, in reality, consumers might also receive telecommunication content that is unwelcome or that carries inherently negative connotations. The interpretation of a haptic sensation depends on the context and message in which the touch is embedded, and accordingly, it is likely that multiple symbolic meanings can be extracted from a particular haptic sensation (Burgoon 1991; Burgoon, Walther, and Baesler 1992). Thus, while we chose to focus on positive content in this initial exploration, we acknowledge that haptic alerts might operate differently if accompanying negatively valenced message content. It is also worth noting that in our investigation we compared the relative efficacy of messages with or without haptic feedback but did not compare these to a condition in the absence of any messages at all. Future researchers may wish to further explore the efficacy of messages themselves, regardless of alert type.

Relatedly, it might also be interesting to explore contexts in which technology-mediated haptic feedback is transmitted in the absence of any accompanying message content. For example, the creator of the TapTap wristband (still a prototype) describes the product as a way to allow couples to discretely share feelings over a distance: when one wristband is tapped, a signal is sent to the other wristband, which vibrates in turn, letting the recipient know the sender is thinking of them (Bertucci 2015). While this represents a more explicit form of social touch than we considered in the current research, we believe it might be interesting to explore the long-term effects of such technologically facilitated haptic exchanges on interpersonal relationships. Similarly, as mentioned in this article's introduction, the HAPIfork and Lumo Sensor buzz when the user is eating too quickly or slouching, respectively. It might be interesting to explore the different processes through which haptic feedback unaccompanied by content might take on specific learned meanings in order to shape downstream consumer responses.

An examination of the effect sizes across our studies also provides interesting insights and potential directions for further research. For example, while the average effect size of mobile phone–delivered haptic feedback on performance was $\eta_p^2 = .04$ in our studies, the effect size for smartwatch-delivered haptic feedback was notably larger ($\eta_p^2 = .10$). This suggests that the power of haptic feedback may differ according to device type (or perhaps depending on where on the body haptic feedback is delivered). It is also worth noting that the effect size on social presence was smaller (averaging $\eta_p^2 = .03$ across studies 3 and 4). This suggests that while the conceptualization of social presence employed in this work (access to another intelligence acting with agency and intention; Biocca 1997; Gunawardena and Zittle 1997) may serve as one route through which haptic feedback improves performance, there may be additional mechanisms. For example, some scholars consider intentionality as mere baseline, arguing that true social presence manifests in exchanges that are perceived to be intentionally warm, sociable, and personal (Aragon 2003; Short et al. 1976). Other potential mechanisms might be more physiological in nature. For example, while self-reported arousal levels did not increase as a result of haptic feedback, future research might explore alternative biometric markers.

Additionally, the current work focused on the most pervasive form of haptic feedback currently on the market: vibrational alerts. We acknowledge that this is a relatively rudimentary form of haptic stimulation, and it might be interesting to develop a more nuanced account of how various specific technology-mediated sensations map onto consumer perceptions and responses. In fact, some gadget manufacturers are already spending considerable sums to develop more refined forms of haptic feedback in their devices. For example, Apple's smartwatch features a "Taptic Engine," producing alerts meant to feel as though someone is tapping your wrist (Vanhemert 2015), and has recently received a patent for technology allowing touchscreen devices to simulate texture and temperature (MacGregor 2016). Given that our research and past literature demonstrates positive attitudinal outcomes stemming from even a crude form of technology-mediated haptic feedback, it would be extremely interesting to see if such effects are further enhanced by more sophisticated haptic stimulation.

Lastly, while we examined specific contexts (fitness and overall wellness) in which haptic feedback motivates consumer responses, our theorizing would predict the positive effects of haptic alerts should also apply to other tasks where interpersonal touch and social support matter. For example, healthcare practitioners and scholars argue that a physician's touch can be instrumental in comforting patients (Stepansky 2016), yet a growing number of doctor-patient consultations (including mental health assessments) are transpiring through technological interfaces (e.g., the Doctor on Demand app allows consumers to video-connect to a physician via a smartphone; Hermar 2016). It might be interesting to explore whether and how technology-mediated forms of haptic feedback might augment telemedicine interactions, help health providers connect with their patients more intimately, and perhaps even boost patient compliance.

As consumers rely on technology-mediated services in more and more contexts and consumer-product interactions become increasingly imbued with online connectivity, we believe haptic sensations will play an important role in shaping consumer perceptions, judgments, and behaviors, just as they do in our offline world.

DATA COLLECTION INFORMATION

The first author supervised research assistants collecting data for study 1 at the University of Oxford in the winter of 2018. Both authors collected the data for study 2 at the University of Pompeu Fabra in the spring of 2015. The first author managed the collection of data for study 3 using the Qualtrics panel as described in the Methods section in the fall of 2017. Both authors collected the data for study 4 at Baruch College in the fall of 2018. All data were jointly analyzed by both authors.

Appendix A

TASK INSTRUCTIONS IN STUDIES 1, 2, AND 4

INSTRUCTIONS: STEPS CHALLENGE

We are testing out a new coaching service that operates through text messages.

For this challenge, we would like you to try to march in place for 4 minutes.

Your goal is to try to get as many steps as you can in the 4 minutes.

Please stay in front of your computer while marching in place.

Please hold onto the mobile phone the entire time you are marching. In the meantime, you will get text messages on the mobile phone.

Please read the text messages as you receive them.

Please do not use the mobile phone for any other purpose.

PLEASE DO NOT PROCEED TO THE NEXT PAGE until you receive a text message instructing you to do so. Once you get the text message, proceed to the next page and start marching in place.

Appendix B

TEXT MESSAGE SCRIPT IN STUDIES 1, 2, AND 4

"Proceed to the next page and begin marching."

"You're doing great! Keep it up."

"If you feel tired, take a deep breath."

"Great job! You're getting lots of steps."

"You're almost there, just a little bit longer."

Appendix C

TASK INSTRUCTIONS IN STUDY 3

Below, you will find a link to download the **Activity Reminders** app.
Please install this on your device and log in within the next 30 minutes.

Tomorrow, you will periodically receive messages through the app.

These messages are meant to help you stay active and healthy.

Please read the messages as you get them.

On the next day, you will receive a link to a 15 minute survey,which will conclude the study.

Click on the link below to download and install the **Activity Reminders** App.

Appendix D

TEXT MESSAGE SCRIPT IN STUDY 3

"Write down everything you eat today. Keeping a log is important for tracking your diet."

"Take a short walk (even five minutes can make a difference)!"

"Try to eat more fruits and vegetables today!"

"Don't forget to drink water! Aim for multiple glasses today."

"Avoid eating sugary drinks and snacks. Your body will thank you!"

"Being active is important- try to do some exercise today!"

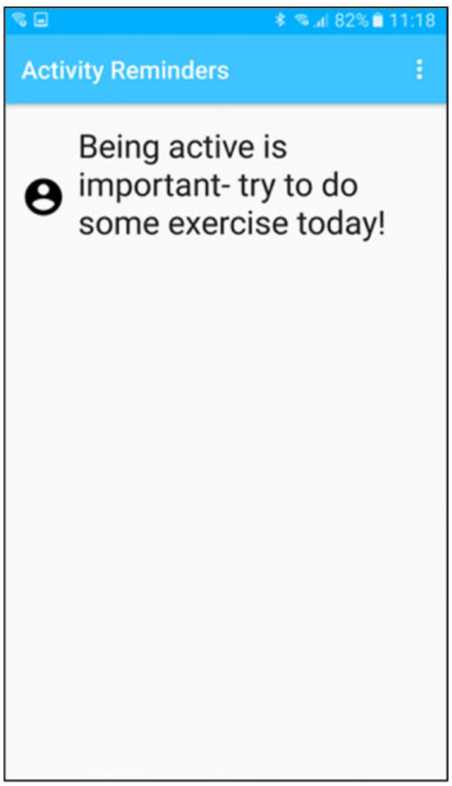
"Practice some deep breathing while relaxing your muscles one at a time."

"Do some light stretches. It's good for you!"

"Try to get plenty of sleep tonight- rest is important."

Appendix E

Screenshot of the app interface in study 3



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