Emotion
2016, Vol. 16, No. 5, 657–670

1528-3542/16/$12.00 http://dx.doi.org/10.1037/emo0000157

When to Throw the Switch: The Adaptiveness of Modifying Emotion Regulation Strategies Based on Affective and Physiological Feedback

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Particular emotion regulation (ER) strategies are beneficial in certain contexts, but little is known about the adaptiveness of switching strategies after implementing an initial strategy. Research and theory on regulatory flexibility suggest that people switch strategies dynamically and that internal states provide feedback indicating when switches are appropriate. Frequent switching may predict positive outcomes among people who respond to this feedback. We investigated whether internal feedback (particularly corrugator activity, heart rate, or subjective negative intensity) guides people to switch to an optimal (i.e., distraction) but not nonoptimal (i.e., reappraisal) strategy for regulating strong emotion. We also tested whether switching frequency and responsiveness to internal feedback (RIF) together predict well-being. While attempting to regulate emotion elicited by unpleasant pictures, participants could switch to an optimal (Study 1; reappraisal-to-distraction order; $N = 90$) or nonoptimal (Study 2; distraction-to-reappraisal order; $N = 95$) strategy for high-arousal emotion. A RIF score for each emotion measure indexed the relative strength of emotion during the initial phase for trials on which participants later switched strategies. As hypothesized, negative intensity, corrugator activity, and the magnitude of heart rate deceleration during this early phase were higher on switch than maintain trials in Study 1 only. Critically, in Study 1 only, greater switching frequency predicted higher and lower life satisfaction for participants with high and low corrugator RIF, respectively, even after controlling for reappraisal success. Individual differences in RIF may contribute to subjective well-being provided that the direction of strategy switching aligns well with regulatory preferences for high emotion.

Keywords: emotion regulation, flexibility, feedback, corrugator, heart rate

People regulate their emotional reactions using a variety of strategies. For example, they can think differently about emotional situations (i.e., cognitive reappraisal) or shift attention to emotionally neutral information (i.e., distraction; Sheppes, Scheibe, et al., 2014). The strategies people choose depend on a number of factors, including stimulus intensity, contextual demands, and their ability to use the various strategy alternatives (Aldao & Nolen-Hoeksema, 2013; Bonanno & Burton, 2013; Opitz, Gross, & Urry, 2012; Sheppes, Scheibe, et al., 2014). However, the strategies people choose are not always effective (Gross, 2013; Kalisch, 2009), even though they may have worked well in the past (Tice & Bratslavsky, 2000), in which case it may be necessary to switch to another strategy. A recent review suggested that two broad sources of feedback guide this switching process: internal information about one's own emotion and external information from other people's responses (Bonanno & Burton, 2013). At present, little research has investigated the role of feedback in strategy switching.

To begin to address this deficit, the current article describes an experimental paradigm focused on the role of internally generated feedback in emotion regulation (ER) strategy modification. We measured responsiveness to internal feedback (RIF) using subjective and physiological measures of negative affect. We tested whether internal feedback guides the switching between two of the most frequently used regulatory strategies: reappraisal and distraction. We used the paradigm to examine switching from reappraisal to distraction in Study 1 and switching from distraction to reappraisal in Study 2. In both studies, we examined the relative adaptiveness of this behavior by testing associations between strategy switching, RIF, and well-being.

The bulk of research on ER has compared the effectiveness (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Hofmann, Heering, Sawyer, & Asnaani, 2009; Webb, Miles, & Sheeran, 2012) and adaptive or maladaptive consequences (Garnefski, Kraaij, & Spinhoven, 2001; Gross & John, 2003) of particular strategies. ER is ultimately a dynamic process, however, in which different strategies may be used together or in succession. Indeed, people often use more than one strategy to regulate emotions in their daily lives (Aldao, Jazaieri, Goldin, & Gross, 2014). Critically, multiple strategies may be called upon to regulate emotion elicited by a single

This article was published Online First February 22, 2016.
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We thank Charles Burton for his extremely valuable input on the study design. We thank M. Han, S. Huang, M. Rothstein, and K. Wang for assistance with recruitment, data collection, and processing. We thank Z. Zhu for important feedback throughout the research process. Finally, we thank F. Wilhelm and P. Peyk for making ANSLAB, a suite of open source Matlab routines used to process physiological data, available as freeware in the Society for Psychophysiological Research Software Repository (http://www.sprweb.org/repository).
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stimulus (Aldao & Nolen-Hoeksema, 2013). It is likely that people select, abandon, and attempt new ER strategies dynamically over time in response to changes in the external environment and the internal success or failure of the current ER attempt (Aldao, Sheppes, & Gross, 2015; Bonanno & Burton, 2013). Individual differences in this dynamic ER may contribute substantially to the wide variability in how different people experience emotions over time (Kuppens, Oravecz, & Tuerlinckx, 2010). There are few studies to date that investigate whether people do, in fact, switch strategies in response to low ER success or outright ER failure (Vujovic, Opitz, Birk, & Urry, 2014). Most importantly, it is not yet known whether people switch strategies based on internal information or under what circumstances switching strategies may be adaptive.

In the present studies, we tested two hypotheses: that people use internal feedback to guide ER dynamically and that individual differences in the extent to which people switch has implications for well-being. In Study 1, we tested the use of internal feedback when participants had the option to switch from reappraisal to distraction, the latter strategy being optimal for regulating high-intensity emotion. In Study 2, we tested the same phenomenon when participants had the option to switch from distraction to reappraisal, the latter strategy being nonoptimal for regulating high-intensity emotion.

In testing our first hypothesis, we acknowledge that various sources of feedback (i.e., social cues) may drive ER strategy choices. However, the present studies focused exclusively on internal feedback. Much past research has explored the identification, selection, and implementation phases of ER (Gross, 2015), but the regulatory stage explored in the present studies is a late post-implementation stage after ER is already well underway. Theorists (Bonanno & Burton, 2013; Gross, 2015) have outlined three possible choices relevant to processing dynamics at this phase: ER stopping, ER maintenance, and ER switching. We are specifically concerned with the final two possibilities: What guides people to switch or maintain strategies?

There is a paucity of research regarding choices at this late stage of ER. Research reveals that people often use multiple regulation strategies even when instructed to use just one strategy, especially for intense stimuli (Opitz, Cavanagh, & Urry, 2015). However, it is unclear how often ER switching occurs after a strategy has already been implemented and the factors that drive such behavior. Online monitoring of internal feedback is a likely candidate for a factor that drives switching (Kalisch, 2009). However, use of feedback is a relatively unexplored area of study. For example, although higher emotional awareness is associated with higher frequency of ER use (Barrett, Gross, Christensen, & Benvenuto, 2001), it is unknown whether such awareness allows people to monitor internal feedback specifically for the purpose of adjusting ER strategies and, furthermore, whether the resulting choices involve not only initial strategy selection but also strategy switches (Bonanno & Burton, 2013). Nevertheless, there is evidence for the regulatory use of internal feedback. For instance, higher detection of internal signs of emotion such as heart rate (HR) are indeed linked to improved regulation (Füstös, Gramann, Herbert, & Pollatos, 2012).

In the present studies, we defined internal feedback as the continuous, emotional information during ER that indicates the success or failure of a presently implemented strategy. This internal feedback involves subjective awareness of affective states or emotion-related physiological processes. We defined RIF as the degree to which the choice to switch strategies during ER is guided by internal feedback. Specifically, we operationalized RIF as the coupling between negative affect during the first several seconds of an ER attempt and the subsequent decision to try a new strategy later during this same ER attempt. Our rationale was that emotional feedback arising during the early stages of an ER attempt provides useful information that should inform how one proceeds with ER in the next moments (Bonanno & Burton, 2013).

We measured RIF in four emotional domains: subjective intensity of negative emotion and three emotion-sensitive physiological sources. The physiological measures included tension of the facial corrugator supercilii muscle, HR, and electrodermal activity. All three physiological indices have shown responsiveness to unpleasant stimuli relative to emotionally neutral stimuli (Bradley & Lang, 2000; Jackson, Malmstadt, Larson, & Davidson, 2000; Norris, Larsen, & Cacioppo, 2007). Additionally, ER strategies have been shown to modulate all three physiological channels. For instance, Dunn, Billotti, Murphy, and Dalgleish (2009) demonstrated that certain ER strategies modulate HR and electrodermal activity. Urry (2010) showed that attempts to increase negative emotion via reappraisal increased corrugator activity, HR, and electrode corrugator supercilii rmal activity. Notably, in this same study, attempts to decrease negative emotion via reappraisal decreased corrugator activity but did not change HR or electrodermal activity.

Corrugator activity appears to be a particularly sensitive physiological measure of the successful down-regulation of negative emotion. Lower corrugator activity is a reliable physiological indicator of ER success (Lapate et al., 2012) while heightened corrugator activity is associated with subjective unpleasant experience across a wide variety of negative emotions (Cacioppo, Martzke, Petty, & Tassinary, 1988). Critically, increased and decreased corrugator activity, respectively, are associated with increased activation in the amygdala and ventromedial prefrontal cortex (Heller, Lapate, Mayer, & Davidson, 2014) suggesting, as Heller et al., (2014) noted, that corrugator activity, and expressive signals more broadly, convey crucial information about internal emotional experience.

In both studies we constrained participants to the use of two ER strategies, cognitive reappraisal and distraction, in order to maintain experimental control. These two very commonly used and studied ER strategies (Lee, Heller, van Reekum, Nelson, & Davidson, 2012; Sheppes, Brady, & Samson, 2014; Thayer, Newman, & McClain, 1994) are both successful in reducing negative affect (McRae et al., 2010). Indeed, a meta-analysis suggested that reappraisal and distraction are among the most effective ER strategies, with reappraisal being slightly more effective than distraction at repairing negative affect (Augustine & Hemenover, 2009). Whereas reappraisal changes emotion by reframing a situation's affective meaning (Gross, 2002), distraction reduces negative emotion by changing the deployment of attention during the situation and thereby involves a disengagement from affective meaning (McRae et al., 2010). Much research has explored the emotional outcomes associated with these two ER strategies. Reappraisal has been associated with numerous benefits, including subjective well-being as evidenced by elevated satisfaction with life (Gross & John, 2003). However, research suggests that distraction also has its own advantages. For example, McRae et al. (2010) found that distraction reduces amygdala activity more than reappraisal.

There are times when distraction may be better suited to the demands of the situation, particularly when negative emotions are particularly intense. Sheppes, Scheibe, et al. (2014) demonstrated that people choose distraction more frequently than reappraisal for high-intensity negative stimuli. Whereas reappraisal engages the meaning of emotional stimuli and allows for the depth of processing needed for long-term memory to service long-term goals, distraction, in contrast, can be helpful in cases of high emotional intensity such that people can use distraction to “[block] emotional information early before it gathers force” (p. 165). Indeed, recent neural evidence suggests that distraction can be more effective and less effortful than reappraisal for high-intensity emotion (Shafir, Schwartz, Blechert, & Sheppes, 2015).

Study 1

Participants were instructed on each trial to utilize cognitive reappraisal and then later given the option to maintain this strategy or to switch to a distraction strategy. We used this particular order (reappraisal first, distraction second) as the most natural way to switch between the strategies. That is, the motivation to switch strategies due to failed ER using reappraisal dovetails well with previous findings that people prefer to use distraction when emotional intensity is high. Therefore, switching to distraction should be a normal response to high emotion during ER using reappraisal. Taking the points above into consideration, we hypothesized that strong emotional responses in each emotion measure during an early phase of ER should be associated with switches from reappraisal to distraction during a later phase of ER.

Our second hypothesis extended the empirical investigation of the regulatory flexibility framework (Bonanno & Burton, 2013) by predicting that individual differences in RIF should play a role in determining well-being. It is known that awareness of internal processes is associated with emotional reactivity and regulation. Accurate perception of one’s own heart activity is positively associated with the intensity of subjectively experienced emotion (e.g., Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004; Herbert, Pollatos, & Schandry, 2007) and with improved ER success (Füstös et al., 2012). Research is needed, however, to determine whether people who actually *use* such information to guide ER experience heightened well-being. We propose that, just as the awareness of internal processes aids ER success, changing ER behavior in line with internal feedback may have beneficial consequences. Indeed, this ability to engage with ER dynamically may allow for optimally effective regulation over the long term.

Some authors have argued for the relative adaptiveness or maladaptiveness of specific ER strategies (Aldao et al., 2014; Gross & John, 2003). Research bears out the claim that cognitive reappraisal, in particular, seems to be a generally adaptive strategy (Gross, 2002; Gross & John, 2003). Nevertheless, there is reason to believe that frequent switching of ER strategies could be more effective than maintaining just one adaptive strategy such as reappraisal. According to the model of regulatory flexibility, frequent switches in strategy should be adaptive when made appropriately with respect to one’s ER success or failure (Bonanno & Burton, 2013). In the context of dynamic ER, we propose that it is effective to maintain working strategies and cease failing ones but ineffective to cease working strategies and maintain failing ones. A key aspect of ER skill therefore involves the ability to make ER strategy decisions based on successfully monitoring the immediate success or failure of the currently employed strategy. We propose that this ability is afforded by high RIF and that frequent switching should be relatively adaptive when based on feedback (i.e., high RIF) and relatively maladaptive when not based on feedback (i.e., low RIF; see Figure 1). Because the regulatory flexibility framework posits that dynamic strategy switches should promote well-

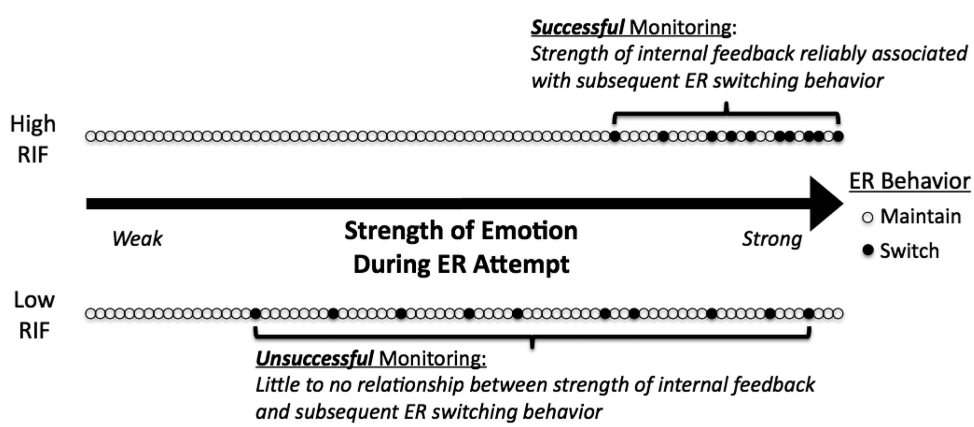

Figure 1. The figure depicts how responsiveness to internal feedback (RIF) can be measured using strength of emotion and subsequent emotion regulation (ER) behavior. The *x*-axis represents strength of the emotional signal in the relevant channel (subjective or physiological internal feedback). The circles represent emotional trials of varying degrees of intensity during which people choose to maintain (white) or switch (black) strategies. The top portion of the figure represents people with high RIF who tend to switch to a different strategy when the current ER attempt is failing but maintain the original strategy when it is succeeding. In contrast, the bottom portion represents people with low RIF who make their decisions about whether to maintain or switch strategies without respect to their internal feedback.

being only when switches are indeed needed, we hypothesized that higher frequency of switching ER strategies would be associated with higher life satisfaction but only among people with high RIF.

Method

Participants. Ninety adults (50 females; M_{age} = 31.60 years; SD_{age} = 9.66 years) responded to online advertisements and participated for monetary compensation. Participants were racially and ethnically diverse: 47.78% Black or African American, 23.33% Caucasian, 12.22% Asian or Asian American, 1.11% American Indian or Alaska Native, 3.33% two or more racial categories, and 11.11% declined to provide this information. Of the total sample, 20.00% endorsed being of Hispanic origin, and 6.67% declined to provide this information. All study procedures were approved by the Institutional Review Board at Teachers College, Columbia University. All participants provided written informed consent prior to participating in the study.

Cognitive reappraisal task (CRT). This task was designed to serve two purposes. First, it assessed whether the unpleasant pictures induced negative emotion in the self-reported and physiological measures (first manipulation check). Second, it measured individual differences in the ability to use cognitive reappraisal for the down-regulation of negative emotion (second manipulation check). It is critical to measure reappraisal ability because one's tendency to switch from one ER strategy to another may be influenced by one's ability to use the initial strategy. Indeed, frequency of reappraisal use covaries with reappraisal ability (McRae, Jacobs, Ray, John, & Gross, 2012). Moreover, just as people are likely to choose strategies at which they are especially skilled, they may also abandon strategies at which they are unskilled. Therefore we used reappraisal ability measured during the CRT as a covariate in testing the second hypothesis.

Participants first completed cognitive reappraisal training. This ER strategy was introduced as "the reframing strategy" in which participants were instructed to "decrease" negative emotion elicited by the pictures by reframing how they thought about the depicted situation. The training explained that any of the following approaches to use the reframing strategy: think about how the depicted situation was not as bad as it first seemed, imagine ways that the depicted situation could improve for the better, or think of the depicted situation in any new ways that helped them feel less bad. Following this explanation of the strategy, the training consisted of an experimenter-generated example of reframing with an unpleasant picture, a chance for participants to verbalize their own example of reframing with a different unpleasant picture, and six practice trials including all three conditions. Participants were also exposed to trails in which they were instructed to simply view the pictures as they normally would.

The CRT consisted of 60 trials divided into two equal blocks with a brief participant-determined break between blocks. Each trial consisted a fixation cross (1,000 ms), a visually presented instruction word ("Decrease" or "View"; 1,000 ms), a picture (10,000 ms; emotionally neutral or unpleasant), a rating of negative emotion until participants responded, and an intertrial interval with a jittered duration (1,000 to 3,000 ms). Pictures were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005).[1] The self-report rating (see above) was worded as follows: "Please indicate the extent to which you felt negative emotion (e.g., distress, anger, fear, sadness) by typing a number between 1 and 7." The scale anchors were 1 (*not at all*), 3 (*a little bit*), 5 (*moderately*), and 7 (*extremely*). There were three conditions based on pairings of instruction word and picture type: view neutral, view negative, and decrease negative. The order of these conditions was fully randomized within each block. There were a total of 20 trials in each of these three conditions in the task.

Responsiveness to internal feedback task (RIFT). This task was designed for two purposes. First, it measured ER variability (see Aldao et al., 2014). Specifically, the task assessed individual differences in the frequency of ER strategy switching during down-regulation of negative affect elicited by a single stimulus. Second, it measured the degree to which subjective and physiological emotional feedback predicted the decision to switch ER strategies. For each participant, a RIF score was computed for each emotional channel (self-report, corrugator activity, HR, and skin conductance level). The RIF score is an empirical indication of the strength of the association between emotional responding early during incidents of attempted ER and the choice to switch strategies later during those same incidents. The RIF score is the key measure used for testing both Hypotheses 1 and 2.

The task consisted of 78 trials divided into three blocks of 26 trials with a brief break between each block. The task design was identical to the CRT with three differences. Most crucially, participants were instructed that they would hear a tone 4 s after the picture onset and that, if they felt the reframing strategy was not working, they could attempt to decrease negative emotion by distraction. This involved pressing the Spacebar anytime after the tone, which caused four smaller neutral pictures to appear in the four corners of the screen while the central picture remained on the screen for the remainder of the picture presentation (up to 6,000 ms de-

[1] In the CRT and DT, the following 40 IAPS images were presented for the view-negative and decrease-negative conditions (random assignment to conditions): 2456, 2095, 3301, 3530, 3350, 3016, 6350, 3030, 6520, 9252, 3230, 9921, 9220, 9810, 9560, 2811, 6212, 2375.1, 9326, 6360, 9322, 9332, 9181, 9300, 9901, 3181, 9420, 9902, 9908, 9903, 6821, 9295, 2799, 9050, 6260, 3017, 6570.1, 9331, 9424, and 6213. The following 20 IAPS images were presented for the view-neutral condition: 5535, 2493, 7036, 7050, 7040, 2210, 7150, 7590, 2480, 7037, 7018, 7211, 7491, 7217, 7038, 7032, 2190, 7055, 2890, and 9422. The images were selected such that the normative valence ratings were significantly lower for negative (M = 2.24, SD = 0.29) than neutral (M = 4.80, SD = 0.12) images, $t(56.72) = -47.91$, $p < .001$, and the normative arousal valence ratings were significantly higher for negative (M = 5.82, SD = 0.78) than neutral (M = 3.26, SD = 0.72) images, $t(58) = 12.33$, $p < .001$. In the RIFT, the following 78 IAPS images were presented as the central image: 2800, 9187, 9405, 9635.1, 3101, 2703, 9571, 9254, 9414, 6022, 6540, 3500, 9435, 3051, 9911, 2141, 2900, 6838, 7380, 6312, 3220, 3215, 9000, 9250, 9423, 2751, 9620, 8485, 9922, 6825, 3185, 9290, 6834, 8230, 9180, 9426, 6220, 9417, 2753, 2700, 9145, 9395, 9046, 9495, 9341, 9912, 1220, 5973, 6940, 7360, 9596, 2399, 8480, 9270, 8231, 1930, 2115, 9445, 2745.2, 1070, 6800, 7092, 9080, 1505, 9582, 7013, 7137, 7290, 2770, 6930, 3210, 7011, 7595, 7025, 2441, 2458, 2383, and 7705. The following 20 IAPS images were presented as neutral distractor images in the RIFT for both studies and in the DT for Study 2: 7175, 7006, 2840, 7059, 7009, 7010, 7950, 7034, 7235, 7020, 7002, 7045, 7161, 7012, 7000, 7003, 7160, 7004, 7287, and 2570. The central images were chosen to vary considerably in valence (M = 3.21, SD = 0.87, range: 1.78–4.77) and arousal (M = 5.21, SD = 0.91, range: 2.65–6.99). Nevertheless, the images were selected such that the normative valence ratings were overall lower for central than distractor (M = 4.94, SD = 0.07) images, $t(80.79) = -17.37$, $p < .001$, and the normative arousal valence ratings were significantly higher for central than distractor (M = 2.68, SD = 0.52) images, $t(52.36) = 16.33$, $p < .001$.

pending on the time of the button press). A second difference was that the instruction word “Decrease” appeared on every trial since the RIFT was designed to measure how people switch strategies and not how well they use reappraisal. The third difference was that the pictures were selected to vary continuously from highly unpleasant valence to not at all unpleasant valence without within-subjects conditions. The reason for this difference was that it was important to establish a normal distribution for each of the emotion measures for each participant.

Each trial consisted of the following sequence: a fixation cross (1,000 ms), a visually presented instruction word (“Decrease”; 1,000 ms), an emotionally neutral or unpleasant picture (4,000 ms), a tone (100 ms), the remainder of the picture (6,000 ms), the rating of negative emotion until participants responded (see above), and an intertrial interval with a jittered duration (1,000 to 3,000 ms).

Questionnaires. Our measure of subjective well-being was the Satisfaction With Life Scale (SLS; Diener, Emmons, Larsen, & Griffin, 1985). We chose this measure because it covaries with ER choices and skills. Reappraisal ability (McRae et al., 2012) and reappraisal frequency (Gross & John, 2003; McRae et al., 2012) are both positively correlated with SLS score. We also collected the following demographic information: age, sex, race, ethnicity, education level, marital status, number of children, and number of people living in household. We assessed self-reported reappraisal ability with a short scale at the end of the CRT. Participants indicated the extent to which they agreed with each of the following four statements using a 5-point Likert scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 *strongly* = *agree*): “I was able to use the reframing strategy in this task to feel less negative emotion,” “I could think of aspects of the depicted situations that were not as bad as they first seemed,” “I was able to imagine ways that the depicted situations could improve for the better,” and “I could think of the depicted situations in new ways that helped me feel less bad.” In order to be able to test whether this scale assessed reappraisal ability independently from liking of reappraisal use, we added an extra item to the statements above: “I did not like trying to decrease negative emotion to the unpleasant pictures.” Additionally, we collected information about mood symptoms, coping abilities, and attentional control that will not be reported in the present manuscript because they are not the focus of the current hypotheses.

Procedure. Three sets of electrodes were attached to participants (see below), followed by a resting state task in which participants looked at a fixation cross for 2 min while remaining quiet and still. They completed a task assessing interoceptive accuracy of heartbeat activity (Pollatos, Herbert, Matthias, & Schandry, 2007). Performance from this task will not be discussed further in the present article. Next, participants completed the CRT, the RIFT, and the questionnaires. Finally, participants were debriefed. The total duration of the study session was approximately 120 min. Participants were compensated with $20.

Physiological data collection and reduction. Physiological activity was recorded for the three channels (facial electromyography, electrocardiography, and electrodermal activity) at a sampling rate of 1,000 Hz using the wireless BioNodamix MP150 hardware (Biopac, Goleta, CA) and AcqKnowledge 4.3.1 software. Data from each physiological channel was sent wirelessly from a small, lightweight transmitter secured via Velcro straps on participants’ nondominant arms and torsos to the relevant receiver module located several feet away.

Corrugator electromyography activity was measured using 4-mm Ag/AgCl electrodes. Following site preparation with an electrode preparation pad, two electrodes were attached to the corrugator muscle on the brow just above the left eyebrow, and a third electrode was attached on the back of the neck as a ground. Offline, a 60-Hz notch filter was applied. Data were rectified, filtered with a 10-Hz high-pass filter and a 16-Hz low-pass filter, decimated to 4 Hz, and smoothed with a 1-s prior moving average filter. These steps were completed in part using ANSLAB routines (Wilhelm & Peyk, 2005) in Matlab software (Mathworks, Natick, MA).

Electrocardiography was measured using three Ag/AgCl electrodes with 1-cm diameter. These electrodes were pregelled with 7% chloride gel and were attached in the following locations: beneath the left collarbone, beneath the right collarbone, and on the lower torso near the left hip. The electrocardiography signal was downsampled offline to 400 Hz and smoothed with a lowpass filter of 40 Hz. HR was calculated by identifying interbeat intervals using R-spikes that were identified in ANSLAB and corrected using second-by-second visual inspection for artifacts. The interbeat interval data were converted to HR in beats per minute. HR data were decimated to 10 Hz and smoothed with a 1-s prior moving average filter.

Sweat gland activity from the fingers was used to measure sympathetic nervous system activation (Dawson, Schell, & Filion, 2007). We recorded electrodermal activity using two disposable Ag/AgCl electrodes with a 1-cm diameter contact area that was pregelled with 0.5% chloride isotonic gel. After cleaning the nondominant hand with hypoallergenic wipes, we attached the two electrodes to the middle phalanges of the index and middle fingers and connected them to a wireless transmitter. Electrodermal level was recorded with DC coupling. Prior to each task the wire clips were temporarily unattached from the electrodermal electrodes in order to calibrate the system to establish a 0-μS baseline level. Offline, electrodermal activity was decimated to 10 Hz, and linearly detrended on a trial-by-trial basis.

Variables of internal emotion. Self-reported negative affect during the CRT trials was calculated for each condition by averaging negative affect values across trials. Self-reported negative affect during the reappraisal phase of the RIFT trials was measured as the negative intensity value reported for each trial regarding the first 4 s of the picture presentation. The physiological variables were baseline-corrected in order to measure trial-related changes in emotion by subtracting out the physiological values immediately before the presentation of the instruction and picture. Therefore, the baseline period for all three physiological measures (corrugator activity, HR, electrodermal activity) and for both tasks (CRT, RIFT) was the final epoch of the fixation cross before the instruction and picture appeared: 0.25-s epoch for corrugator activity and 0.10-s epoch for HR and electrodermal activity. Mean changes in corrugator activity, HR, and electrodermal activity were calculated for each condition across the full 10-s picture duration of the CRT and across the 4-s duration of the reappraisal phase of the RIFT. Note that higher negative emotional responding is indicated by higher picture-related increases in corrugator activity, more HR slowing (i.e., greater magnitude of HR deceleration following picture onset), and higher electrodermal activity (see Urry, 2010).

Results

Data retention. For manipulation checks, participants with extreme outliers were excluded from specific analyses involving the following variables calculated from the CRT. High and low extreme outliers are defined as values more than three times the interquartile range above the 75th percentile and below the 25th percentile, respectively. For the manipulation check of induced negative affect, for self-reported negative affect, four participants were removed due to high values for the view-neutral condition (three) and unsaved self-report rating data due to a technical error (one). For the manipulation check of regulation success, for self-reported negative affect, just the one participant without self-report data was excluded. For the manipulation check of induced negative affect, for corrugator activity, nine participants were excluded due to high values for the view-negative condition (five) or high values for the view-neutral condition (four). For the manipulation check of regulation success, for corrugator activity, eight participants were excluded due to high values for the view-negative condition (five) or high (two) or low (one) values of the decrease-negative condition. For the manipulation check of induced negative affect, for electrodermal activity, eight participants were excluded due to high values for the view-negative condition (five) or high (two) or low (one) values for the view-neutral condition. For the manipulation check of regulation success, for electrodermal activity, six participants were excluded due to high values for the view-negative condition (five) or high values for the decrease-negative condition (one). For HR activity, no participants were excluded for either manipulation check.

For hypothesis testing, RIF scores could not be computed for 12 participants because they never chose to switch ER strategies during RIFT.[2] Participants with extreme outliers were excluded from analyses involving the following variables calculated from the RIFT. For negative affect RIF score, no participants were excluded. For corrugator activity, one participant was excluded due to a high value for the corrugator RIF score. For HR activity, one participant was excluded due to a high value for the HR RIF score. In addition, for Hypothesis 2 specifically, one participant was excluded because no SLS data were reported, and six participants were excluded for high (five) or low (one) values of reappraisal success corrugator scores from the CRT.

Manipulation checks. To determine whether the pictures successfully induced negative affect, a paired-samples t test was conducted for each of the four measures of emotion measured during the CRT. The conservative family wise adjusted criterion for significance testing for these t tests was $p < .013$ (where α/[number of tests] = .05/4 = .013). These t tests compared the two conditions on which participants simply viewed the pictures without attempting to regulate emotion: view-negative and view-neutral. As expected, compared to neutral pictures, negative pictures were associated with greater self-reported intensity of negative affect, $t(85) = 19.24$, $p < .001$, M_{neg} (SD_{neg}) = 4.00 (1.38), M_{neu} (SD_{neu}) = 1.23 (0.31), greater corrugator activity, $t(80) = 3.74$, $p < .001$, M_{neg} (SD_{neg}) = 0.42 μV (0.92 μV), M_{neu} (SD_{neu}) = −0.04 μV (0.77 μV), and greater decelerations in HR, $t(89) = -4.05$, $p < .001$, M_{neg} (SD_{neg}) = −2.93 bpm (2.15 bpm), M_{neu} (SD_{neu}) = −2.31 bpm (2.12 bpm). However, unexpectedly, there was no difference in electrodermal activity between negative and neutral pictures, $t(81) = 0.20$, $p = .839$, M_{neg} (SD_{neg}) = 0.01 μS (0.02 μS), M_{neu} (SD_{neu}) = 0.01 μS (0.02 μS). Therefore, we examined subjective negative intensity, corrugator activity, and HR decelerations (but not electrodermal activity) as the three measures of emotion to test the remaining analyses, including the two main hypotheses.

To determine whether there was any evidence of ER success using reappraisal, we conducted a paired-samples t test for self-reported negative affect, corrugator activity, and HR during the CRT. The conservative family wise adjusted criterion for significance testing for the three t tests was $p < .017$ (where α/[number of tests] = .05/3 = .017). These t tests compared the two conditions involving negative pictures: decrease-negative (reappraisal) and view-negative (no reappraisal). As expected, compared to the view-negative condition, the decrease-negative condition was associated with reduced self-reported intensity of negative affect, $t(88) = -5.52$, $p < .001$, $M_{decrease\text{-}negative}$ ($SD_{\text{decrease-negative}}$) = 3.51 (1.20), $M_{view\text{-}negative}$ ($SD_{\text{view-negative}}$) = 4.06 (1.40), and reduced corrugator activity, $t(81) = 2.47$, $p = .016$, $M_{decrease\text{-}negative}$ ($SD_{\text{decrease-negative}}$) = 0.23 μV (0.77 μV), $M_{view\text{-}negative}$ ($SD_{\text{view-negative}}$) = 0.49 μV (0.97 μV). However, there were no differences in the magnitude of HR decelerations between the two conditions, $t(89) = -0.65$, $p = .519$, $M_{decrease\text{-}negative}$ ($SD_{\text{decrease-negative}}$) = −3.04 bpm (2.44 bpm), $M_{view\text{-}negative}$ ($SD_{\text{view-negative}}$) = −2.93 bpm (2.15 bpm). In summary, although reactivity to the unpleasant stimuli was evident in subjective negative affect, corrugator activity, and HR, the regulatory effects of reappraisal were evident in subjective negative affect and just one physiological channel: corrugator activity.

Hypothesis Testing

Hypothesis 1. Do people use internal feedback to regulate emotion dynamically? In order to test this important question, we created a RIF score for each of the three measures showing clear evidence of negative affect elicited by the stimuli (see above): subjective negative intensity, corrugator activity, and HR deceleration. For each measure, the RIF score was computed as follows. First, we created standardized measures of emotional responding so that the different emotion measures for the different participants could be expressed on comparable scales. For each participant, we

[2] Twelve (13.33%) of the 90 participants in Study 1 never switched strategies during the RIFT. Therefore, the RIF scores could not be computed and the hypotheses could not be tested for these participants. We ran a post hoc test to evaluate whether these participants were less responsive to the unpleasant emotional stimuli than the rest of the participants. Following Ray, McRae, Ochsner, and Gross (2010), we tested emotional reactivity to unpleasant stimuli by comparing baseline-corrected corrugator activity for the view-negative and view-neutral conditions during the CRT. Consistent with the idea that a lack of internal feedback may be associated with a lack of switching behavior, the never-switch participants ($M = -0.05$ μV, $SD = 0.62$ μV) showed less corrugator reactivity than the rest of the participants ($M = 0.91$ μV, $SD = 2.00$ μV), $t(54.79) = 3.34$, $p = .002$. Participants who never switched had corrugator reactivity scores that did not differ from zero, $t(11) = -0.28$, $p = .784$, whereas the majority of participants who occasionally switched had corrugator reactivity scores significantly greater than zero, $t(77) = 4.02$, $p < .001$. Participants who never switched did not differ from the rest of the participants in age, sex, education, race, or ethnicity, all $ps \geq .147$.

converted the value on each RIFT trial into a *z* score for the distribution of values for that individual participant for the measure in question (see Figure 1). Second, we averaged the *z* scores on the subset of trials on which participants subsequently chose to distract themselves (i.e., switch trials). This mean value reflects individual differences in the strength of emotional feedback associated with the decision to switch strategies. Each participant thus had three RIF scores: negative affect intensity RIF, corrugator RIF, and HR RIF.

We conducted paired-samples *t* tests for each of the three measures comparing the mean of the *z* scores for switch trials and maintain trials. The conservative family wise adjusted criterion for significance testing for these *t* tests was again $p < .017$. As hypothesized, compared to trials on which participants did not switch strategies, trials on which participants decided to switch to distraction were associated with greater self-reported intensity of negative affect, $t(77) = 17.63$, $p < .001$, $M_{switch} = 1.40$ ($SD_{\text{switch}} = 0.82$), $M_{maintain} = -0.22$ ($SD_{\text{maintain}} = 0.15$), greater corrugator activity, $t(76) = 3.61$, $p = .001$, $M_{switch} = 0.11$ ($SD_{\text{switch}} = 0.30$), $M_{maintain} = -0.02$ ($SD_{\text{maintain}} = 0.10$), and greater decelerations in HR, $t(75) = -3.33$, $p = .001$, $M_{switch} = -0.08$ ($SD_{\text{switch}} = 0.30$), $M_{maintain} = 0.05$ ($SD_{\text{maintain}} = 0.15$). When all statistical outliers were included in the analyses, the results of the *t* tests were still significant and consistent with the hypothesis, $p = .001$ for corrugator activity, and $p = .011$ for HR activity.

We conducted two additional paired *t* tests to examine whether normative arousal and valence ratings of the central RIFT pictures differed for trials on which participants chose to switch versus maintain strategies. These tests addressed three potential confounds: observed negative emotion during the early phase of ER and switching behavior may not be related to regulation failure of the picture-elicited emotions, as we hypothesized, but rather dislike for using the initially prescribed reappraisal strategy, interest in the distractor images, or boredom with the task. Therefore we analyzed the relationships between the normatively rated valence and intensity of the stimuli (Lang et al., 2005) and participants' switching behavior. There were three potential outcomes of relevance. First, if participants' strategy switches were largely driven by their dislike of reappraising (Confound 1) or interest in the distractor images (Confound 2) rather than being driven by the variable emotional intensity of the pictures, then we expected to see little to no relationship between the pictures' normative ratings and participants' switching behavior. Second, if participants' strategy switches were largely driven by boredom (Confound 3), then we expected to see that switching behavior would be especially likely for low-arousal stimuli because boredom is a low-arousal emotion (see Vujovic et al., 2014). Third, if participants' strategy switches were largely driven by their failure to regulate emotion elicited by the specific pictures, then we expected to see that switching behavior was associated with unpleasant and high-arousal stimuli.

For the test of valence, 13 participants were excluded due to never switching on any trials (12) or a high extreme mean valence on maintain trials (one). Supporting our expectations and consistent with the results for Hypothesis 1, stimuli on trials for which participants switched from reappraisal to distraction were rated as significantly less pleasant ($M = 2.49$, $SD = 0.37$) than stimuli on trials for which they maintained the reappraisal strategy ($M = 3.33$, $SD = 0.10$), $t(76) = -19.15$, $p < .001$, $d = 3.10$. The findings were similar when the outlier was included, $p < .001$. Also supporting our expectations and consistent with the results for Hypothesis 1, stimuli on trials for which participants switched from reappraisal to distraction were rated as significantly more arousing ($M = 5.73$, $SD = 0.27$) than stimuli on trials for which they maintained the reappraisal strategy ($M = 5.11$, $SD = 0.10$), $t(77) = 18.27$, $p < .001$, $d = 3.05$. In summary, the findings for these post hoc tests were consistent with the a priori tests of internal emotion (self-report, corrugator activity, and HR activity): unpleasant, intense emotion predicted regulatory switching behavior from reappraisal to distraction.

Hypothesis 2. Does the frequency of strategy switching during ER predict well-being only for people with high RIF? We tested this question by calculating the proportional frequency of strategy switching for each participant (switch trials/total trials).[3] On average, participants switched on 13.61% of trials ($SD = 13.04\%$). We conducted a linear regression analysis for each RIF measure using PROCESS in SPSS (Hayes, 2013). In the first analysis we entered the proportional frequency of ER strategy switches as the predictor, SLS score as the dependent variable, corrugator RIF score as the moderator, and reappraisal success using corrugator as a covariate. The model was significant, $R^2 = 0.16$, $F(4, 65) = 3.67$, $p = .009$. Reappraisal success predicted higher SLS score to a marginally significant degree, $b = 2.158$, $p = .095$, 95% confidence interval [CI] [−0.382, 4.699]. Higher corrugator RIF predicted higher SLS score to a marginally significant degree, $b = 6.098$, $p = .064$, 95% CI [−0.373, 12.569]. As an independent predictor, switching frequency did not predict SLS score, $b = 4.077$, $p = .623$, 95% CI [−12.417, 20.571]. Critically, the interaction of switching frequency and corrugator RIF predicted SLS score, $b = 97.944$, $p = .002$, 95% CI [37.514, 158.375]. We used the *pick-a-point* approach to explore the nature of this observed moderation effect (Bauer & Curran, 2005). As hypothesized, among participants with high RIF (modeled at 1 *SD* above the mean), higher switching frequency was associated with higher SLS score, $b = 32.279$, $p = .017$, 95% CI [6.075, 58.483]. In contrast, among participants with low RIF (modeled at 1 *SD* below the mean), the opposite association was evident: higher switching frequency was associated with lower SLS score, $b = -24.125$, $p = .029$, 95% CI [−45.642, −2.609]. Among participants with moderate RIF (modeled at the mean), switching frequency was not associated with SLS score, $b = 4.077$, $p = .623$, 95% CI [−12.417, 20.571], consistent with the observed null

[3] Switch trials were RIFT trials on which participants pressed the Spacebar during the 4-s reappraisal phase. However, participants very occasionally pressed number keys (1–7) during this phase (1.03% of RIFT trials across all participants in Study 1). These presses were considered to be mistakenly early responses to the negative affect question rather than attempts to distract. Consistent with this idea, these pressed number keys ($M = 1.97$, $SD = 1.58$) were as low as the mean ratings of negative affect for maintain trials ($M = 2.20$, $SD = 1.56$) and lower than the mean ratings of negative affect for switch trials ($M = 4.26$, $SD = 1.87$). These trials were therefore counted as maintain trials. Participants very rarely pressed keys that were neither the Spacebar nor number keys during the 4-s reappraisal phase (0.09% of RIFT trials across all participants). These presses were considered to be attempts to distract (switch trials) because they were either keys close to the Spacebar (i.e., Alt, Ctrl) or keys typically used for advancing to a new screen (i.e., right arrow, Enter).

effect of switching frequency as an independent predictor (see Figure 2).

We repeated the same regression analyses using HR RIF score and self-reported negative affect RIF score. For both of these tests we entered the same predictor, outcome, and covariate variable as in the test involving the corrugator RIF score (see above). The test in which HR RIF was entered as a moderator was not significant, $R^2 = 0.07$, $F(4, 64) = 1.11$, $p = .360$, and there was no main effect of switching frequency, $b = 0.240$, $p = .982$, 95% CI [−20.734, 21.214], no main effect of HR RIF, $b = 2.217$, $p = .589$, 95% CI [−5.938, 10.372], and no interaction of switching frequency and HR RIF score, $b = 21.547$, $p = .638$, 95% CI [−69.494, 112.589]. Similarly, the test in which negative affect RIF was entered as a moderator was not significant, $R^2 = 0.07$, $F(4, 66) = 0.99$, $p = .417$, and there was no main effect of switching frequency, $b = 5.312$, $p = .695$, 95% CI [−21.596, 32.219], no main effect of negative affect RIF, $b = 1.083$, $p = .605$, 95% CI [−3.080, 5.246], and no interaction of switching frequency and negative affect RIF score, $b = 12.411$, $p = .472$, 95% CI [−21.857, 46.680]. The three regression tests above were repeated with all statistical outliers included. The inclusion of statistical outliers did not modify the results in any meaningful way.[4]

Discussion

Study 1 shed light on ER as a dynamic process that changes over time in response to emotional internal feedback. A diverse sample of adults did indeed switch from reappraisal to distraction during attempted ER, and they seemed to switch strategies in response to internal feedback. Our results suggested that changes in facial tension, decelerations in HR, and subjective negative affect may lead people to abandon reappraisal in the favor of a new strategy, distraction. Furthermore, switching strategies seems not to be an inherently wise or unwise decision for subjective well-being across all emotional experiences. Rather, our findings suggest that switching strategies during ER may enhance well-being if the switches are guided by internal feedback (i.e., high RIF) but diminish well-being if the switches are unrelated to internal feedback (i.e., low RIF). These findings support the important point raised by Aldao et al. (2014) that not all ER variability is necessarily adaptive. It may be that changing strategies due to strong internal feedback is generally adaptive—even if switching away from a typically effective ER strategy such as reappraisal (Gross, 2002; Gross & John, 2003). Furthermore, it appears that switching strategies haphazardly without regard to internal feedback may be maladaptive.

It is interesting that three RIF measures (corrugator, HR, and self-reported negative affect) all predicted switching behavior (Hypothesis 1), but only the corrugator RIF score moderated the relationship between switching frequency and well-being (Hypothesis 2). Relevant to this point, corrugator activity was the only physiological channel in the present study that responded to unpleasant stimuli (negative > neutral) and was also influenced by reappraisal (negative decrease < negative view). This changeable, objective index of ER success may thus serve as a source of internal feedback useful for ER tracking (Bonanno & Burton, 2013; Gross, 2013; Kalisch, 2009). This idea is consistent with research showing that facial muscle activity may be implicated in embodied cognition related to emotional processing (see Niedenthal, 2007). Furthermore, corrugator activity is reliably modulated by the valence of emotional stimuli even when people try to inhibit outward displays of emotional facial expressions (Cacioppo, Bush, & Tassinary, 1992). Corrugator activation therefore seems to track emotional valence partially independently from its role in emotional communication (i.e., visible frowning behavior).

A key strength of the RIF measurement was that the decision to switch strategies was measured in such a way that the button press did not merely indicate a cognitive decision to switch strategies but actually *caused* distractors to appear. This design builds upon the work of Sheppes, Scheibe, et al. (2014) regarding distraction choice and Vujovic et al. (2014) regarding button-pressing as a measure of ER behavior. An additional strength was the statistical control for reappraisal success in understanding the effect of switching from reappraisal to distraction. Although reappraisal success marginally predicted satisfaction with life, the moderated association between strategy switching and satisfaction with life remained even after controlling for individual differences in this measure of the ability to use the initial ER strategy.

Study 2

The results of Study 1 supported both hypotheses, suggesting that participants generally switched in accord with internal feedback and that switching in this manner was supportive of well-being. Because distraction is consistently preferred over reappraisal for high-intensity emotional stimuli (Sheppes, Scheibe, et al., 2014), in Study 1, we focused only on this optimal switch pattern. A limitation of this design, however, was that we did not examine the nonoptimal switching pattern of distraction to reappraisal. We therefore designed Study 2 to address this question. Specifically, in Study 2, participants were instructed to use distraction initially and then given the opportunity to switch to a reappraisal strategy. Because reappraisal is not a generally preferred strategy in the context of high-intensity emotion, this creates two competing motivations: (a) the need to switch strategies if negative emotion is not reduced, and (b) the desire to use the optimal strategy by distracting for high-intensity stimuli and reappraising for low-intensity stimuli. As a result of these competing motives at both high- and low-intensity emotion, we predicted that the association between internal response and strategy switching would be inconsistent and nonsystematic across participants. In other words, on some trials participants may maintain the original strategy even when they are unable to regulate adequately, and thus continue using distraction, while on other trials they may switch in order to explore whether reappraisal would be more successful. Accordingly, we anticipated that we would not observe an association between internal feedback and strategy switching in this study. It should be noted that evaluating the validity of a null

[4] The model with corrugator RIF as the moderator was still significant ($p = .001$), the interaction of switching frequency and corrugator RIF was still significant ($p = .001$) with higher switching frequency still predicting higher life satisfaction among high-RIF participants ($p = .003$) and lower life satisfaction among low-RIF participants ($p = .026$). In contrast, for the models involving HR RIF score and self-reported negative affect RIF score, none of the main effects, or interactions were significant, all $ps \geq .403$. In summary, corrugator RIF score significantly moderated the association between switching frequency and satisfaction with life, but HR RIF and negative affect RIF did not moderate that association.

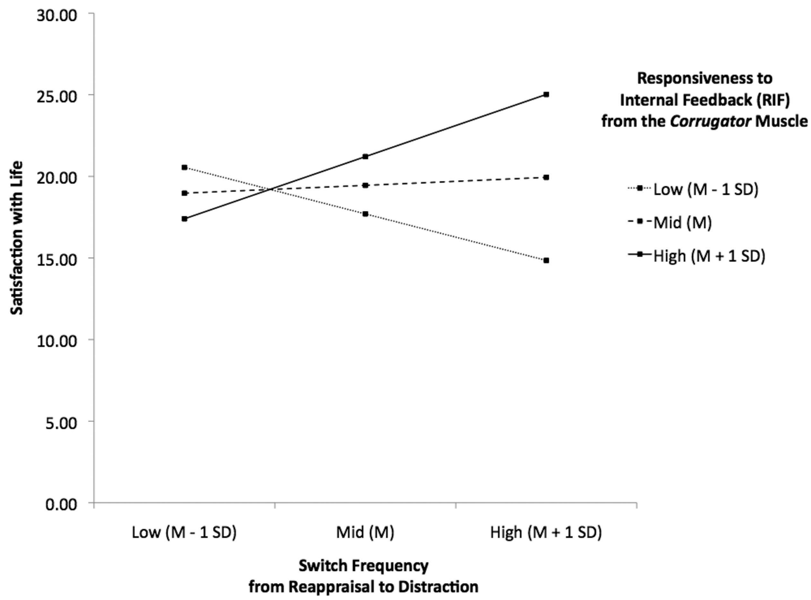

Figure 2. The figure depicts how frequency of switching regulatory strategies and responsiveness to internal feedback (RIF) from the *corrugator* muscle interact to predict satisfaction with life in Study 1. The predictor (switch frequency) on the *x*-axis and the moderator (*corrugator* RIF score) were each modeled in a linear regression analysis at three levels: low (1 *SD* below the mean), medium (at the mean), and high (1 *SD* above the mean). Reappraisal success was modeled as a covariate on the dependent measure (satisfaction with life). The effect of switch frequency on satisfaction with life differed for high (solid line; $b = 32.279$, $p = .017$, 95% CI [6.075, 58.483]), medium (dashed line; $b = 4.077$, $p = .623$, 95% CI [−12.417, 20.571]), and low (dotted line; $b = -24.125$, $p = .029$, 95% CI [−45.642, −2.609]) RIF.

hypothesis is difficult because a demonstrated lack of association among variables may reflect the true absence of an effect, on the one hand, or a true, but undetected, effect due to noise or insufficient statistical power, on the other hand. Nevertheless, we saw no clear reason to anticipate an association between internal feedback and strategy switching in Study 2 or that RIF scores would be related to psychological well-being.

Method

Participants. Ninety-five adults (49 females; $M_{age} = 28.23$ years; $SD_{\text{age}} = 7.60$ years) responded to online advertisements and participated for monetary compensation. The race and ethnicity of participants were similar to Study 1: 48.42% Black or African American, 23.16% Caucasian, 12.63% Asian or Asian American, 2.11% American Indian or Alaska Native, 6.32% two or more racial categories, and 7.37% declined to provide this information. Of the total sample, 16.84% endorsed being of Hispanic origin, and 3.16% declined to provide this information. All study procedures were approved by the Institutional Review Board at Teachers College, Columbia University, and participants provided written informed consent prior to participating in the study.

Materials and procedure. All materials and procedures were the same as in Study 1 except for four key changes. First, the CRT was replaced with a distraction task (DT). On trials with the "Decrease" instruction, the DT instructed participants to try to decrease negative emotion elicited by the central picture by looking at other pictures in the corners of the screen. On trials with the "View" instruction, participants were instructed to simply view the pictures as they normally would. Second, in order to allow participants to perceive the content of the pictures before actively looking away from them for the remaining duration of the picture presentation, the distractor pictures appeared 1 s after the onset of the central picture and remained on screen for 9 s until the picture's offset. Third, participants began each trial of the RIFT task by using distraction instead of reappraisal. As in the DT, the first 4 s of each picture presentation consisted of 1 s of the central picture with no distractors followed by 3 s of the central picture with distractors. Also as in the DT, participants were instructed to decrease their negative emotion specifically using distraction as soon as the distractors appeared in the corners of the screen. Fourth, participants were instructed that they would hear a tone 4 s after the picture onset and that, if the distraction strategy was not working to decrease negative emotion, they could press the Spacebar to choose to use reappraisal anytime after this sound. If participants pressed the Spacebar, the four smaller neutral pictures disappeared from the corners of the screen so that they could focus directly on the central picture to reframe its meaning during the remainder of the picture presentation (up to 6,000 ms depending on the time of the button press).

The same variables of emotion and the same baseline-corrected procedure were used as in Study 1. Because we examined self-reported intensity of affect, corrugator activity, HR activity but not electrodermal activity in Study 1 for the main hypotheses, we examined those same variables for all tests in Study 2. As in Study 1, for the manipulation checks of negative affect induction, mean changes in the physiological channels were calculated for each condition across the 10-s picture duration of the DT because participants simply viewed the central picture for its full duration on each trial in the view-negative and view-neutral conditions.

Regarding physiological processing for the main hypotheses, there were two differences between Study 1 and Study 2 due to the slightly delayed appearance of the distractor images in DT and RIFT in Study 2 relative to Study 1. First, for the manipulation checks of regulation success, mean changes in the physiological channels were calculated for each condition across the last 9 s of the 10-s picture duration of the DT (i.e., the full phase of distraction strategy use). Second, for the testing of Hypotheses 1 and 2, mean changes in the physiological channels were calculated across the last 3 s of the 4-s duration of the initial picture phase of the RIFT (i.e., the initial phase of distraction strategy use before the opportunity to switch strategies).

Results

Data retention. Five participants were excluded due to sessionwide problems: two participants for task-noncompliance, two participants for technical difficulties with physiological equipment, and one participant for a session interrupted by a building evacuation.

For manipulation checks, participants with extreme outliers were excluded from specific analyses as defined in Study 1. For the manipulation check of induced negative affect using self-reported negative affect, 10 participants were removed due to high values for the view-neutral condition. For the manipulation check of regulation success using self-reported negative affect, no participants were removed. For the manipulation check of induced negative affect using corrugator activity, six participants were excluded due to high (one) or low (four) values for the view-negative condition or low (one) values for the view-neutral condition. For the manipulation check of regulation success using corrugator activity, six participants were excluded due to high (two) or low (three) values for the decrease-negative condition or low (one) values for the view-negative condition. No participants were excluded for HR activity for either manipulation check.

For hypothesis testing, RIF scores could not be computed for two participants because they never (one) or always (one) chose to switch ER strategies during RIFT. For negative affect, two participants were excluded for high (one) mean *z* scores for maintain trials or for high (one) mean *z* scores for switch trials. For corrugator, two participants were excluded for high (one) mean *z* scores for maintain trials or for high (one) mean *z* scores for switch trials. For HR activity, one participant was excluded for low mean *z* scores for switch trials, and one participant was excluded for extremely noisy HR data specifically during the RIFT. In addition, for Hypothesis 2, four participants were excluded for having high (three) or low (one) values for the corrugator measure of distraction success, and one participant was excluded because of absent SLS data.

Manipulation checks. To determine whether the pictures successfully induced negative affect, a paired-samples *t* test was conducted for each of the three measures of emotion measured during the DT. The conservative family wise adjusted criterion for significance testing for these *t* tests was $p < .017$ (where α/[number of tests] = .05/3 = .017). These *t* tests compared the two conditions on which participants simply viewed the pictures as they normally would without attempting to regulate emotion: view-negative and view-neutral. As expected and consistent with Study 1, compared to neutral pictures, negative pictures were associated with greater self-reported intensity of negative affect, $t(79) = 25.38$, $p < .001$, M_{neg} (SD_{neg}) = 4.40 (1.18), M_{neu} (SD_{neu}) = 1.12 (0.14), greater corrugator activity, $t(83) = 6.23$, $p < .001$, M_{neg} (SD_{neg}) = 0.61 μV (1.09 μV), M_{neu} (SD_{neu}) = −0.30 μV (0.91 μV), and greater decelerations in HR, $t(89) = -3.85$, $p < .001$, M_{neg} (SD_{neg}) = −3.12 bpm (2.29 bpm), M_{neu} (SD_{neu}) = −2.41 bpm (2.01 bpm). Therefore, as in Study 1, the negative pictures elicited negative emotion.

To determine whether there was evidence of ER success using distraction, we conducted a paired-samples *t* test for self-reported negative affect, corrugator activity, and HR during the CRT. The conservative family wise adjusted criterion for significance testing for these *t* tests was again $p < .017$. These *t* tests compared the two conditions involving negative pictures: decrease-negative (distraction) and view-negative (no distraction). As expected, compared to the view-negative condition, the decrease-negative condition was associated with reduced self-reported intensity of negative affect, $t(89) = -9.28$, $p < .001$, $M_{decrease\text{-}negative}$ ($SD_{\text{decrease-negative}}$) = 3.57 (1.21), $M_{view\text{-}negative}$ ($SD_{\text{view-negative}}$) = 4.43 (1.15), and reduced corrugator activity, $t(83) = 2.75$, $p = .007$, $M_{decrease\text{-}negative}$ ($SD_{\text{decrease-negative}}$) = −0.32 μV (4.51 μV), $M_{view\text{-}negative}$ ($SD_{\text{view-negative}}$) = 0.29 μV (2.93 μV). However, as in Study 1, there were no differences in the magnitude of HR decelerations between the two conditions, $t(89) = -1.17$, $p = .244$, $M_{decrease\text{-}negative}$ ($SD_{\text{decrease-negative}}$) = −2.90 bpm (2.34 bpm), $M_{view\text{-}negative}$ ($SD_{\text{view-negative}}$) = −3.10 bpm (2.34 bpm). In summary, the results of these manipulation checks were entirely consistent with the parallel results in Study 1. Although reactivity to the unpleasant stimuli was evident in subjective negative affect, corrugator activity, and HR, the regulatory effects of distraction were evident only in subjective negative affect and corrugator activity.

Hypothesis Testing

Hypothesis 1. We created a RIF score for each of the three measures (see above for details). The conservative family wise adjusted criterion for significance testing for these *t* tests was $p < .017$. We conducted paired-samples *t* tests for each of the three measures comparing the mean of the *z* scores for switch trials and maintain trials. As predicted, generally the relationship between switching and these indices were nonsignificant. Compared to trials on which participants did not switch strategies, trials on which participants decided to switch to reappraisal were associated with marginally lower—not higher—self-reported intensity of negative affect, $t(85) = 2.26$, $p = .026$, $M_{switch} = -0.05$ ($SD_{\text{switch}} = 0.56$), $M_{maintain} = 0.17$ ($SD_{\text{maintain}} = 0.40$), but this effect did not meet the adjusted criterion for statistical significance. Switch trials differed from maintain trials in neither corrugator activity, $t(85) = 1.25$, $p = .214$, $M_{switch} = -0.01$ ($SD_{\text{switch}} = 0.18$), $M_{maintain} = 0.02$ ($SD_{\text{maintain}} = 0.14$), nor decelerations in HR, $t(85) = 0.86$, $p = .391$, $M_{switch} = -0.06$ ($SD_{\text{switch}} = 0.22$), $M_{maintain} = -0.04$ ($SD_{\text{maintain}} = 0.17$). When all statistical outliers were included in the analyses, the results of the three *t* tests were still nonsignificant,

p = .052 for self-reported negative affect, p = .246 for corrugator activity, and p = .227 for HR activity.

As in Study 1, we conducted two post hoc paired t tests to examine whether normative valence and arousal ratings of the central RIFT pictures differed for trials on which participants chose to switch versus maintain strategies. For the test of valence, three participants were excluded due to switching on all trials (one), never switching (one), and a low extreme value for mean valence on maintain trials (one). Consistent with our expectations, we found that stimuli on trials for which participants switched from distraction to reappraisal were not rated as significantly more or less arousing (M = 5.29, SD = 0.32) than stimuli on trials for which they maintained the distraction strategy (M = 5.22, SD = 0.24), $t(87)$ = 1.23, p = .221, d = 0.25. The result was similar when the outlier value was included, p = 380. For the test of arousal, two participants were excluded due to switching on all trials (one) and never switching (one). Again, consistent with our expectations, the stimuli on trials for which participants switched from distraction to reappraisal were not rated as significantly more or less pleasant (M = 3.19, SD = 0.34) than the stimuli on trials for which they maintained the distraction strategy (M = 3.15, SD = 0.25), $t(86)$ = 0.67, p = .504, d = 0.13. In summary, these post hoc results were consistent with the results of the a priori tests of internal emotion (corrugator and HR activity) in that negative emotion did not predict regulatory switching behavior from distraction to reappraisal.

Hypothesis 2. Does the frequency of strategy switching from distraction to reappraisal predict well-being differently for people with high and low RIF? We tested this question as in Study 1 by calculating the proportional frequency of strategy switching for each participant. The mean switching proportion across participants was 42.37% of trials (SD = 21.05%). In a linear regression similar to Study 1, we entered the proportional frequency of switches in ER strategy as the predictor, SLS score as the dependent variable, corrugator RIF score as the moderator, and the measure of distraction success using corrugator as a covariate on the dependent measure. Consistent with the hypothesis, the model was not significant, R^2 = 0.01, $F(4, 76)$ = 0.16, p = .958, and there was no main effect of switching frequency, b = −0.722, p = .723, 95% CI [−11.669, 10.224], no main effect of corrugator RIF, b = −1.909, p = .723, 95% CI [−12.587, 8.769], and no interaction of switching frequency and corrugator RIF, b = 0.385, p = .989, 95% CI [−55.801, 56.571]. Furthermore, the covariate, distraction success score, did not predict satisfaction with life, b = 0.598, p = .513, 95% CI [−1.212, 2.407].

We repeated the same regression analyses using HR RIF score and self-reported negative affect RIF score. The test in which HR RIF was entered as a moderator was not significant, R^2 = 0.01, $F(4, 77)$ = 0.18, p = .950, and there was no main effect of switching frequency, b = −2.302, p = .702, 95% CI [−14.243, 9.640], no main effect of HR RIF, b = −2.589, p = .572, 95% CI [−11.670, 6.492], and no interaction of switching frequency and HR RIF, b = −4.455, p = .818, 95% CI [−42.913, 34.003]. Similarly, the test in which negative affect RIF was entered as a moderator was not significant, R^2 = 0.03, $F(4, 76)$ = 0.52, p = .719, and there was no main effect of switching frequency, b = −2.034, p = .708, 95% CI [−12.826, 8.758], no main effect of negative affect RIF, b = −1.225, p = .593, 95% CI [−5.775, 3.325], and no interaction of switching frequency and negative affect RIF, b = 2.800, p = .746, 95% CI [−14.369, 19.971]. The three regression tests above were repeated with all statistical outliers included, and none of the models, main effects, or interactions were significant, all ps ≥ .112. In summary, switching frequency from distraction to reappraisal did not predict satisfaction with life, and none of the RIF scores moderated the association.

Discussion

The distraction strategy reduced subjective negative affect and picture-related corrugator activity. However, as predicted, there was no clear evidence that higher (or lower) internal emotional feedback was associated with subsequent strategy switching, nor was there evidence that RIF moderated the relationship between switching frequency and well-being.

General Discussion

Our collective findings suggested that internal feedback about the experience of intense negative emotion guides the decision to switch from reappraisal to distraction (Study 1) but not the reverse order of strategies (Study 2). These results were consistent with previous research indicating a preference for distraction as the optimal strategy for regulating high-intensity negative emotion (Sheppes, Scheibe, et al., 2014). Additionally, for the reappraisal-to-distraction order (Study 1), the extent to which internal feedback aligned with the decision to switch strategies seemed to have implications for well-being. Among people showing a pattern consistent with high RIF, frequent strategy switching to distraction predicted higher well-being. In contrast, among people showing a pattern consistent with low RIF, frequent switching to distraction predicted lower well-being.

The lack of association between internal responses and switching in Study 2 may be explained by conflicting motivations. In Study 1, the preference to switch strategies due to ER failure would have likely aligned with the preference to distract in high-intensity contexts. The prescribed alternative strategy of distraction may have resolved both of these motivations naturally and without conflict. In Study 2, on the other hand, the preference to switch strategies due to ER failure may have conflicted with the preference to distract in high-intensity contexts. Similarly, the preference to maintain strategies due to ER success may have conflicted with the preference to reappraise in low-intensity contexts. For this reason switching and maintaining may have both been nonoptimal options for both high- and low-intensity trials such that internal feedback could not serve to direct participants toward making any appropriate regulatory choice.

It is worth considering two alternative accounts that may explain the discrepancy in results between the two studies. The apparent difference in responsiveness to feedback could be related to the fact that the initial strategy was prescribed in both studies. If participants would have voluntarily selected reappraisal more than distraction for the present stimuli, then the switching behavior in Study 2 may have been influenced by the inappropriateness of the starting point to a greater degree than in Study 1. If so, the specific influence of ER failure on strategy switching may have been obscured in Study 2 relative to Study 1. The fact that switching frequency was higher in Study 2 (M = 42.37% of trials) than Study

1 (M = 13.61% of trials) is consistent with this possibility. Furthermore, it may be that people often prefer to use reappraisal but not distraction as an initial strategy (but see Suri, Whittaker, & Gross, 2015). Many of the negative experiences we face on a daily basis are mildly intense and therefore may be suitably managed by reappraisal (e.g., accidentally dropping your fork at a restaurant, hearing about the cancer diagnosis of a famous actor, getting caught in the rain without an umbrella). The design of Study 1 may adhere more closely to the way ER works in the real world than that of Study 2. It may be that studying switches from distraction to reappraisal would be fitting only in cases of highly intense negative emotion when people would typically select distraction as their initial strategy (Sheppes, Scheibe, et al., 2014). Even in that case, the appropriate signal to switch to reappraisal may be a tapering of emotion (i.e., ER success) rather than a continued elevation of emotion (i.e., ER failure). Indeed, as Gross (2015) speculates, "when managing a highly intense emotional situation, it may be best to first employ distraction to bring the intensity of the emotion down, and only then employ reappraisal" (p. 17).

A second account that could explain the findings is that people may attend to internal feedback when using an engagement strategy (e.g., reappraisal; Kalisch, 2009), but they may turn attention away from internal feedback (as well as the eliciting stimulus itself) when using a disengagement strategy (e.g., distraction). Distraction may achieve its beneficial, fast-acting regulatory effects (Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011) at the cost of monitoring the success of the strategy less closely. Future research should address the possibility.

The studies had a few notable limitations. First, as previously mentioned, 12 participants simply never switched strategies in Study 1 and therefore were not included in our analyses. Thus this sample may not be entirely representative of the general population. Not surprisingly, relative to the majority of participants, these never-switch participants were less reactive when viewing unpleasant stimuli. However, they did not differ in demographic characteristics from the rest of the participants (see Footnote 1). Second, some participants did switch but infrequently, and therefore the RIF estimates are may have low reliability for these participants. Despite this limitation, however, the self-report, corrugator, and HR RIF scores were significantly different from zero in the expected directions in Study 1, suggesting that the RIF measures were indeed sensitive to the use of internal feedback. A third limitation was that the RIF scores were necessarily correlational; they indexed the coupling between natural variations in the strength of emotion during early ER and strategy switching during later ER. We maintain that RIF scores reflect RIF in Study 1, but the possibility remains that strategy switching decisions were *not* influenced by prior emotional signal strength. A fourth limitation is that well-being was only measured at one time point. Without a longitudinal design, we can only infer that switching from reappraisal to distraction frequency may lead to higher well-being among high-RIF people and lower well-being among low-RIF people.

There are several future directions worth pursuing. The mechanisms by which feedback-driven strategy switching might contribute to improved well-being are unknown. It is possible that people who are highly responsive to internal feedback achieve high life satisfaction because their enhanced navigation of emotional situations leads them to repeatedly make optimal decisions in spite of challenging circumstances. Bechara, Damasio, Tranel, and Damasio (1997) showed that anticipatory autonomic responses preceded disadvantageous decision making in a healthy population that ultimately learned to make advantageous decisions on the same task. Future research should determine whether RIF predicts the quality of decision making in emotional contexts. Second, it would be informative to repeat this same paradigm in clinical populations to assess whether switching frequency predicts their anxious or depressive symptoms in a way that depends on RIF. Relevant to this future direction, there may be a general rule that it is beneficial to flexibly switch to distraction when emotion remains strong, but there may be notable exceptions to the rule, particularly with respect to clinical populations. For example, the success of exposure therapy to reduce high-intensity negative emotion for anxiety disorders seems to be hindered by distraction (Kamphuis & Telch, 2000). Third, future research should determine whether people typically use internal feedback to make decisions with or without conscious awareness (Bechara et al., 1997). Mauss, Bunge, and Gross (2007) suggest that ER occurs automatically much of the time. It may be that people use feedback without deliberate control to achieve their regulatory goals.

In conclusion, the findings suggest that internal feedback may dynamically guide changes in ER strategies but that this role of feedback may be more instrumental in the context of switching from reappraisal and/or to distraction than it is when switching from distraction and/or to reappraisal. The decision to maintain or switch strategies seems to depend partly on transient bodily signals (i.e., corrugator muscle) and HR slowing as well as the subjective intensity of unpleasant emotion. The findings suggest that the tendency to switch ER strategies in line with this internal feedback—particularly corrugator activity—may have important implications for well-being. Although the present findings are necessarily correlational, they support the idea that life satisfaction may be enhanced for people who use internal feedback to decide when to stop reappraising and start distracting. The findings are also consistent with the idea that life satisfaction may be reduced for people who stop reappraising and start distracting often but for no good reason. We propose that RIF is an important, measurable construct that may allow for situation-appropriate, flexible ER in the short term and improved well-being in the long term.

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Received March 2, 2015
Revision received December 11, 2015
Accepted December 14, 2015 ■