DAILY FEEDBACK IMPROVES SUN PROTECTION AMONG PATIENTS WITH AN ELEVATED RISK OF SKIN CANCER

by

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ABSTRACT

Every year, over two million people are diagnosed with skin cancer. The primary method recommended for skin cancer prevention is reducing ultraviolet radiation (UVR) exposure. However, consistent daily sun protection is often inadequate, even among higher risk patients.

This study tested both 1) the effectiveness of a daily, online intervention that provided color-coded feedback illustrating duration of UVR exposure on specific body sites, and 2) theoretically derived predictions regarding the process of reducing UVR exposure in response to feedback. Participants (*n*=47; 53.3% women, mean age=49.87) were recruited from dermatology clinics and had an elevated risk of skin cancer. The majority (63.8%) had a history of skin cancer, including 44.7% with melanoma. At baseline, then 1 and 2 months later, sun exposure was assessed by reflectance spectroscopy, an objective measure of skin color, and by the self-report Minutes of Unprotected Sun Exposure (MUSE) Inventory. Participants were randomly assigned to either a feedback, self-monitoring, or control condition. For feedback participants, the 14-day intervention included daily sun-protection reminders, the MUSE Inventory, color-coded feedback diagrams, and survey items on health-relevant cognitions and emotions. To control for the potential benefit of reporting one's behavior, self-monitoring participants completed these assessments but did not receive feedback. Control participants only received daily reminders.

On the MUSE Inventory, feedback participants reported less sun exposure than self-monitoring participants during the intervention. In these conditions, higher perceptions of goal fulfillment for sun exposure occurred when reported sun exposure was lower and these perceptions predicted higher self-efficacy for sun protection. Only feedback participants reported decreased sun exposure at the 2-month follow-up; significant decreases in sun exposure were reported in the lower face, arms, and lower legs, which are common sites for melanoma. Reflectance spectroscopy measurements did not change over time or by condition, potentially because they were taken on a limited number of body sites (wrist, upper face) for which exposure did not decrease substantially.

This study supports the feasibility and effectiveness of an online, daily feedback intervention for sun exposure among higher risk patients. Future directions include testing it among less compliant populations and investigating additional mechanisms (e.g., changes in goals) through which feedback operates.

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INTRODUCTION

One in five Americans will be diagnosed with skin cancer during their lifetime (Robinson, 2005). Every year, over two million people are diagnosed with skin cancer and the incidence of skin cancer has increased over time (Rogers et al., 2010). Reducing ultraviolet radiation (UVR) exposure is the primary method recommended for prevention of skin cancer, since over 80% of all skin cancers are associated with UVR exposure (Koh, Geller, Miller, Grossbart, & Lew, 1996; Parkin, Mesher, & Sasieni, 2011). Among those at an elevated risk of skin cancer through factors such as a personal history of skin cancer, having one or more first-degree relatives with a history of skin cancer, or atypical moles (Diao & Lee, 2014), reducing UVR exposure is especially important.

Although public knowledge about skin cancer and sun protection has increased in the last few decades (Baum & Cohen, 1998), unprotected sun exposure, and even sunburn, are frequently reported (Bränström et al., 2009). Sun protection is a challenging behavior because it must be consistently performed to be effective and because sun-protective strategies may be inconvenient for some activities. Sun protection is less common among men, those who have skin types that are less sensitive to the sun, are younger, have a positive view of suntans, and those who perceive themselves as having a lower risk of skin cancer (Bränström et al., 2009; Glanz, Lew, Song, & Cook, 1999; Kasparian, McLoone, & Meiser, 2009). Sun protection is also less common among those who perceive greater barriers to the behavior, such as difficulty with implementing sun protection as a daily habit (Bränström et al., 2009). Among those with a history of skin cancer, sun protection often increases immediately following initial diagnosis (Meyer, Pruvost-Balland, Bourdon-Lanoy, Maubec, & Avri, 2007). However, sun protection may still be inadequate; for instance, in one study, over 40% of those with a recent nonmelanoma skin cancer diagnosis reported never or rarely using sunscreen (Renzi et al., 2008). Furthermore, among those with a history of skin cancer, sun protection often decreases by the end of the first year following diagnosis (Idorn, Datta, Heydenreich, Philipsen, & Wulf, 2014).

Several interventions have produced overall reductions in sun exposure using a number of methods, such as providing education about protection and promoting social norms of sun protection use. Yet, the consistent practice of sun-protection behaviors remains a challenging behavior and there is room for improvement in many interventions. For instance, although members of high-risk families who received genetic counseling and genetic test results reported overall improvements in sun protection use 2 years later, 42% nevertheless reported receiving at least one sunburn in the last 6 months (Aspinwall, Taber, Kohlmann, Leaf, & Leachman, 2013). Among skin cancer survivors, interventions have mainly been directed toward those with a previous diagnosis of melanoma. These interventions often include educational components, especially education about the practice of skin self-examinations, but do not tend to emphasize sun protection (McLoone, Menzies, Meiser, Mann, & Kasparian, 2013).

Behavioral feedback promotes behavior change

Behavioral feedback is an important tool for health behavior change that may improve the effectiveness of interventions (Bandura, 2012; Fishbach, Eyal, & Finkelstein, 2010). Delivery of feedback often involves feedback recipients first observing and reporting on their own behavior. Such behavioral observations, which are often referred to as self-monitoring, can enhance health behaviors even without the presence of feedback (Baker & Kirschenbaum, 1998; Burke, Wang, & Sevick, 2011; Lightfoot, Rotheram-Borus, Comulada, Gundersen, & Reddy, 2007; Miller, Gutschall, & Holloman, 2009; Schreurs, Colland, Kuijer, de Ridder, & van Elderen, 2003). The limited research examining whether behavioral feedback influences behavior to a greater extent than self-monitoring alone suggests that feedback leads to greater behavior change than self-monitoring alone (Burke et al., 2011).

Both self-monitoring and feedback are thought to be effective because they alert participants to discrepancies between their current state and a desired state. Such discrepancies are an important element in several theoretical frameworks for the self-regulation of behavior, including control theory (Carver & Scheier, 1990, 2001) and self-discrepancy theory (Higgins, 1997). According to these theories, people are motivated to reduce discrepancies between their current and desired behavior, which often produce negative feelings. For a perceived discrepancy to influence behavior, it must not only be available (that is, it must actually exist) but also accessible (Higgins, 1997). Monitoring one’s behavior and/or receiving feedback likely makes existing discrepancies more accessible, leading to changes in behavior and negative emotions, depending on the degree of discrepancy.

Although discrepancy-based models provide a general framework for understanding how feedback may impact motivation, conclusions about the reasons why feedback is effective and the conditions that increase its effectiveness are difficult to reach, especially in the context of intervention studies. Challenges to exploring the effects of feedback include the following: 1) feedback varies greatly in delivery method, type (e.g., normative vs. ipsative), and target (e.g., self vs. group) and 2) feedback is often delivered in the context of other intervention components (DiClemente, Marinilli, Singh, & Bellino, 2001), making it difficult to isolate whether effects are due to the feedback itself. For instance, motivational interviewing interventions that include feedback on drinking patterns and the current consequences of one's alcohol consumption have been found to decrease alcohol consumption, but it is difficult to isolate to what extent effects are due to feedback per se since it is delivered in the context of a counseling session also aimed at promoting self-efficacy, establishing goals, and imagining a positive future (Monti et al., 1999). In experimental studies, the effects of feedback have been more systematically investigated. In the next section, I describe several constructs that have been identified as explanations for how and when feedback is effective.

Feedback helps people effectively pursue goals

Feedback is an important input for how people set and pursue goals. According to goal-setting theory (Locke & Latham, 2002), goals energize action, directing our attention and effort to a purpose and helping us to persist in our striving over time. The presence of feedback also is beneficial for goal pursuit because it allows individuals to adjust the amount of effort devoted toward a goal and to adopt new strategies if necessary. Furthermore, feedback also improves commitment to goals and self-efficacy, which are also beneficial for performance.

Negative feedback promotes goal-relevant behavior when people are committed

Fishbach and colleagues (2010) have investigated the differential effects of positive feedback (i.e., feedback about meeting or exceeding their goal) and negative feedback (i.e., feedback that one has not met his or her goal) on later performance. Their general finding across several studies is that positive feedback is useful for promoting *commitment* to a task because such feedback increases outcome expectancies (i.e., perceptions about the positive consequences of one's actions) as well as self-efficacy. In contrast, negative feedback is most useful for promoting *progress* toward a goal and is most effective among those who are already committed to a goal. For instance, Louro, Pieters, and Zeelenberg (2007) found that once people were committed to a weight loss program, negative feedback (about how much weight they had left to lose) was more effective at promoting effort than positive feedback (about how much weight had already been lost).

Feedback improves self-efficacy

The degree to which feedback influences performance also depends on one's self-efficacy. Self-efficacy – the perceived ability to perform an action – is an important element in social cognitive theory (Bandura, 1997). In tests of social cognitive theory, individuals have been found to exert more effort when they experience both a negative discrepancy between their behavior and their goal and when they have high self-efficacy for the task (Bandura & Cervone, 1983, 1986). For instance, when participants received negative feedback related to their goals for operating an exercise device, those with higher self-efficacy for performing the task later devoted more effort toward it (Bandura

& Cervone, 1983).

Social cognitive theory not only proposes that self-efficacy is an important moderator but also describes various ways in which self-efficacy may be enhanced (Bandura, 2012). Observing others perform an action, receiving encouragement from others that one can do a task, and being in a positive mood can enhance self-efficacy. Additionally, experiences with successfully completing an action (i.e., mastery experiences) can enhance self-efficacy, especially when these experiences involve overcoming obstacles. To the extent that performance is improving, feedback can help people link their own actions with such mastery experiences. For instance, children completing writing tasks over a 3-week period perceived greater self-efficacy at the end of the study when they were in a condition in which they were provided periodic feedback (Schunk & Swartz, 1993).

Feedback is more effective when its valence matches one's regulatory focus

Regulatory focus (Higgins, 1997) is one's general approach toward achieving goals and has also been proposed to influence how individuals respond to feedback. If an individual has a *prevention* focus, she typically pursues goals by striving to avoid mistakes; if an individual has a *promotion* focus, she typically pursues goals by striving to maximize gains. For instance, a student who has a *prevention* focus might focus on avoiding errors on assignments and following directions properly. Further, performance is also improved to the extent that there is a good fit between one's regulatory focus and the demands of a task. For instance, a *prevention*-focused student may earn a higher grade in courses that emphasize following the course instructions than in courses that emphasize creativity and seeking out additional information. Consistent with this theory, Idson and Higgins (2000) found that the effectiveness of negative feedback depended on one's primary regulatory focus. Those with a primarily *prevention* focus improved their performance based on negative feedback to a greater extent than those in a primarily *promotion* focus.

In summary, feedback often helps people to pursue their goals by alerting them to discrepancies between their current and desired behavior and by enhancing self-efficacy. Past studies have found that feedback is most effective when people have high self-efficacy for the target behavior, are committed to a goal, and when the form of feedback fits one's regulatory focus. These factors have been mainly identified through between-subjects studies. Additional insight regarding the effects of feedback on goal pursuit can also be gained by examining its effects at a daily level, which enables the examination of possible within-subjects changes on subsequent goal pursuit. Because sun protection often involves multiple different behaviors that may change with the demands of one's activities and because sun protection must be consistently practiced each day to be effective, understanding the day-to-day self-regulation of behavior is especially critical in this domain.

Self-regulation of daily goals

An increasing number of studies focus on the day-to-day regulation of goal pursuit. Methodologies such as daily dairies and experience sampling allow researchers to obtain information on within-person aspects of goal regulation. Studies investigating within-person processes involved in goal pursuit are important because the within-person and between-person effects within certain models are not always equivalent and may reflect different underlying processes. For example, in a daily diary study of chronic pain sufferers, Karoly, Okun, Enders, and Tennen (2014) found that morning pain intensity predicted the favorability of goal schemas (i.e., the conceptualization of how important and attainable the goal was), but that the direction of the effect depended on whether pain intensity was examined at the within-person or between-person level. Specifically, when participants' reported pain that exceeded their own average level of pain, goal schemas were less positive, but participants who *on average* reported more intense pain (that is, collapsing pain intensity ratings across the 21 days of the daily diary study) reported *more positive* goal schemas. As this example demonstrates, understanding how a phenomenon works as a function of differences *between people* does not always translate into an understanding of how the same phenomenon functions *within the same person over time*.

Within-subjects methodologies provide an important opportunity to test elements of self-regulation theories at a daily level. Studies that investigate daily level processes involved in self-regulation can help to identify strengths of existing theories. For instance, using experience sampling methods, Moberly and Watkins (2010) examined relationships between goal-related attributions and negative affect at multiple timepoints during one week. Consistent with self-discrepancy theory (Higgins, 1997), participants reported the most negative affect on measurement occasions during which they perceived low progress, but high importance, for the goal they were currently pursuing. Such studies can also highlight potential limitations in self-regulation theories. For example, using daily diaries, Holman, Totterdell, and Rogelberg (2005) tested components of Carver and Scheier's (1990, 2001) model in a study on work-related goal pursuit among a sample of 15 mental health social workers. Across 28 days, they found that greater goal distance predicted more negative emotions, but, contrary to Carver and Scheier's model, perceptions of low velocity of goal progress did not.

Few studies have investigated the self-regulation of *health* goals specifically at the daily level. Findings from studies that have addressed daily health goals are important for not only addressing theoretical questions but also for informing health behavior interventions. For instance, in a 30-day study of women with fibromyalgia, Affleck et al. (1998) found that women reported more progress toward both fitness and life goals on days when they perceived pain to interfere less with the goal. Kiene, Tennen, and Armeli (2008) found that attitudes toward condom use varied over time. On days when participants had more favorable attitudes toward condom use and greater intentions to use condoms, they were more likely to use condoms. Lastly, accelerometer-assessed physical activity was found to be greater on days when participants spent more time on activities related to goals that facilitated physical activity goals (Presseau, Tait, Johnston, Francis, & Sniehotta, 2013). While these findings are not surprising, they suggest that one-time only measures of behavior-related attitudes and cognitions may not be sufficient. For instance, interventions that target condom use should not just focus on targeting *who* has less favorable attitudes toward condom use but should also focus on *when* and *why* such attitudes emerge.

In summary, studies investigating the daily process of goal pursuit have both theoretical and practical significance. Such studies allow researchers to test whether effects predicted by theories and tested through between-subjects designs are also evident at a different level of analysis. These investigations are especially important because effects are not always equivalent both between- and within-subjects. Most importantly, studies that investigate the daily pursuit of health goals can help researchers identify daily-level moderators of goal pursuit that can be targeted in interventions. Daily process studies can likewise help researchers understand how and when feedback promotes behavior change.

Using personalized feedback for sun exposure to promote daily sun protection

Few studies have used feedback to motivate people to reduce sun exposure. Personalized feedback for sun exposure has mainly focused on measures of cumulative risk rather than on the adequacy of one's current behavior. Personalized feedback is available for skin cancer risk through UV photography, which shows the extent of damage that has been done through cumulative sun exposure (Taylor, Stern, Leyden, & Gilchrest, 1990). Viewing these photographs has been linked to decreased tanning bed use in some studies (e.g., Gibbons, Gerrard, Lane, Mahler, & Kulik, 2005). However, presumably because these photographs reveal damage that has already been sustained over many years, these photographs do not always lead to behavior change (Hollands, Hankins, & Marteau, 2010) and they at times evoke defensive responses, such as *increased* subsequent UVR exposure (Schüz, Schüz, & Eid, 2013).

Although feedback is available for cumulative skin damage, individuals do not typically receive useful feedback regarding their successful or consistent implementation of sun-protection behaviors. Such feedback is largely unavailable for the implementation of daily methods of sun protection *before* substantial skin damage has occurred (i.e., in the form of a painful sunburn). Further, UVA exposure, which does not burn skin, can also lead to skin cancer (Moan, Dahlback, & Setlow, 1999). Thus, sunburns do not provide adequate information about accumulated UVR exposure. Finally, estimating one's degree of sun protection may be difficult because individuals may not account for all types of sun protection used and may not be aware of important details such as how long their sunscreen lasts (Wang & Dusza, 2009).

Another approach to providing feedback is to focus on the adequacy of current sun-protection strategies and to provide advice on how to improve these strategies. This approach was employed for the development of a computer-tailored program that delivered feedback on sunscreen use as well as related cognitions and behaviors reported by participants (de Vries et al., 2012). In their initial program evaluation, de Vries et al. (2012) recruited both participants with a skin cancer history (n=132) and members of the general public who did not have a cancer history (n=255). Participants completed an online questionnaire assessing predisposing/demographic factors (e.g., skin type), sun tanning and sun-protection behavior, knowledge about sun protection, risk perceptions, attitudes toward sunscreen use, social influence, self-efficacy for sunscreen use, and intentions to use sunscreen. Immediately-delivered feedback messages were tailored based on questionnaire responses and addressed any weaknesses, such as low rate of sunscreen use and unfavorable cognitions related to sunscreen. For instance, those who reported lower self-efficacy for sunscreen use were provided with advice on how to make plans to use sunscreen.

While the effect of this intervention on subsequent behavior has not yet been evaluated, participants generally provided positive evaluations of the program, with individuals with a skin cancer history rating the program more positively. However, some participants commented that the feedback, which consisted of up to six multisentence messages, was too long. Interventions that provide brief feedback may be more positively received. Furthermore, a limitation of this intervention is that it only provides feedback on one sun-protection behavior – sunscreen use. (The authors noted that pilot testing revealed that providing feedback on multiple behaviors would make the feedback messages too long.) In contrast, the feedback provided in the current study was a brief, mainly pictorial, display that presents feedback on overall sun protection regardless of the method used.

The present study

The present study introduced a computerized daily feedback intervention that, based on participants' daily self-reports of outdoor activities, provided details on time spent outdoors during peak and nonpeak hours and minutes of unprotected exposure on specific body sites, corrected for the practice of any sun-protection behaviors (e.g., sunscreen, protective clothing). The provision of *daily* feedback for sun exposure likely has several advantages. In general, frequent feedback has been found to be more effective (Salmoni, Schmidt, & Walter, 1984) because it allows individuals the opportunity to learn more about, and more accurately assess, their behavior. Because it reflects only the sun exposure that has occurred over a short interval rather than exposure accumulated over one's lifetime, people may also respond less defensively to daily feedback. Furthermore, the feedback format used in the present study included several elements that have been shown to be effective: it is personalized, delivered over multiple days, and includes an engaging visual display (Noar, Benac, & Harris, 2007). In this study, I examined whether the provision of a daily sun protection feedback intervention improved sun-protection behaviors both in the short term (1 month after the start of the intervention) and over a longer interval (2 months). Intervention effects were compared between a self-monitoring+feedback condition (hereafter referred to as the feedback condition), a self-monitoring only condition (which reported on outdoor activities and sun protection during the 14-day intervention but did not receive feedback), and a control group (which only received daily reminders during the 14-day intervention).

The provision of daily feedback regarding sun exposure and the assessment of daily measures of goal-related processes provided the opportunity to examine the daily process of behavior change for sun protection and ways in which feedback may influence this process. An understanding of the dynamics of daily self-regulation of sun exposure has not only theoretical but also practical significance. Multicomponent computerized interventions for health behaviors, including sun exposure, are becoming increasingly available (Krebs, Prochaska, & Rossi, 2010). These interventions provide several advantages, including being cost-effective (Fotheringham, Wonnacott, & Owen, 2000) and amenable to the use of dynamic tailoring (Krebs et al., 2010). That is, computerized interventions can be adjusted based on *current* behavior, attitudes, and emotions.

Hypotheses

Overall effects of feedback

Compared to the control condition, participants in both the daily feedback and self-monitoring conditions were expected to reduce sun exposure to a greater extent both 1 month and 2 months following the start of the intervention. I further expected that the feedback group would reduce their sun exposure at a faster rate than the self-monitoring group due to the receipt of more concrete information relevant to how to improve successful practice of sun protection (i.e., specific body sites with the greatest exposure).

Process of behavior change

The extent to which individuals perceived that they have met the goal of reducing sun exposure, which should be related to the amount of sun exposure actually reported, was predicted to influence several variables that are relevant to self-regulation and goal pursuit. First, perceptions of goal progress were expected to predict the degree of negative affect experienced. Among people committed to a goal, being farther from one's goal (i.e., having lower perceptions of goal fulfillment) was expected to predict greater intentions to devote effort toward sun protection. Second, intentions to devote additional effort toward sun protection were predicted to be greater when affect is more negative because negative affect serves as additional information that one's goal has not been achieved (Schwarz & Clore, 1983). Third, self-efficacy was expected to be higher on days in which individuals perceived that they had gotten closer to fulfilling their goal. As people begin receiving feedback and/or monitoring their sun exposure, because they are learning more about how their actions link to outcomes, their confidence in their ability to effectively protect themselves may increase.

Testing whether differences between feedback and self-monitoring in the process model of daily regulation of sun-protection behavior depend on confidence in perceived goal fulfillment

While the same daily process of self-regulation of sun protection was proposed within both the feedback and self-monitoring conditions, it was nevertheless predicted that those in the feedback condition would report lower subsequent sun exposure. The receipt of both objective and specific information about one's exposure in the feedback group may give individuals greater confidence in their own perceptions of goal fulfillment, leading to these perceptions having a greater influence on related cognitions and emotions. Thus, I predicted that in the feedback group, participants would report more confidence in their perceptions of goal fulfillment, which would, in turn, lead these perceptions to have a greater effect on self-efficacy, emotions, and intended effort. For example, when individuals perceive they have not fulfilled their goal, greater increases in negative emotions are proposed in the presence of feedback than self-monitoring alone.

Potential moderators of intervention effects on sun exposure

Several factors may moderate impact of feedback on behavior. One's regulatory focus for health behavior may influence outcomes. Those with a prevention focus may be more likely to benefit from this intervention because it provides feedback which is framed negatively. One's current stage of change for sun protection may also influence responses to the feedback intervention. Since negative feedback is most effective once people are committed to a goal, those who already intend to use sun protection may be most likely to benefit from this feedback intervention. Perceived response efficacy for sun protection may also moderate effects – those who more strongly believe that sun protection will be effective for preventing a future skin cancer may reduce their sun exposure to a greater extent.

METHOD

Participants

Fifty adults were recruited for this study through two physicians who specialized in the treatment of skin cancer at dermatology clinics at Huntsman Cancer Institute. Participants were recruited through a handout that was presented to potential participants by the physician or other clinic staff. The study handout explained that the study was for individuals who were interested in reducing their sun exposure; it also included a brief description of the study and its eligibility requirements (daily access to a computer with an internet connection, no history of color-blindness, elevated skin cancer risk status). Interested participants returned the flyer to clinic staff with contact information. Then the experimenter or an undergraduate research assistant contacted the participant to confirm eligibility and schedule the first study appointment. Participants received a $10 gift card for each completed in-person assessment and an additional $20 for completing the daily diary portion of the study (or a prorated amount if fewer than 10 days were completed).

The final sample for the main analyses was 47 participants (16 feedback, 17 self-monitoring, 14 control). Two participants (1 feedback, 1 control) left the study between their first and second visits due to family events and an additional control group participant did not complete the final visit due to scheduling conflicts with work events. Data from these participants are not reported. For daily-level analyses of the process of behavior change within the feedback and self-monitoring conditions, the final sample was

32; 1 participant (self-monitoring group) completed the MUSE Inventory, but did not complete any of the other questionnaire items and was therefore excluded from analyses involving the daily-level process of behavior change. Participants in the two experimental groups completed an average of 11.44 of 14 daily assessments (81.7%), and completion rates did not vary by condition.

Participants began the study during July or August of 2015. All participants identified themselves as White, with one participant additionally identifying as Hispanic. Age ranged from 25 to 83 (M=49.87, SD=15.86) and the sample included 21 males (44.7%). The sample was educated (93.6% completed at least a 2-year community college degree) and had a high income (83% reported a household income greater than $70,000; only 1 participant reported an income less than $40,000).

A majority of the sample (63.8%) had a history of skin cancer, with melanoma being the most common type of skin cancer (reported by 44.7% of the sample). At baseline, 89% of the sample reported consistently engaging in sun protection on a stage of change question. However, about one-third of the sample (31.9%) reported that they had sustained at least one sunburn in the past year.

Measures

MUSE Inventory

To obtain daily self-reports of sun exposure as well as the information needed to tailor feedback, we used the MUSE Inventory, which is a computerized measure of sun exposure based on the outdoor activities that a participant completes during a particular reporting window (Stump, Aspinwall, Taber, Edwards, & Leachman, 2013, 2014). The MUSE Inventory differs from other self-report measures of sun-protection behaviors, which typically assess total time outdoors and participants' separate ratings of their frequency of practice of multiple specific sun behaviors. Such measures can be hard to interpret because they do not account for the functional overlap among multiple sun-protection methods (i.e., sunscreen, protective clothing, UVR avoidance). For example, it is unclear if someone who reports sometimes wearing long sleeves and sometimes wearing sunscreen is 1) changing type of sun-protection depending on the activity, but using at least one method at all times, or 2) sometimes using both methods simultaneously (but at different body sites) and at other times using no sun protection. Furthermore, this measurement technique does not take into account the possibility that individuals rely on a primary sun protection method; a person who consistently uses protective clothing should still be considered protected even if he or she rarely uses sunscreen. In contrast to frequency-based approaches, MUSE scores take into account whether *any* sun-protection method is used to protect specific body sites during specific outdoor activities. Thus, MUSE scores represent the total unprotected sun exposure received in a single day, with overall scores taking into account the proportion of the body's surface area that was unprotected and for how long. The surface area of various body sites was estimated using charts that characterize the extent of burns (Wedro, 2012; Zinn, n. d.). The MUSE Inventory was used to generate color-coded feedback regarding the minutes of unprotected exposure on multiple body sites (see Figure 1). Overall MUSE scores serve as the primary self-report measure of sun exposure in the present study.

In this study, several different reporting windows were used for the MUSE Inventory. For in-person assessments, the reporting windows were a typical weekday in the past 2 weeks and a typical weekend day in the past 2 weeks. These windows

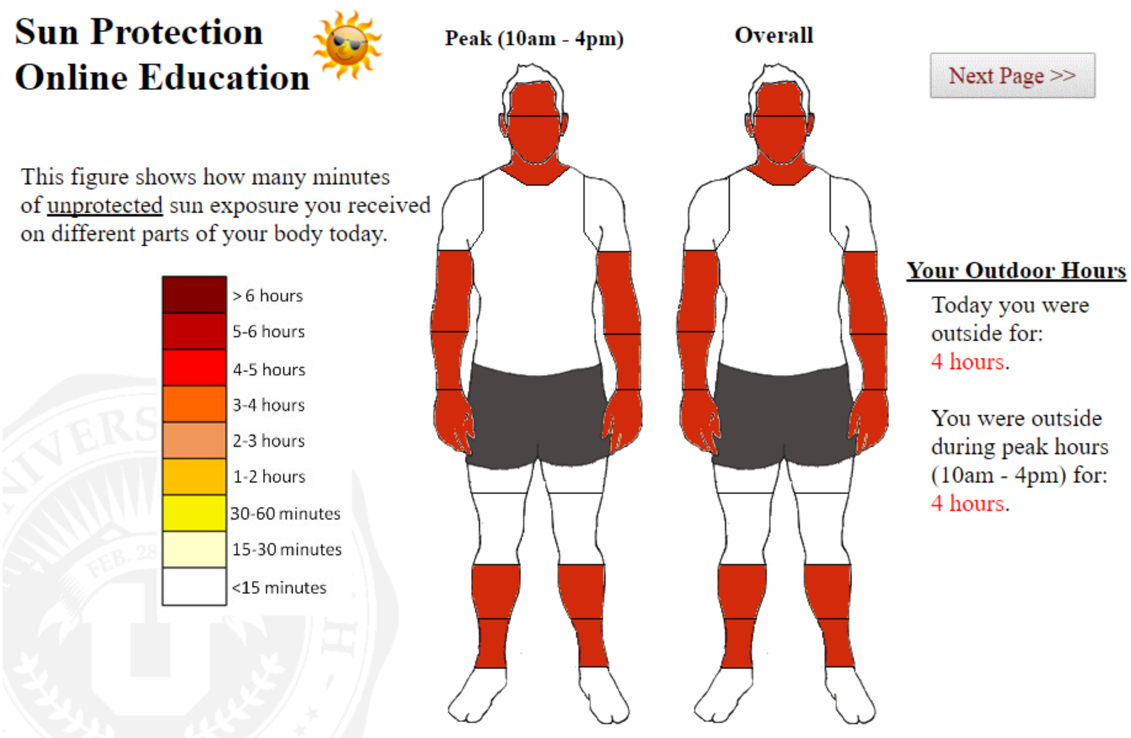

Figure 1 End-of-the-day sun exposure feedback provided based on responses to the Minutes of Unprotected Sun Exposure (MUSE) Index.

were selected to provide an estimate of one's current level of sun exposure during recent days at each assessment (with 2 weeks selected so that the reports at the 1 month follow-up would not overlap with reports during the intervention period). In the daily diaries completed each evening during the 14-day intervention period, the current day was used as the reporting window so that feedback would be provided for the most recent day of sun exposure. For each reporting window, participants were first asked to provide details on the outdoor activities they performed for longer than 15 minutes during daylight hours (6 AM to 6 PM). On a single screen, they entered details on the time and duration of each activity, and briefly listed the activity they were doing (e.g., walking the dog). On that same screen, they indicated what they were wearing by selecting clothing pictures that vary in degree of body coverage. After describing all outdoor activities that took place during each reporting window, participants were then asked about all instances of sunscreen use during that day, including when and where they applied (or reapplied) sunscreen, and the SPF of sunscreen used.

Overall MUSE scores reflect both the extent of body exposure during an activity as well as the duration of the activity. For instance, an individual who spends 4 hours doing yard work with no hat, a T-shirt, shorts, and tennis shoes would receive an overall MUSE score of 81.6, which corresponds to 34% of the body being exposed for 240 minutes. That same individual would receive an overall MUSE score of 0 if he or she had reported applying (and reapplying) sunscreen to all exposed body sites during the activity. Analyses from a prior study support the validity of the MUSE Inventory (Stump et al., 2013, 2014). Overall MUSE scores were related to self-reports of time outdoors, reflectance spectroscopy measures, and time outdoors as measured by a UVR dosimeter.

Reflectance spectroscopy

Skin color was assessed using a Minolta Chroma meter. This handheld device measures various attributes of skin color, including hue (from red to green; a* scale), lightness (from black to white; L* scale), and saturation (from yellow to blue; b* scale). Readings were made on four typically exposed body sites: forehead, cheek, nose, and left wrist, and on two less exposed body sites: lower back and under arm. For each body site, five readings were taken at slightly different points on the skin and averaged for analysis. These measurements are used to calculate Melanin Index scores, with higher Melanin Index scores indicating greater sun exposure (e.g., Robinson, Friedewald, Desai, & Gordon, 2015).

Measures assessing process of behavior change in daily diaries

Perceived goal fulfillment

Perceived goal fulfillment was measured using two items adapted from a previous study of goal pursuit (Louro et al., 2007). Participants were asked: "In your opinion, how close did you get today to your goal (of limiting your unprotected sun exposure to no more than 15 minutes)?" and "How large is the distance between how much sun exposure you got today and your goal (of limiting your unprotected sun exposure to no more than 15 minutes)?" Response options ranged from 1 (none) to 7 (a lot) for the first item and 1 (small) to 7 (large) for the second item, which was reverse-scored. These items were highly correlated in a prior study (Louro et al., 2007), r=.76, p<.01. In the present study, they were moderately correlated at the day 1 assessment, r=.43, p=.03, although it should be noted that correlations varied over time, ranging from r=.27 (p=.20) to r= .75 (p<.01). Table 1 provides additional descriptive information on this scale and the other daily

Table 1

Descriptive statistics for measures used to analyze daily behavior-change

	Range of 14 Daily Means	Range of 14 Daily *SD*s	Mean of Intra-Individual *SD*s
Confidence in Goal Fulfillment Perceptions	6.24-6.78	.46-1.44	.60
Coherence for Sun Exposure	4.61-4.89	.34-.64	.30
Perceptions of Goal Fulfillment	5.58-6.35	.98-1.88	.71
Negative Emotions	1.03-1.18	.07-.50	.18
Positive Emotions	2.34-2.96	.79-1.16	.30
Intended Effort	5.92-6.35	.85-1.16	.31
Self-efficacy for Sun Protection	5.67-6.28	.92-1.30	.42

Note. For coherence, negative emotions, and positive emotions, endpoints were 1 to 5. For all other scales, endpoints were 1 to 7.

process measures.

Confidence in own perceptions of goal fulfillment

Confidence in own perceptions of goal fulfillment was assesed with a single item immediately following the above assessment of perceived goal fulfillment: “I am confident that my perception of whether or not I met my goal (of limiting my unprotected sun exposure to no more than 15 minutes) is accurate.” Response options ranged from 1 (not at all) to 7 (very much). An additional three items assessed the related concept of coherence for sun exposure, which refers to participants’ understanding of how much sun exposure they received; these items were adapted from the illness coherence subscale of the Illness Perceptions Questionnaire – Revised (Moss-Morris et al., 2002). Two example items are “I have a clear picture or understanding of the amount of sun exposure I received today,” and “The amount of sun exposure I received today is a mystery to me” (reverse-scored). Response options ranged from 1 (strongly agree) to 5 (strongly disagree). In the present study, this scale demonstrated low reliability at the day 1 assessment, α=.65. Internal reliability for the remaining days was highly variable, ranging from α=.10 to α=.90. This variation in reliability may have been due to the low range of values (see Table 1) or to misunderstandings resulting from item wording, especially the reverse-worded item.

Self-efficacy for sun protection

Self-efficacy was measured using a single item adapted from a prior study (Andersen et al., 2008): “Whether or not you currently do so, how confident are you that you can limit your unprotected sun exposure to no more than 15 minutes each day?,” with response options ranging from 1 (not at all) to 7 (extremely).

Negative and positive emotional reactions to feedback and/or self-monitoring efforts

Negative and positive emotional reactions to feedback and/or self-monitoring were assessed using the short form of the Positive and Negative Affect Scale (PANAS; MacKinnon et al., 1999). These items were assessed following the above items pertaining to goal fulfillment and self-efficacy, and participants were instructed to answer questions based on the extent to which they were currently experiencing each of the listed emotions right now. Although the primary predictions regarding the daily process of behavior change pertained to the experience of negative affect, positive affect was also assessed to explore whether positive affect has an independent effect on the goal pursuit process. For instance, greater perceptions of goal fulfillment may produce positive emotions that individuals strive to maximize by continuing to put effort toward sun protection. Participants were asked to what extent they were currently feeling each of 10 emotions, such as upset and inspired, with options ranging from 1 (very slightly to not at all) to 5 (extremely). The positive and negative affect scales have demonstrated good reliability in prior research (αs=.78 and .87, respectively).

In the present study, reliability was quite low for the negative emotions scale. At the day 1 assessment, internal reliability was poor, α=.55; on the remaining days reliability ranged from α=-.17 to α=.94. These low reliabilities may be attributable to the low degree of variability in scores. The scale standard deviation was below .30 for all but 2 days (see Table 1). Given this issue with reliability, in addition to using models that included the negative affect scale, exploratory analyses were also conducted using the single item that demonstrated the greatest variability (distressed). In contrast, for the positive emotions scale, there was more variability and reliabilities were excellent. At the day 1 assessment, α=.87; on the remaining days reliability ranged from α=.82 to α=.92.

Intended effort

Intended effort was measured using a 3-item scale adapted from prior research on goal pursuit that has demonstrated excellent reliability in past research (α=.95; Louro et al., 2007). An example item is "How hard will you work tomorrow to reach your goal (of limiting your unprotected sun exposure to no more than 15 minutes)?" Response options ranged from 1 (not at all) to 7 (very much). In the present study, these items demonstrated excellent reliability. At the day 1 assessment, α= .95; in the remaining assessments, reliability ranged from α=.88 to α=.98.

Baseline moderators of intervention effects

Stage of change

Stage of change refers to one's current evaluation of his or her intention to perform a health behavior (Porchaska et al., 1994). Stage of change at baseline was assessed using a single item regarding whether participants consistently use sun protection (adapted from Nigg et al., 1999; Rossi, Blais, Redding, & Weinstock, 1995). For this item, the methods of protecting oneself from the sun (by sunscreen, protective clothing, or avoiding/limiting exposure to the sun during peak hours) were first described. Then participants were asked, "Do you protect yourself from exposure to the sun consistently according to that definition?" Response options were 1 (No, and I do not intend to start protecting my skin in the next 6 months), 2 (No, but I intend to start doing so in the next 6 months), 3 (No, but I intend to start doing so in the next 30 days), 4 (Yes, I have been, but for LESS than 6 months), and 5 (Yes, and I have been for more than 6 months).

Health-specific regulatory rocus

Health-specific regulatory focus was assessed by the 3-item health prevention subscale and the 5-item health promotion subscale (Gomez, Borges, & Pechmann, 2013). An example item assessing health promotion focus is "I see myself as someone who does my utmost to improve my health" and an example item assessing health prevention focus is "When I implement a health behavior, it's because I want to protect myself from getting sick." Response options ranged from 1 (strongly disagree) to 7 (strongly agree). This scale has demonstrated high test-retest reliability, and predictive validity for health behaviors, which exceeded what was observed for a more general measure of regulatory focus (Gomez et al., 2013). As in past research, in the present study, these scales were treated as distinct constructs, and were not significantly correlated, r=.25, p=.08. Both scales demonstrated adequate reliability in the present study: for prevention, α=.73; for promotion, α=.89.

Response efficacy for sun protection

Response efficacy for sun protection was measured by four items adapted from Manne and Lessin (2006). An example item is, "Protecting my skin from the sun lowers (or would lower) my chances of getting moles or growths on my skin that are cancerous or may become cancerous," with responses ranging from 1 (strongly disagree) to 5 (strongly agree). Reliability for this scale from prior work is unavailable because these items were adapted from a larger, 7-item scale that was used for a different risk-reduction behavior (skin self-exams). In the present study, reliability was good, α=.80.

Design

This study followed a 3 (intervention condition) X 3 (time of assessment) design. Participants were randomly assigned to one of the three intervention conditions – feedback, self-monitoring, and control. A self-monitoring condition was included because the act of consistently monitoring and reporting behavior has been found to lead to behavior change even when no additional feedback is provided (e.g., Baker & Kirschenbaum, 1998). Including this group allows us to determine whether and how feedback contributes to behavior change to an extent that cannot be attributed to repeatedly providing self-reports of behavior.

Procedure

Baseline

At the baseline visit, all participants completed questionnaires and the MUSE Inventory to assess baseline sun exposure. Reflectance spectroscopy measurements of the skin were also taken to serve as objective measures of sun exposure on multiple, frequently exposed body sites, such as the face and wrist. All participants were then also reminded of the American Academy of Dermatology's recommendation to use sunscreen with an SPF of 30 or higher; seek shade and/or wear protective clothing any time they are outdoors; and to avoid sun exposure between 10 AM and 4 PM, when the sun's rays are the strongest ("How do I prevent skin cancer?", 2014). Due to their elevated risk of skin cancer, all participants were instructed to adopt the goal of limiting unprotected sun exposure to no more than 15 minutes each day. At this visit, participants were randomly assigned to one of the three conditions –feedback, self-monitoring, or control – which determined the content of an online daily diary completed during the first 14 days of the study.

Intervention/daily diaries

For the next 14 days following the baseline visit, participants completed online daily diaries each evening. For all conditions, this diary included a daily true/false question about sun protection and ended with daily reminders about how to protect oneself from the sun. In the feedback condition, participants additionally completed a self-report sun exposure measure, the Minutes of Unprotected Sun Exposure (MUSE) Inventory, and then received feedback on minutes of unprotected exposure on various body sites based on responses to the MUSE Inventory (see Figure 1). The self-monitoring group completed the MUSE Inventory, but did not receive feedback. Feedback and self-monitoring participants then completed short questionnaire items on perceptions of goal fulfillment, confidence in these perceptions, current emotions, self-efficacy for sun protection, and intended effort for next-day sun protection (see *Measures* for complete information about these scales). Participants in the control condition neither completed the MUSE Inventory nor these additional questions about health-related cognitions and emotions.

Follow-up visits

All participants completed in-person follow-up visits, both 1 and 2 months following the baseline assessment. At these visits, they also completed the MUSE Inventory with reference to typical days in the past 2 weeks in order to assess the short- and long-term intervention effects on sun-protection behavior. Reflectance spectroscopy measures were also taken to assess cumulative tanning throughout the month. At the 2-month follow-up, participants were asked about their experiences in the study, especially regarding their impressions of how easy it was to participate in the feedback program and whether and why it was or was not useful to them.

RESULTS

Short- and long-term effects of feedback on sun exposure

To test the prediction that those in the feedback and self-monitoring conditions would reduce sun exposure to a greater extent than those in the control condition at 1 month, and that this change would be sustained at 2 months in the feedback condition only, I conducted a mixed-model analysis of variance (ANOVA) for each outcome measure (overall MUSE scores, Melanin Index values). In these analyses, experimental condition (feedback, self-monitoring, control) was entered as a between-subjects factor. Repeated measures over three time points (baseline, 1 month, and 2 months) were entered as the within-subjects factor. When MUSE scores served as the outcome variable, there was a significant overall effect of time $F(1.95,80.05)=3.25$, $p=.03$; overall, participants decreased sun exposure between the baseline and 2-month assessments.[1] There was also a significant main effect of experimental condition; sun exposure was lower in the two experimental conditions than in the control condition, $F(2,41)=4.15$, $p=.02$. Contrary to

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[1] This analysis excluded three outliers (2 control, 1 self-monitoring) with MUSE scores that were three standard deviations higher than the means of the non-zero MUSE scores (*M*s=14.27-19.82, *SD*s=18.15-22.83) at least one timepoint. The outlying values ranged from 74.44 to 164.53. In an analysis including these participants, there was no overall decrease in MUSE scores, $p = .22$. As before, there was a significant effect of condition, $F(2, 44)=4.36$, $p=.02$. Overall, MUSE scores were higher in the control group than in the feedback or self-monitoring groups, which did not differ from one another.

predictions, this effect was not qualified by a condition by time interaction, $F(3.91, 80.05) = 1.00$, $p = .41$. That is, even at the baseline assessment, participants in the control condition reported significantly greater overall MUSE scores than those in the self-monitoring ($p = .01$) and feedback conditions ($p = .04$). However, consistent with hypotheses, post hoc analyses revealed a significant long-term decrease in sun exposure among participants in the feedback condition only ($M_{baseline} = 16.29$, $M_{two\text{-}month} = 7.74$, $d = .81$, $p = .02$). At the 2-month assessment, overall MUSE scores were higher in the control condition than in the feedback ($p < .01$) or self-monitoring groups ($p = .03$), which did not differ from one another. Figure 2 displays condition means over time.

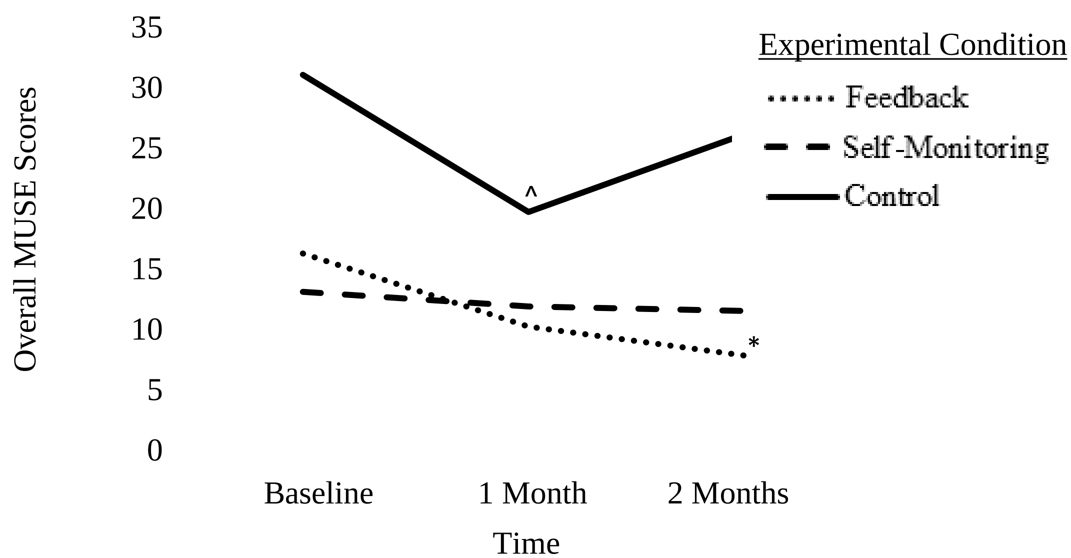

Figure 2 Overall MUSE scores over time as a function of feedback, compared to self-monitoring and control conditions.

Note. Higher scores indicate greater sun exposure.
*Denotes a significant change from baseline ($p < .05$);
^Denotes a marginally significant change from baseline ($p < .10$).

Because participants in the control condition already reported higher sun exposure at baseline, an analysis of covariance analysis was conducted that statistically controlled for baseline overall MUSE scores.[2] In this analysis, there was neither a main effect of time, $F(1,40)=1.21$, $p=.28$, nor a significant time by condition interaction, $F(2,43)=.06$, $p=.94$. The overall effect of experimental condition was also not significant, $F(2,40)=1.10$, $p=.34$. However, post hoc analyses revealed that at the 2-month follow-up, compared to controls (*AdjM*=19.29), feedback condition participants tended to report lower sun exposure (*AdjM*=15.22, $d=.58$, $p=.07$).

The ANOVA was repeated using Melanin Index scores as the outcome measures.[3] Melanin Index readings from 3 exposed facial sites (nose, cheek, forehead) were averaged to form a facial Melanin Index scale, α's=.85-.86. Separate analyses were conducted with the facial and left wrist Melanin Index scale serving as outcome variables. For both body sites, there was no main effect of time [Face: $F(1.68,70.61)=.45$, $p=.45$; Wrist: $F(2,84)=1.74$, $p=.18$], condition (Face: $F(2,42)=.48$, $p=.48$; Wrist: $F(2,42)=.06$, $p=.95$), or condition by time interaction (Face: $F(3.36,70.61)=.45$, $p=.45$; Wrist: $F(2,84) = 2.25$, $p=.07$).[4] Post hoc

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[2] As in prior analyses, this analysis excluded three outliers (1 self-monitoring, 2 control. Analyses including these participants yielded different results. In this analysis, there was a significant effect of experimental condition, $F(2,43)=4.69$, $p=.01$. At the 1-month follow-up, participants in the control group (*AdjM*=25.55) reported a trend toward higher sun exposure than those in the feedback condition (*AdjM*=11.34, $p<.10$), but did not differ from the self-monitoring condition (*AdjM*=12.32, $p=.12$). At the 2-month follow-up, compared to controls (*AdjM* =27.39), participants reported lower sun exposure in the feedback (*AdjM* =9.64, $p=.01$) and self-monitoring (*AdjM* =12.86, $p=.04$) conditions.

[3] For these analyses, $n=45$. In addition to the 3 participants who withdrew, reflectance data were unavailable for 1 participant at the 1-month follow-up due to an equipment malfunction and for 1 participant at the 2-month follow-up who completed her participation by phone.

analyses were conducted to explore the marginally significant condition by time interaction for wrist Melanin Index values. As can be seen in Figure 3, contrary to predictions, these analyses indicated that there was a significant increase in wrist Melanin Index values between baseline and the 1-month visit in the feedback condition only.

Examining change over time in specific body sites

To determine for which particular body sites overall MUSE scores changed over time in the feedback condition, MUSE scores were calculated separately for each body site and then analyzed in a series of mixed-model ANOVAs following the same 3 (Between: Condition) X 3 (Within: Time) design used in prior analyses. As seen in Table 2, changes between baseline and 2 months were reported at multiple body sites for feedback participants: lower half of the face, upper arms, forearms, calves, and ankles. At 2 months, exposure for the upper arms and forearms was significantly lower in the feedback condition than in the self-monitoring condition (*p*s<.05). Figure 4 displays MUSE scores over time in each experimental condition for the body sites for which long-term change was observed among feedback participants.

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[4] To account for the possibility that the Melanin Index may correspond better to sun exposures in some people than others (due to skin characteristics), the ease with which skin tans or burns was assessed and controlled for in separate ANCOVAs. In separate analyses, three individuals with type 1 skin (white skin that always burns and minimally tans) were excluded because sun exposure does not predict consistent changes in skin color in these individuals. Despite these adjustments and exclusions, the results for change over time were nonsignificant.

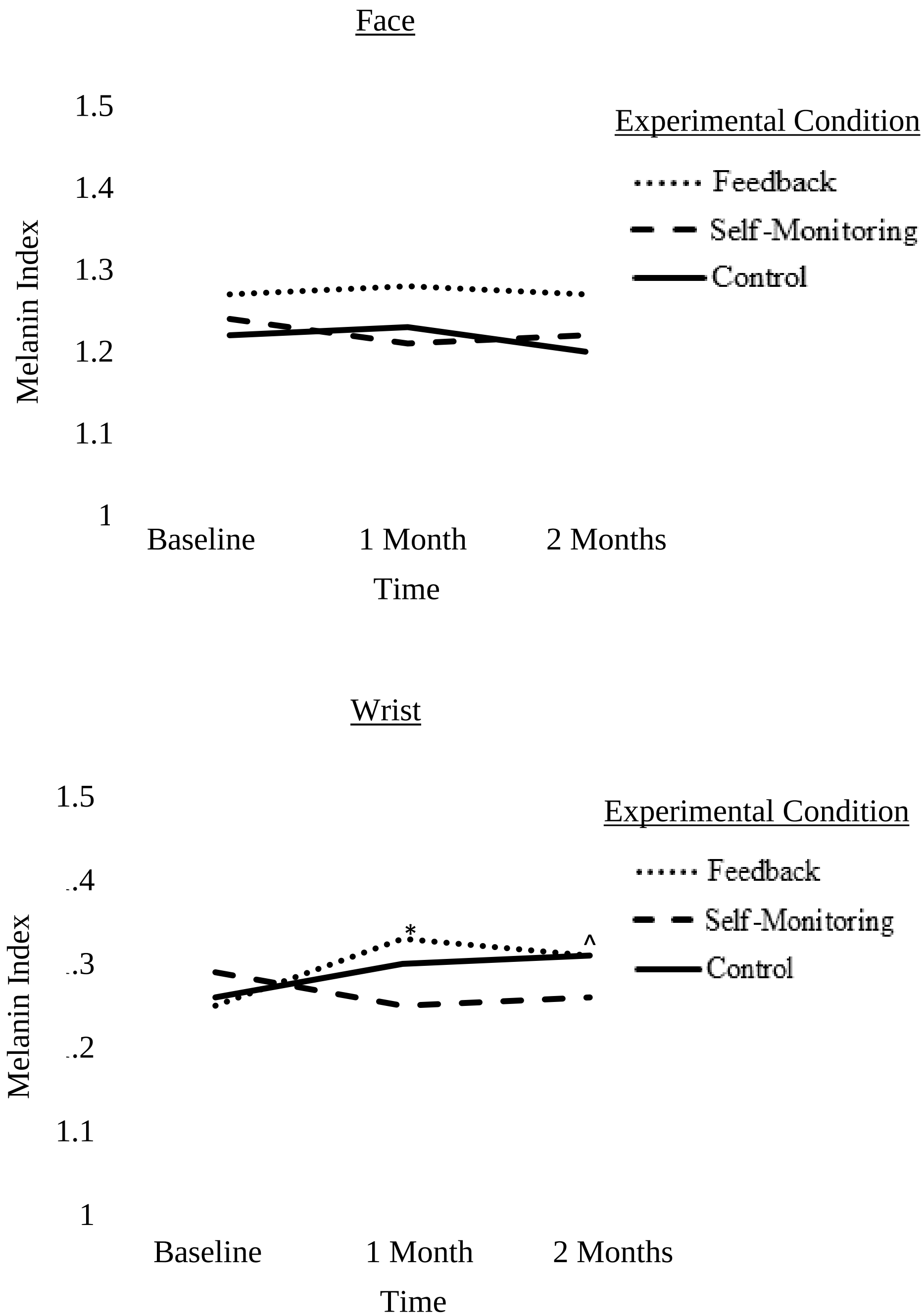

Figure 3 Melanin Index scores over time as a function of feedback, compared to self-monitoring and control conditions.

Note. Higher scores indicate greater sun exposure.
*Denotes a significant change from baseline (*p*<.05);
^Denotes a marginally significant change from baseline (*p*<.10).

Table 2

Individual MUSE scores over time within each group

		Control		Self-Monitoring		Feedback	
Site (% body)		Mean	*SD*	Mean	*SD*	Mean	*SD*
Scalp							
(3.5%)	Baseline	**42.50**$_a$	48.67	20.21	27.41	15.69	27.06
	1 Month	**10.48**$_b$	17.87	29.43	32.78	8.19	17.28
	2 Month	**44.35**$_a$	71.53	26.43	36.48	5.80	16.03
Face - Upper							
(1.5%)	Baseline	**33.93**$_a$	44.89	8.64	13.36	11.66	22.06
	1 Month	**8.69**$_b$	15.21	19.05	28.01	5.17	14.91
	2 Month	**35.06**$_a$	61.03	20.29	34.06	1.26	5.20
Ears							
(.25%)							
	Baseline	88.21	76.89	26.07	27.99	27.33	32.02
	1 Month	67.00	97.74	29.20	32.20	13.89	21.81
	2 Month	82.82	82.82	25.56	32.41	12.47	18.37
Face - Lower							
(1.75%)	Baseline	**79.05**$_{a,b}$	57.13	27.79	28.56	**30.86**$_a$	27.78
	1 Month	**57.36**$_a$	65.50	28.62	30.76	**14.52**$_{a,b}$	21.54
	2 Month	**79.42**$_b$	70.33	27.56	31.64	**10.33**$_b$	16.19
Neck							
(2%)	Baseline	75.83	62.31	24.93	29.08	29.98	28.74
	1 Month	55.57	66.47	28.62	30.76	14.52	21.54
	2 Month	75.49	72.79	26.13	32.49	12.09	17.95
Midsection							
(13%)	Baseline	6.07	14.21	**5.64**$_a$	13.94	2.46	6.45
	1 Month	4.64	11.18	**0.00**$_b$	0.00	1.20	2.93
	2 Month	2.32	8.04	**0.29**$_{a,b}$	1.11	0.82	2.54
Back							
(13%)	Baseline	2.86	9.90	3.43	13.28	0.00	0.00
	1 Month	2.86	9.90	0.00	0.00	0.00	0.00
	2 Month	0.00	0.00	0.00	0.00	0.00	0.00
Shoulders							
(4%)	Baseline	9.29	23.53	6.14	15.08	3.66	8.96
	1 Month	4.64	11.18	0.00	0.00	2.39	5.86
	2 Month	5.36	14.05	0.57	2.21	1.63	5.09
Upper arms							
(4%)	Baseline	**57.62**$_a$	65.59	31.14	30.92	**36.53**$_a$	30.91
	1 Month	**32.48**$_b$	37.72	18.48	29.13	**0.27**$_{a,b}$	32.99
	2 Month	**58.89**$_a$	74.50	22.13	30.87	**15.85**$_b$	19.76

Table 2 Continued

Site (% body)		Control Mean	Control *SD*	Self-Monitoring Mean	Self-Monitoring *SD*	Feedback Mean	Feedback *SD*
Forearms							
(6%)	Baseline	59.76	64.71	**35.07**$_{a}$	30.42	**37.16**$_{a}$	31.79
	1 Month	33.52	38.51	**20.62**$_{b}$	28.29	**21.03**$_{a,b}$	32.95
	2 Month	62.28	72.47	**26.13**$_{a,b}$	34.53	**19.38**$_{b}$	28.37
Hands							
(5%)	Baseline	**63.21**$_{a}$	62.80	30.93	23.48	45.61	35.66
	1 Month	**51.73**$_{b}$	48.69	40.14	36.13	32.12	39.74
	2 Month	**64.42**$_{a}$	83.99	38.28	36.74	24.05	28.50
Thigh Area							
(9.5%)	Baseline	1.07	3.71	0.57	2.21	0.00	0.00
	1 Month	2.86	9.90	3.14	11.04	0.00	0.00
	2 Month	0.00	0.00	0.14	0.55	0.00	0.00
Knee Area							
(9.5%)	Baseline	**40.83**$_{a}$	54.32	15.14	29.82	14.50	23.37
	1 Month	**20.45**$_{a,b}$	27.49	15.14	30.21	16.85	34.16
	2 Month	**23.53**$_{b}$	30.35	13.28	30.13	6.76	18.12
Calf Area							
(7%)	Baseline	**52.26**$_{a}$	58.42	19.29	28.02	**42.77**$_{a}$	35.52
	1 Month	**35.69**$_{a,b}$	43.55	19.90	30.07	**21.41**$_{b}$	36.03
	2 Month	**30.85**$_{b}$	35.49	21.70	35.51	**17.89**$_{b}$	38.90
Ankle Area							
(7%)	Baseline	60.83	58.63	26.36	30.58	**41.26**$_{a}$	31.79
	1 Month	40.21	41.24	23.90	33.58	**18.91**$_{b}$	33.59
	2 Month	48.35	56.64	22.28	35.21	**23.06**$_{a,b}$	37.51
Feet							
(7%)	Baseline	49.64	86.85	3.14	9.23	9.45	14.36
	1 Month	33.69	100.56	9.43	20.37	12.84	31.83
	2 Month	52.20	118.54	6.29	22.08	5.46	11.70

Note. Within each condition, mean differences over time are in boldface and means with differing subscripts differ significantly over time, $p < .05$. Data from participants that were excluded in testing the main intervention outcomes were likewise excluded here.

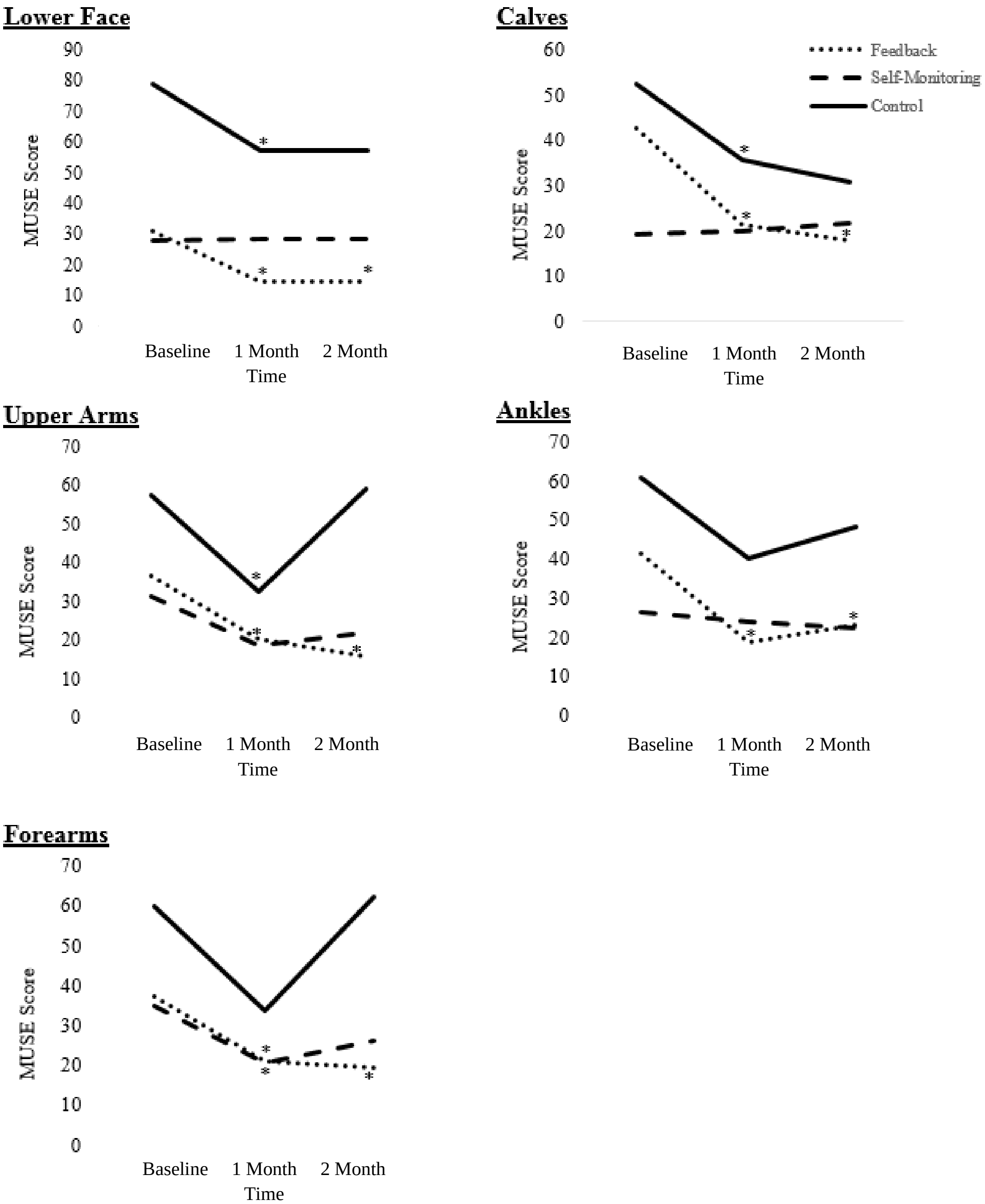

Figure 4 Individual body-site MUSE scores over time as a function of feedback, compared to self-monitoring and control conditions.

Note. *Indicates significant difference from baseline.

Rate of change during the intervention

To test the prediction that the feedback group would report lower sun exposure during the intervention and that behavior change would occur more rapidly in this condition, daily data were analyzed using multilevel modeling. For these multilevel models, MUSE scores served as the dependent variable. Day (1-14) was used as a level-1 predictor, and centered at 7 days. Experimental condition was dummy coded and entered at level 2 in order to predict the level-1 intercept and slope. As displayed in Figure 5, during the intervention period, sun exposure was lower in the feedback condition than the self-monitoring condition (γ_{01}= -7.70, p=.04). However, the linear effect of time was not significant (p=.23), and the time slope did not vary between the experimental groups (p=.40), indicating a lack of difference in the speed with which the intervention led to reductions in sun exposure.

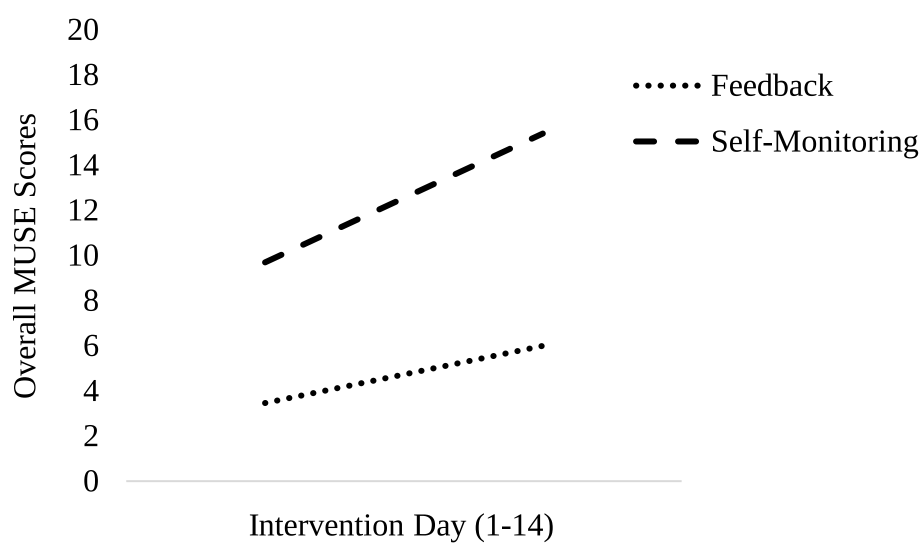

Figure 5 Effect of experimental condition on overall MUSE scores during the intervention.

Analysis of process of behavior change

during the 14-day intervention

Next, I tested predictions about the process through which both self-monitoring and feedback may influence sun-protection behavior as well as ways in which feedback may lead to a greater decrease in sun exposure than self-monitoring alone. At the daily level, I predicted that, in both conditions, greater perceived progress toward a sun protection goal would lead to greater self-efficacy, lower negative emotions, and greater intended effort to use sun protection the next day. I additionally predicted that feedback would increase confidence in individual's perceptions that he or she met their goal, which would, in turn, amplify the effects of perceived goal fulfillment on each of the mediators. These predictions were tested through a series of separate multilevel models (one for each of the six variables that serves as an outcome variable, see Figure 6). For example, when self-efficacy was the outcome variable, perceived goal fulfilment was person-centered and entered as a level-1 predictor. Thus, the following multilevel model tested the predictions that greater perceived goal fulfillment would lead to heightened self-efficacy, and that the effects of perceived goal fulfillment would be greater among those who had more confidence in their perceptions of goal fulfillment:

Level 1: $\textit{Self-Efficacy}_{ij} = \beta_{0j} + \beta_{1j}*(\textit{Perceived Goal Fulfillment}_{ij}) + r_{ij}$

Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}*(\textit{Confidence in Perceptions of Goal Fulfillment}_{j}) + u_{0j}$

$\beta_{1j} = \gamma_{10} + \gamma_{11}*(\textit{Confidence in Perceptions of Goal Fulfillment}_{j}) + u_{1j}$

As seen in Figure 6, results from the multilevel models supported some, but not all, of the theoretically derived predictions regarding daily change in sun protection and proposed mediating variables. As anticipated, lower reported sun exposure predicted

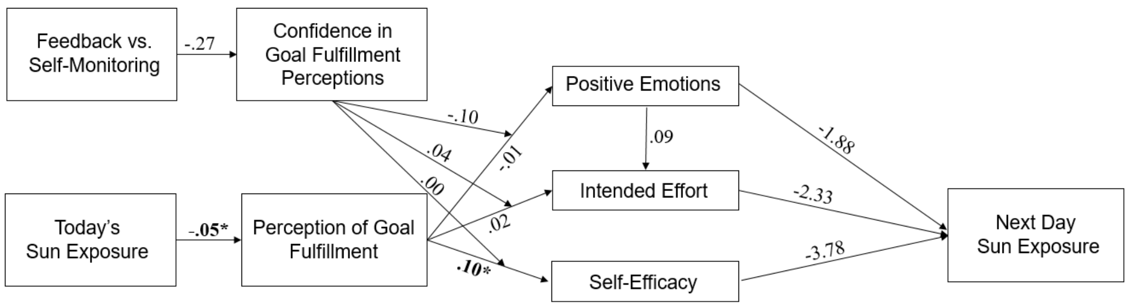

Figure 6 Tests of daily process model of change in sun protection and mediating variables[5]

Note. Unstandardized parameter estimates are derived from the separate multilevel models described above. Significant associations are bold, *p < .05. Feedback vs. Self-Monitoring was coded such that 1=Feedback, 0=Self-Monitoring.

[5] In these models, emotions are represented by positive emotions only. Because of the low internal reliability and low variability observed for negative emotions at multiple timepoints, results from this variable are not reported above. Analyses were conducted separately for the negative emotions subscale and for the single item, distressed, which demonstrated the most variability. None of the associations with negative emotions were significant in these models. Parallel analyses were also conducted replacing "confidence in goal fulfillment perceptions" with a scale measuring a related construct: understanding of how much sun exposure was received ("coherence for sun exposure"). In these analyses, the same pattern of results was observed, except that the cross-level interaction between coherence and perceptions of goal fulfillment (predicting positive emotions) was not significant.

greater perceptions of goal fulfillment, and greater perceptions of goal fulfillment predicted greater self-efficacy. The remaining relationships were not significant, and none of the mediating variables predicted next-day sun exposure.

Additional analyses indicated no differences between feedback and self-monitoring participants on the proposed mediators. Specifically, a series of independent *t*-tests revealed no significant differences between the self-monitoring and feedback conditions in average scores (i.e., collapsed across day) for any of these variables ($p>.05$). Furthermore, when experimental condition (feedback vs. self-monitoring) was entered as the moderator instead of confidence in perceptions of goal fulfillment in each of the multilevel models, it did not moderate any of the relationships depicted in the model.

<u>Potential moderators of overall intervention effects</u>

Regression analyses were conducted to analyze the impact of potential moderators of the feedback intervention's reduction in sun exposure, as measured by the MUSE Inventory. Study condition was represented in these models by dummy codes for feedback and self-monitoring conditions; the control condition served as the reference group. The following variables were analyzed as potential moderators: melanoma history, gender, age, response efficacy for sun protection, health promotion orientation, health prevention orientation.[6] The Appendix presents descriptive statistics and correlations among these variables. Regression analyses were conducted separately for each moderator and each follow-up session to account for baseline differences. Baseline

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[6] Stage of change was not analyzed as a moderator because it demonstrated very low variability, with 89% of participants indicating that they were in the maintenance phase for sun protection behavior

MUSE scores were included to control for baseline differences in sun exposure, and the feedback and self-monitoring dummy codes were entered. The moderator of interest in each analysis was centered at its mean (if continuous) and added as well as the interaction of the moderator with each of the dummy codes. As shown in Table 3, the only significant moderator was prior melanoma diagnosis. As seen in Figure 7, post hoc analyses probing this interaction revealed that in the control group only, sun exposure differed as a function of having a previous melanoma; those with a melanoma history reported *greater* sun exposure ($p < .05$). However, it should be noted the melanoma diagnoses were not equally distributed across experimental conditions and that there were only 4 participants in the control condition who also reported a previous melanoma (in the feedback conditions, 9 of 17 had a previous melanoma; in the self-monitoring condition, 8 of 15 had a previous melanoma).

<u>Exploration of seasonal variability in each group</u>

<u>and impact on outcome variables</u>

Although random assignment to experimental condition was used to eliminate the influence of the date during the summer that each in-person study assessments took place, the following analyses were conducted to ensure that random assignment was successful in this respect and to explore changes in sun exposure as a function of time of year of each in-person assessment, which varied from July to October. Study day was calculated by subtracting earliest possible baseline assessment (July 6, 2015) from the date of each visit. For each visit, univariate ANOVAs revealed no difference in study day as a function of experimental condition, *p*s>.05. Seasonal effects were additionally explored through correlating the study day of each visit with corresponding overall MUSE scores.

Table 3

Effects of potential moderators on overall MUSE scores.[7]

	1-Month MUSE Scores (*B*)	2-Month MUSE scores (*B*)
Prior Melanoma Diagnosis		
R^2	0.23	0.59
Intercept	8.33	1.1
Baseline MUSE score	.36*	.61***
Feedback	1.88	-1.45
Self-Monitoring	-2.05	0.65
Melanoma	0.06	19.31*
Feedback X Melanoma	-11.24	-22.7*
Self-Monitoring X Melanoma	1.73	-15.48
Gender		
R^2	0.23	0.55
Intercept	8.03	16.7
Baseline MUSE score	.35*	.53***
Feedback	-1.21	-18.51
Self-Monitoring	3.71	-14.48[†]
Gender (1=Male)	1.92	-13.27
Feedback X Gender	-7.25	15.59
Self-Monitoring X Gender	-11.25	18.39

[7] These analyses were also conducted with wrist and face Melanin Index scores serving as the outcome variable. These results are not reported in the main text since there was no overall intervention effect observed using these measures. In brief, three interactions with experimental condition were significant. For face values, at the 1-month follow-up, feedback was more effective among those with a prior melanoma diagnosis (p=.01), and at the 2-month follow-up, females in the control condition had lower Melanin Index scores than females in the self-monitoring condition. For wrist values, at the 2-month follow-up, a higher promotion orientation resulted in higher Melanin Index scores in the feedback condition only, p=.02. These findings are not interpreted further because they were neither predicted nor were they consistent across body sites and assessment time points.

Table 3 Continued

	1-Month MUSE Scores (*B*)	**2-Month MUSE scores (*B*)**
Age		
R^2	0.24	0.55
Intercept	-8.23	-16.36
Baseline MUSE score	.38*	.66***
Feedback	-2.64	-7.34
Self-Monitoring	0.55	-1.76
Age	0.3	.42†
Feedback X Age	-0.6	-0.41
Self-Monitoring X Age	-0.14	-0.42
Response Efficacy		
R^2	0.20	0.52
Intercept	8.86	7.77
Baseline MUSE score	.36*	.60***
Feedback	-4.59	-9.42†
Self-Monitoring	-1.54	-4.05
Response Efficacy	4.74	-2.07
Feedback X Response Efficacy	-3.88	-1.52
Self-Monitoring X Reponse Efficacy	0.73	2.42
Health Promotion		
R^2	0.19	0.57
Intercept	16.04	7.55
Baseline MUSE score	.36*	.61***
Feedback	-3.93	-9.89†
Self-Monitoring	-1.05	-4.54
Promotion	-1.37	-0.2
Feedback X Promotion	2.67	1.74
Self-Monitoring X Promotion	2.89	8.8
Health Prevention		
R^2	0.20	0.53
Intercept	9.34	6.57
Baseline MUSE score	.38*	.55***
Feedback	-4.45	-7.46
Self-Monitoring	-2.62	-1.89
Prevention	1.87	-3.91
Feedback X Prevention	-3.83	3.15
Self-Monitoring X Prevention	0.06	0.78

***p<.001, **p<.01, *p<.05, †p<.10

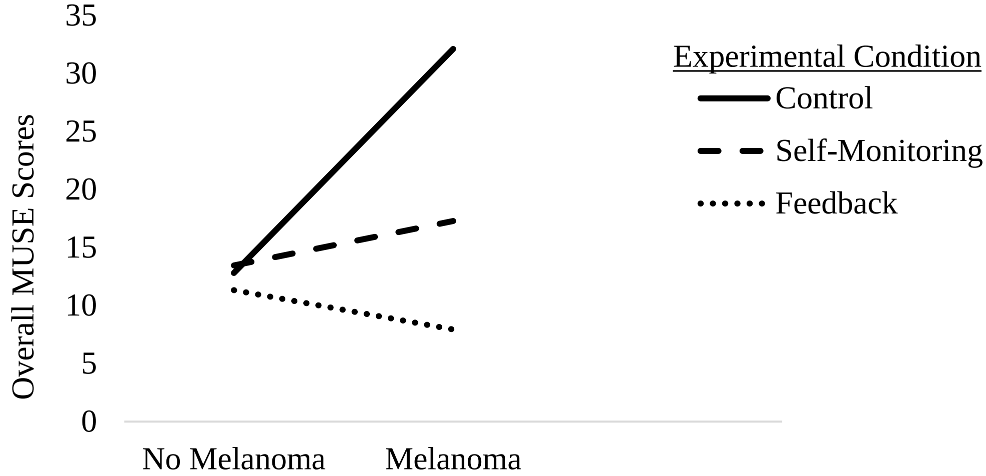

Figure 7 Adjusted Overall MUSE scores as a function of melanoma status and experimental condition at 2 months.

Note. Means control for baseline overall MUSE scores.

At baseline, a marginally significant association between higher overall MUSE scores and study day was observed, r=.24, p=.09. This correlation was nonsignificant when MUSE outliers were excluded (r=-.13, p=.38). For the follow-up assessments, study day did not predict overall MUSE scores (rs=-.01, .15, ps=.94, .23). These correlation analyses were also run for Melanin Index values. While most of these correlations were nonsignificant (ps>.05), lower Melanin Index values for the face were associated with having a 2-month follow-up visit that fell later in the season (r=-.31, p=.04). Since results did not show a decrease in facial Melanin Index, and experimental conditions did not vary with respect to the date of the 2-month assessment, this difference is regarded as having a negligible impact on conclusions.

DISCUSSION

Results from this study provide mixed support for the effectiveness of a feedback intervention for sun exposure. As measured by self-report (the MUSE Inventory), sun exposure decreased from baseline to 2-month follow-up, with this decrease being significant in the feedback condition only. An additional analysis that controlled for baseline overall MUSE Inventory scores also supported the beneficial effects of the feedback condition, which differed from the control condition at both the 1-month and 2-month follow-ups. The average change in MUSE scores from baseline to 2 months was 8.55 in the feedback condition. For participants who wore the modal baseline outfit of no hat, a T-shirt, knee-length shorts, and tennis shoes (which leaves 34% of the body exposed), this change in score corresponds to an additional 25 minutes of protection on these exposed sites each day.

In the feedback condition, significant reductions in sun exposure were reported in multiple body sites, including the lower half of the face, upper arms, forearms, calves, and ankles. Reductions in sun exposure at these body sites are noteworthy because they correspond to several sites for which melanoma is more common. In men, the incidence of melanomas is greatest for the face, upper arm, and back. For women, in addition to these sites, the forearm and lower leg are also common areas for the development of melanoma. The incidence of nonmelanoma skin cancer is greatest for the face, for which sun protection improved in the feedback condition (Youl et al., 2011).

In contrast, when sun exposure was measured using reflectance spectroscopy, analyses did not reveal significant decreases at the 2-month follow-up. One reason for the lack of change may be participants' current high degree of compliance with sun protection procedures. At baseline, 89% of participants reported that they were already consistently using sun protection and had been doing so for more than 6 months. Given this low degree of initial sun exposure, the magnitude of change in sun exposure observed in this study may not have been sufficient to produce a change in melanin content. It should also be noted that these measurements were taken on a limited number of body sites (wrist, upper face), for which exposure did not decrease substantially.

Timing of reductions in sun exposure during the 14-day intervention

It was hypothesized that participants in the feedback condition would improve their sun protection at a faster rate than would those in the self-monitoring condition due to having more specific information to act on with regard to sun protection. Multilevel analyses indicated that during the intervention, participants in the feedback condition reported lower overall sun exposure than those in the self-monitoring condition. However, there was not a significant time slope; participants did not consistently improve sun protection as the intervention progressed. Likewise, feedback condition did not impact the time slope. This lack of change over time may have been due to initial compliance with sun protection recommendations. At the beginning of the intervention, participants may have been more compliant not only because of the daily level intervention itself but also because they had received detailed information about sun protection at the baseline session the previous day.

Analysis of process of reducing sun exposure during the 14-day intervention

Another aim of this study was to test the intra-individual variations in health-related cognitions and emotions that may underlie reductions in sun exposure. As predicted, greater perceptions of goal fulfillment predicted higher self-efficacy. However, self-efficacy did not predict changes in next-day sun exposure across the 14 days. Perceptions of goal fulfillment were unrelated to the other mediators – affect and intended effort. These results should be interpreted in light of the fact that perceived goal fulfillment was actually quite high in most cases. Thus, even when individuals perceived they had not come as close to meeting their goal, these perceptions may not have reached a low enough point to influence emotions or to cause individuals to consciously decide to invest more effort toward the goal of reducing sun exposure.

Although negative emotional responses play an important role in many theories of self-regulation, including the discrepancy-based models that guided this project, we neither found changes in emotion based on perceptions of goal fulfillment nor did we find that emotions predicted intended effort to perform sun-protection behaviors the next day. While the extremely low endorsement of negative emotions across all participants gives us confidence that the feedback does not alarm people, the lack of variation in negative emotion is seemingly inconsistent with prominent models of self-regulation. However, other psychological mechanisms may be operating to mitigate the effects of lower perceived goal fulfillment on emotions. For example, participants may justify their behavior based on the context and blame factors beyond their control, such as having to run an unexpected outdoor errand or attending an outdoor event that took longer than anticipated. These external attributions generally decrease the immediate emotional effects of negative events (Weiner, 2001). Data relevant to this prediction were not collected in the present study, but future studies should investigate this possibility along with other ways that people may respond to minor (e.g. forgetting to reapply sunscreen as recommended) and major self-regulation failures (e.g., sunburns) in the domain of sun protection.

Another plausible explanation for these findings is that the measure of negative emotions used in this study may not have been applicable to this specific health context. Internal reliability was quite low for this measure, and scores were highly skewed to the low end of the scale. Three of the five emotions listed were ones that can be characterized as more activated, agitation-related emotions: scared, nervous, afraid (with the remaining two referring to a more general negative emotional response – upset and distressed). According to self-discrepancy theory, the experience of agitation-related negative emotions is promoted by not reaching a goal when that goal is one that is perceived as a duty or obligation set by others for oneself, and, thus, can result in punishment (Higgins, 1987). Although unmeasured, in the present context, it seems unlikely that, for most individuals, the goal of reducing sun exposure arises from a sense of duty to others. Instead, lowering sun exposure is likely a target set by oneself in response to knowledge of an elevated risk of cancer. Such discrepancies are associated with dejection or self-critical emotions (such as guilt), which should be measured in future studies.

Exploring how feedback leads to reductions in sun exposure

Although feedback led to lower sun exposure during the intervention, a specific mechanism through which sun exposure feedback impacts behavior was not identified. It was proposed that while feedback and self-monitoring would help individuals to reduce their sun exposure, feedback would be more effective because it would give participants more confidence in their perceptions of goal fulfillment. However, this relationship was not significant. Confidence in perceptions of goal fulfillment was high across both self-monitoring and feedback participants. In fact, this confidence may have been warranted since increases in sun exposure (as measured by daily MUSE scores) predicted decreases in perceived goal fulfillment for that day, and this association was not moderated by experimental condition. Thus, participants were fairly accurate in their perceptions of the sun exposure they received.

Future studies should explore other mechanisms through which feedback may lead to reductions in sun exposure. For instance, feedback may have led to differences in goal regulation, which refers to the process of setting and modifying one's goals. While both self-monitoring and feedback likely increased the salience of sun exposure received, for feedback participants, this more specific information may have contributed to participants setting more stringent goals, or more specific goals that targeted specific body areas. Receiving feedback on sun exposure may have also increased perceptions of risk for skin cancer, which, in turn led to participants' reductions in sun exposure.

Little evidence of moderation of effects of intervention on sun exposure by demographic or psychological variables

Both demographic (age, gender, prior melanoma diagnosis) and psychological (response efficacy for sun protection, health prevention regulatory focus, health promotion regulatory focus) factors were analyzed to determine if there were certain sub-groups who benefitted from the feedback intervention more than others. While neither gender nor age impacted the effect of the intervention, at the 2-month follow-up, control-condition participants with a previous melanoma diagnosis reported greater sun exposure than those without a prior melanoma history. These results are not in line with prior research indicating that those with a melanoma often *decrease* their sun exposure. However, it is important to note that this finding is based on a small sample of just 4 participants in the control condition who had a prior melanoma.

Contrary to predictions, none of the psychological variables concerning health-specific regulatory focus or response efficacy for sun protection predicted sun exposure, nor did they interact with intervention condition. It should be noted that response efficacy for sun protection was extremely high in the present study, with no participant responding below the midpoint of the scale. While the scores for the promotion and prevention subscales were more variable, neither main effects nor interactions were observed for these variables. A possible reason for this lack of association is that the constructs of prevention and promotion measured in this study were not specific to one's sun exposure goals. According to self-discrepancy theory, prevention versus promotion orientation can vary depending on the situation (Higgins, 1997). Contrary to other health goals, goals to protect one's skin may be more likely to be prevention goals because 1) they are directed toward avoiding a negative outcome – skin damage, 2) effective behavior only leads to the absence of the negative outcome, not to a positive outcome, and 3) the negative possibility of skin damage is continuously present – no amount of protection in one moment can preclude the possibility of future damage. Although these psychological factors did not predict responses in this educated and fairly compliant sample, they may be important to evaluate in future studies with different populations.

Limitations and Future Directions

The results of the present study should be interpreted in the context of several limitations. First, in several cases, the psychometric properties of the measures used, especially within the daily diaries, were inadequate. This was likely due to a restriction of range in some cases as well as to confusing wording and instructions in the case of questions regarding emotions and coherence for daily sun exposure. In future studies, daily diary measures should be more extensively pilot-tested in order to ensure that the measures are understandable and appropriate for the study sample. Second, this study took place during the mid- to late summer, with all participants completing follow-up assessments in late August or later. While this design could have made it difficult to determine whether decreases over time were due to changing seasons as opposed to the intervention, internal analyses suggest that seasonality was equally distributed among study conditions and did not impact MUSE scores. Third, because the sample already demonstrated high compliance with sun protection methods and intending to use sun protection at baseline was an inclusion criterion, the results of this study cannot be generalized to populations receiving a high degree of exposure or who are less motivated to change their behavior. Also, this overall low rate of sun exposure may have made it more difficult to detect changes in Melanin Index scores, assessed by reflectance spectroscopy.

Nevertheless, this study demonstrated several important strengths of the intervention and suggestions for further study. This study successfully targeted a sample of patients with an elevated risk of skin cancer who have a medical need to reduce sun exposure. Participants completed the intervention during about 80% of the days it was available to them, exceeding the level of compliance (~70%) necessary for full compensation.

This intervention was unique among sun exposure interventions because it incorporated feedback on behavior as well as a technology component. Prior skin cancer prevention interventions directed at individuals (as opposed to changing policies or the environment, for instance) have primarily focused on educating individuals about skin cancer and sun protection, and changing attitudes toward sun protection (Saraiya et al., 2004). Even within interventions aimed toward high-risk patients, education related to risk and sun protection is the most common intervention strategy, and more comprehensive, individually tailored behavior change strategies are infrequently employed (Wu et al., *in press*). In contrast, the present intervention provided highly detailed and personally relevant information on sun exposure that may be a better guide to behavior change. Furthermore, health interventions delivered on mobile platforms, such as this one, provide the opportunity to deliver highly individualized content to a wider audience and in a cost-effective manner (Fotheringham et al., 2000).

Future directions for this intervention will include making it compatible with more devices and potentially making use of existing platforms, such as ResearchKit, which can be used to reach a large number of individuals interested in improving their health. Future versions of the feedback intervention may also be made more useful by supplying additional information, such as allowing the user to see during which activities they are acquiring the most exposure and providing recommendations on how to protect one’s skin during those activities, and by showing users changes in their own sun exposure over time. Additional research is needed to determine for how long and how often it is optimal to provide individuals with feedback on their sun exposure. Further investigation of the daily dynamics underlying how and when a daily sun protection feedback intervention works will be useful for tailoring intervention content in future applications of this and other similar behavioral feedback interventions.

Conclusions

Providing patients who have an elevated risk of skin cancer with daily feedback displaying their degree of sun exposure on individual body sites resulted in decreased self-reported sun exposure from baseline to the 2-month follow-up. These reductions were seen especially in the face, arms, and legs, which are common sites for the development of melanoma. Throughout the 14-day intervention period, feedback reduced sun exposure above and beyond reporting on one's behavior alone (self-monitoring), without inducing negative emotions. Analysis of the process of behavior change revealed that on days that their sun exposure was lower, participants reported greater progress toward their sun exposure goal and greater self-efficacy, but they did not reveal a mechanism through which feedback leads to change in sun exposure. Findings were not corroborated by an objective measure of sun exposure – reflectance spectroscopy – potentially due to low overall rates of sun exposure. Although more research is needed to confirm the utility of the intervention, this initial study provides support for the feasibility of a daily feedback intervention for sun protection among a sample of at-risk patients who were motivated to use sun protection.

APPENDIX

Table 4

Descriptive statistics and correlations among potential demographic and psychological moderators of intervention effects on sun exposure

	Melanoma Diagnosis	Age	Promotion	Prevention	Sun Protection Response Efficacy
Gender (1=Male)	.23	.34*	-.24	-.04	.11
Melanoma Diagnosis (1=Diagnosis)		.33*	-.19	-.08	.01
Age			-.12	-.20	-.12
Promotion				.22	.16
Prevention					.45**
Sun Protection Response Efficacy					
Mean		49.87	5.84	4.89	4.18
SD		15.86	.79	1.09	.50

***p<.001, **p<.01, *p<.05, †p<.10

Note. For promotion and prevention scales, scale endpoints were 1 to 7. For sun protection response efficacy, endpoints were 1 to 5.

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