The Psychophysiology of Self-Compassion

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Introduction

Self-compassion has become an established area of scientific inquiry. In this chapter, we focus on the peripheral physiological effects of self-compassion, including physiological measures linked to the autonomic nervous system and to immune functioning. We review the evidence for whether self-compassion affects peripheral stress and immune response systems in a manner that aligns with greater stress resilience and with more adaptive autonomic and immune functioning. Studies encompass various forms of self-compassion, including dispositional or trait self-compassion, defined herein as the self-reported tendency to generally embody a compassionate state or perspective regarding one's own experience; induced state self-compassion, which reflects brief inductions or brief trainings in self-compassion intended to produce an immediate self-compassionate state; and regularly trained self-compassion, which reflects more ongoing, multi-week, formal interventions that aim to increase self-compassion in a more enduring manner. This chapter reviews the findings on self-compassion with regard to peripheral physiology, including psychophysiology and peripheral immune and inflammatory markers.

The stress system in humans is located both within the central nervous system and the periphery. The autonomic nervous system, a division of the periphery, is consisted of three branches: the sympathetic, parasympathetic, and enteric nervous systems. When homeostasis is disrupted by detection of an internal or external stressor or threat (e.g., infection, emotional distress), the sympathetic nervous system and hypothalamic–pituitary–adrenal (HPA) axis are activated (Miller & O'Callaghan, 2002). Activation of these two systems results in the body's stress or fight-or-flight response, wherein the brain stimulates changes in behavior and in periphery physiology to enhance survival, including increased heart rate, blood pressure, respiration rate, peripheral vasoconstriction, and reduced appetite. These changes result in heightened arousal and alertness and increased vigilance and attention, facilitating detecting and responding to threat. Threat detection also results in decreased parasympathetic nervous system activation, which is largely responsible for bodily functions that occur at rest, such as digestion. Whereas time-limited activation of the autonomic stress response systems provides benefits for survival, its prolonged or chronic activation is associated with adverse consequences and poor physical health, including suppressing key functions such as immune functioning. Thus, researchers have been interested in

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understanding the effects of interventions that dampen or enhance recovery of biological responses to acute and chronic stress.

The studies discussed in this chapter evaluate a range of peripheral physiological effects of self-compassion. The most common physiological measure used in these studies is high frequency heart rate variability (HF-HRV) and related HRV measures that assess the parasympathetic nervous system influence on the time intervals between heartbeats via the vagus nerve (the tenth cranial nerve). HF-HRV has been conceptualized as "a transdiagnostic biomarker of self-regulation and cognitive control" (Beauchaine & Thayer, 2015, p. 338), with higher HF-HRV (in general) reflecting greater levels of self-regulation and cognitive control. Heart rate (HR), reported in several relevant studies, reflects both sympathetic and parasympathetic autonomic nervous system influences (Berntson et al., 2007). Skin conductance, the activity of sweat glands, reflects sympathetic nervous system activity (Dawson et al., 2007), and thus is considered a more direct measure of sympathetic activation. Salivary alpha-amylase (sAA), an enzyme found in saliva, also tracks predominantly with the sympathetic nervous system, with higher levels reflecting higher levels of sympathetic activation (Rohleder et al., 2004). Cortisol is produced by the body's other major stress response system, the HPA axis, which in humans tends to be slower acting than the sympathetic nervous system and to respond most robustly to stressors characterized as uncontrollable and socially threatening (Dickerson & Kemeny, 2004).

In addition, significant work has established a robust relationship between higher levels of psychological stress and increased immune activation (Marsland et al., 2017). In regard of this connection, research to date has begun to examine the extent to which self-compassion training can improve immune outcomes, including assessing two markers as correlates of immune system activation: interleukin 6 (IL-6), measured from blood plasma, and salivary immunoglobulin A (sIgA). IL-6 is a commonly studied cytokine, a class of immune system protein broadly involved in cellular signaling and messaging, and has received attention as a proinflammatory cytokine associated with higher levels of psychological stress (Slavich & Irwin, 2014). Though IL-6 is a complicated protein involved in both pro- and anti-inflammatory processes (Del Giudice & Gangestad, 2018), elevations in IL-6 can be interpreted as a metric of proinflammatory activity when they occur in conjunction with the activation of other physiological stress systems, particularly the sympathetic nervous system (Michopoulos et al., 2017). Salivary IgA is a secreted antibody involved in neutralizing and blocking pathogens from accessing various tissues. As it relates to stress research, sIgA is under regulatory control from neuroendocrine circuits activated by psychological stress (Bosch et al., 2002). Lower levels of sIgA (Phillips et al., 2006) are associated with higher rates of illness and infection (Pilette et al., 2001). Thus, sIgA is a metric of immune activity influenced by neural regions associated with psychological stress.

Each of these physiological measures, as well as the biological systems in which they are embedded, is highly complex, responsive to shifts in environmental demands, and interacts with a range of other biological systems, often including one another. However, a full description of their complexity lies beyond the scope of this chapter.

Most of the work on self-compassion and peripheral physiology relies on Neff's (2003a, b) definition of self-compassion, which encompasses three dimensions: "being kind and understanding toward oneself in instances of pain or failure rather than being harshly self-critical; perceiving one's experiences as part of the larger human experience rather than seeing them as isolating; and holding painful thoughts and feelings in mindful awareness, rather than overidentifying with them" (p. 223). Based on this three-part definition of self-compassion, Neff (2003a) developed and validated a corresponding 26-item Self-Compassion Scale (SCS), which serves as the primary self-report measure for trait or dispositional self-compassion used in the studies in this chapter.

While writing this chapter, we identified 23 studies documenting the relationship between self-compassion and physiology. Most of these were published recently, demonstrating an emerging interest in the relationship between self-compassion and physiological outcomes. The included articles reported on a range of biomarkers, and they mostly included healthy adult samples and stress (as opposed to mental health related) outcomes. Ultimately, we categorized the included articles into three sections: (1) observational studies of trait self-compassion, (2) brief laboratory studies and experiments designed to train self-compassion skills, and (3) lengthier clinical interventions. We begin with reviewing the evidence for links between self-compassion and peripheral physiology by focusing on observational studies of trait self-compassion and stress.

Observational Studies of Trait Self-Compassion and Stress

Observational studies provide insight into the relationship between individual differences in self-compassion and physiological responses to laboratory-induced stressors. Biomarkers that have been studied in relation to self-compassion in observational studies include IL-6, sAA, heart rate (HR), HF-HRV, blood pressure (BP), and cortisol. Most of the studies in this area have assessed self-reported self-compassion and biomarkers at baseline, followed by exposure to the Trier Social Stress Test (TSST), a standardized laboratory social performance stressor that includes anticipation, stress, and recovery phases (Kirschbaum et al., 2008); during the TSST in the identified studies, tasks typically included a 5-min speech and a 5-min mental math task, both performed in front of two or three study judges.

Despite limitations including small, homogenous samples and lack of direct manipulation of self-compassion, the available observational studies provide evidence that is consistent with a protective role of trait self-compassion in buffering biological stress responses. For example, in a study of 41 healthy young adults (ages 18–35 years), researchers found that trait self-compassion led to lower proinflammatory markers (IL-6) in response to an initial social performance stressor and lower anticipatory proinflammatory response to a repeated social performance stressor, suggesting greater physiological resilience to social performance stress (Breines et al., 2014). Participants took part in two TSSTs over 2 consecutive days to evaluate responses to both a novel and repeated stressor. On both days, blood draws to assess for IL-6 were taken at baseline as well as 30 and 120 min following the TSST. As expected, IL-6 levels increased following the social stressor during both laboratory sessions, without evidence of a habituated IL-6 response to the repeated stressor. Additionally, as predicted, baseline trait self-compassion negatively predicted day 1 IL-6 response to the TSST, such that higher trait self-compassion was associated with lower levels of a proinflammatory response to the novel stressor. Surprisingly, however, baseline trait self-compassion did not predict Day 2 IL-6 response to the TSST. In additional analyses conducted to better understand this lack of association, findings showed an elevated IL-6 response prior to the TSST on Day 2 for individuals with lower trait levels of self-compassion. The authors hypothesized that this elevated anticipatory IL-6 response could have been due to anticipatory anxiety of the upcoming TSST or rumination regarding the previous day's TSST and prevented a more elevated IL-6 response to the TSST.

Having demonstrated a relationship between trait self-compassion and proinflammatory responding, Breines et al. (2015) next sought to examine whether individuals with greater trait self-compassion display less sympathetic nervous system activation in response to novel and repeated stressors. Given that the proinflammatory response to stress is largely driven by increased sympathetic nervous system activity, lower IL-6 in the previous study would suggest a lower sympathetic nervous system response, as measured here by lower sAA. Thirty-three healthy young adults (ages 18–34 years) completed baseline self-report measures including the SCS (Neff, 2003a). Participants then com-

pleted initial saliva collection, followed by the TSST, with additional saliva collection at multiple timepoints over a 60-min period. Participants completed the TSST again the following day. As predicted, for each individual day of the TSST, higher levels of trait self-compassion were associated with significantly lower sAA responses to the TSST with medium-to-large effect sizes. Additionally, unlike the robust IL-6 response observed across 2 days of social stress tasks (Breines et al., 2014), sAA responses decreased significantly across the repeated stressors, although the overall habituation in sAA from Day 1 to day 2 was not associated with baseline self-compassion, potentially due to an already low sAA response to the novel stressor among self-compassionate individuals.

Importantly, while these studies have contributed to our understanding of the relationship between trait self-compassion and physiological stress, not all researchers view self-compassion as a unidimensional construct, but instead as consisting of two distinct factors composed of positive and negative characteristics (Costa et al., 2015; López et al., 2015). Neff's SCS (Neff, 2003a) assesses a total self-compassion score made up of six subscales – three positive (e.g., self-kindness, common humanity, and mindfulness) and three negative subscales (e.g., self-judgment, self-isolation, and overidentification). Neff et al. (2018) argue that both positive and negative subscales are central to self-compassion. Others posit that the SCS's negative subscales are significantly more related to psychopathology than the positive subscales, thus disproportionately increasing the link between a total SCS score and psychopathology (Muris & Petrocchi, 2017). Moreover, researchers have argued that differential physiological systems might be involved for positive versus negative aspects of compassion (Gilbert et al., 2011).

Given this controversy, Neff et al. (2018) thoughtfully reanalyzed data from the two aforementioned studies (Breines et al., 2014, 2015) to evaluate the relationship between physiological stress response and various subcomponents of self-compassion. A reanalysis was conducted in which data for sAA and IL-6 were available for 33 and 41 healthy young adults, respectively (Neff et al., 2018). In their reanalysis, Neff et al. (2018) examined correlations between these physiological markers and baseline self-compassion scores, including total SCS, positive subscale, negative subscale, and the individual six subscale scores. For the TSST completed on the first day, total SCS and both positive and negative subscale scores all moderately correlated with sAA and IL-6, with no significant difference in the correlations between the physiological markers and each of the positive and negative subscale scores. In terms of individual subscales, two positive subscales (self-kindness and mindfulness) and two negative subscales (isolation and overidentification) significantly correlated with sAA and IL-6 in the expected direction (i.e., negative correlations for the positive subscales and positive correlations for the negative subscales), whereas common humanity and self-judgment did not. On the second day of the TSST, only sAA significantly correlated with SCS scores; again, total SCS and both positive and negative subscale scores moderately correlated with sAA. Of the individual subscales, only isolation was significantly associated with sAA, again in the expected direction. Importantly, the authors noted a smaller sample size as well as smaller intercorrelations for the second day of the TSST. Given these overall findings, the authors concluded that the positive and negative subscales do not each uniquely predict distinct underlying physiology, as both correlate moderately with sympathetic nervous system and pro-inflammatory responding.

In addition to sAA and IL-6, researchers have examined the relationship between dispositional self-compassion and vagally mediated heart rate variability (vmHRV), a biological marker of the parasympathetic nervous system control over heart rate variability and a proposed indicator of the ability to adaptively regulate emotions and stress. In a study of 53 healthy university students, participants completed baseline measurements of trait self-compassion as assessed by the SCS as well as resting vmHRV (assessed with the root mean square of successive differences [RMSSD], e.g., between R-R intervals in the

ECG), measured during a 5-min interval in which participants were instructed to breath slowly and relax (Svendsen et al., 2016). Additionally, a subsample of participants ($n = 26$) wore heart monitors to collect physiological data over 24 h. As predicted, young adults with higher trait self-compassion demonstrated higher resting vmHRV during the baseline period ($r = .52$, $p < .01$). This positive correlation was also found with a 24-h measure of vmHRV assessed outside of the laboratory ($r = .50$, $p < .02$), demonstrating the continued association between higher self-compassion and greater vmHRV in a more naturalistic setting.

Luo et al. (2018) extended the work conducted by Svendsen et al. (2016) by examining vmHRV in the context of the TSST, as opposed to resting and naturalistic vmHRV. In their study, 85 male university students in China completed the SCS, and students with self-compassion scores in the upper and lower 27% were asked to participate in a laboratory session as part of high- and low-self-compassion groups, respectively ($n = 17$ for both groups). Results showed that HR did not differ significantly between groups but vmHRV did differ. Similar to results from Svendsen et al. (2016), baseline vmHRV (assessed via RMSSD) was higher among self-compassionate students. Additionally, self-compassionate students showed significantly higher vmHRV during the social stressor and recovery phases on the TSST, although no difference was found during the anticipation stage of the stressor.

Whereas most studies examined the relationship between self-compassion and physiological functioning among healthy young adults, Bluth et al. (2016) hypothesized a protective function for self-compassion during adolescence, a life stage marked by transitions that can increase stress. Twenty-eight adolescents (ages 13–18 years) completed a laboratory session consisting of physiological (e.g., BP, HR, HF-HRV, and salivary cortisol) and psychological measures as well as the TSST. Analyses were conducted using a median split approach that categorized adolescents into those with higher ($n = 16$) and lower ($n = 12$) baseline trait self-compassion. Systolic BP response to stress was the only physiological measure significantly buffered by trait self-compassion, with an inverse relationship between higher self-compassion and lower systolic BP. No significant differences across the groups emerged in change of HR during stressor tasks or in HF-HRV. Similarly, despite lower overall cortisol output among the more highly self-compassionate adolescents, a group difference did not emerge (Hedge's $g = 0.12$). The authors highlighted ceiling effects in HR on stressor tasks as well as a lack of gender balance between groups (including no male participants in the low self-compassion group) as plausible explanations for a failure to find physiological differences across the two groups.

Like adolescence, older adulthood can represent a life stage often characterized by unique age-related stressors – in this case, more persistent and less controllable stressors like declining physical health. To examine whether self-compassion serves a protective function during older adulthood, a pioneering study evaluated the relationship between trait self-compassion and diurnal cortisol secretion among 233 community-dwelling older adults ages 59–93 years (Herriot et al., 2018). Five salivary cortisol samples were collected per day over 3 nonconsecutive days in a given week; researchers used area-under-the-curve (AUC) to calculate daily cortisol levels, and then computed average cortisol secretion using daily AUC cortisol levels. Self-compassion was assessed using the 12-item Self-Compassion Scale (Raes et al., 2011), a short-form of Neff's SCS (Neff, 2003a). The authors found that among older adults who reported high physical health problems, functional disabilities, and life regrets, only those who were low in self-compassion showed higher levels of cortisol (AUC). Thus, the detrimental effects of physical health problems and functional disability in influencing cortisol levels may be buffered by higher levels of self-compassion. Importantly, there was no evidence for a main effect of stressors on cortisol levels, indicating that individual differences in interpretation of stressors in self-compassionate (or non-self-compassionate) terms rather than the stressors themselves may most significantly impact physiological responses to stress.

In addition to research among adolescents and older adults, one study examined self-compassion and physiological health in a group that may be prone to frequent failure and thus self-criticism – athletes (Ceccarelli et al., 2019). Following baseline measures of HF-HRV and trait self-compassion among 91 adult university or national level athletes (ages 18–40 years) across a variety of sports, participants took part in a standardized laboratory stressor where a researcher read aloud from a guided imagery script, asking participants to recall a recent sport failure. The researcher prompted athletes to recall a mistake or setback in as much detail as possible, focusing attention on emotions and physical sensations experienced at the time of the failure as well as reexperienced in the present moment. Results showed that baseline trait self-compassion was significantly associated with HF-HRV during the brief (2-min) recollection of sport-related failure, such that more self-compassionate athletes displayed increased parasympathetic activity (i.e., higher HF-HRV), and thus increased self-regulation during the stress induction. However, this relationship was not found during a brief (2-min) recovery phase immediately following the stressor, suggesting that trait self-compassion increased athletes' physiological regulation primarily during the stressor itself.

Summary of Observational Studies on Self-Compassion and Stress Physiology

In summary, although research on the association between self-compassion and physiology is in its early stages, a few trends across studies emerged. Across the eight reviewed studies, emerging evidence suggests that dispositional self-compassion can buffer physiological responses to laboratory stressors. Specifically, in response to standardized laboratory stressors, trait self-compassion may positively correlate with HF-HRV and negatively correlate with systolic BP, cortisol, IL-6, and sAA, though several findings were mixed. First, examining indices of heart functioning, studies found some evidence for higher HRV among more trait self-compassionate individuals both at rest (Luo et al., 2018; Svendsen et al., 2016) and during a laboratory stressor (Ceccarelli et al., 2019; Luo et al., 2018) and during stressor recovery in one study (Luo et al., 2018) but not the other (Ceccarelli et al., 2019). In addition, no group differences were found in HRV among high- and low-self-compassionate adolescents completing a social stressor (Bluth et al., 2016); only systolic BP differed. Two studies similarly found no evidence of a significant association between self-compassion and HR (Bluth et al., 2016; Luo et al., 2018), though both were small and thus likely underpowered. Second, two studies evaluated cortisol as an index of HPA axis activity. Herriot et al. (2018) reported a significant moderation effect in which higher self-compassion correlated with lower diurnal cortisol levels in older adults who reported high physical health problems, functional disabilities, and life regrets. Finally, markers of inflammation (IL-6) and sympathetic nervous system activation (sAA) were each examined in only one observational study (Breines et al., 2014, 2015). Breines et al. (2014) found evidence for lower IL-6 response to a novel stressor among self-compassionate individuals, though this association was not significant for a repeated stressor. Similarly, Breines et al. (2015) demonstrated an inverse relationship between trait self-compassion and sAA response to a social stressor, suggesting a protective role of self-compassion.

Given the largely small, homogeneous samples predominantly focused on healthy adults and few studies per biomarker, more research is needed. Future directions might include assessing the link between trait self-compassion and longer term health outcomes, examining trait self-compassion as a continuous variable (rather than use a median split, for example), and assessing the impact of trait self-compassion in response to more naturalistic stressors. A more direct method of examining the influence of self-compassion to stress responding is to manipulate self-compassion directly; we turn next to these studies.

Experimental Studies Related to Self-Compassion and Physiological Stress

Five laboratory experiments have explored the relationship between self-compassion and physiological stress responding. These experiments are largely characterized by brief manipulations of self-compassion in healthy adults to assess both physiological and self-reported stress responses. Biomarkers from these studies included cortisol as a metric of the HPA axis stress response; sAA, SCL, and HR as metrics of the sympathetic stress response; and HF-HRV as a metric of the parasympathetic stress response. Although these studies are largely limited in their use of brief manipulation strategies applied to healthy adults within laboratory settings, the overall results lend greater support to a causal relationship between increased self-compassion and decreased physiological stress responding.

In a study of 105 healthy undergraduate women, researchers examined the impact of a brief self-compassion training on stress-related biomarkers including sAA, HF-HRV, and cortisol (Arch et al., 2014). Participants were randomized to either a *metta* (loving-kindness) meditation condition, an attention placebo condition focused on cognition and problem-solving, or a control condition receiving no intervention. The *metta* meditation condition used both traditional *metta* phrases ("May I be happy. May I be healthy and strong…") and study-specific phrases ("May I know that others struggle along with me. May I love and accept myself completely, just as I am…") that focused on cultivating a sense of common humanity, well-being, and acceptance toward oneself and, to a lesser extent, toward others. All participants attended two laboratory sessions. The first session involved brief condition-specific training (in the *metta* meditation or attention placebo control). The second session involved completion of the TSST, a standardized social stress paradigm that requires participants to prepare and deliver a speech without notes and complete a challenging math task, both in front of judges (Kirschbaum et al., 2008). Between the two sessions, participants in both the self-compassion and attention placebo conditions completed three 10-min recorded training sessions in their assigned intervention. Finally, they completed a briefer training session (in *metta* or placebo control) immediately prior to being introduced to the TSST. Biomarkers assessed at the second TSST-focused laboratory session included sAA and salivary cortisol (collected at 5 points during baseline through 35 min post-TSST) and HF-HRV (collected continuously during baseline through 10 min post-TSST). Results showed that the self-compassion condition endorsed greater trait and state self-compassion from the first to second laboratory session relative to both control conditions. The self-compassion condition also showed a steeper decrease in state anxiety from the TSST speech preparation through the post-TSST recovery phases but not at other study points, relative to both control conditions. Regarding physiological outcomes, the self-compassion condition showed significantly lower sAA (in terms of area under the curve with respect to increase) relative to both control groups in response to the TSST, indicative of a reduced sympathetic stress response (Thayer et al., 2012; Thayer & Lane, 2000). In addition, the self-compassion condition had a more engaged or stable HF-HRV during both the speech preparation phase in anticipation of the TSST and in the recovery phase following the TSST relative to both control groups indicative of increased or maintained parasympathetic control and associated with improved emotion regulation in prior studies (Porges, 2007). No group differences emerged in cortisol responding, perhaps because the TSST represents an uncontrollable performance stressor – characteristics that elicit a robust cortisol response (Dickerson & Kemeny, 2004).

In summary, these results suggest that brief self-compassion training can improve both sympathetic (sAA) and parasympathetic (HF-HRV) markers of stress in the context of a social stress task, though in this study, did not influence HPA axis activation (in the form of cortisol). Together with the self-report findings, the study thus suggests that brief self-compassion meditation training led to shifts in how participants responded to

the stressor – that is, with greater self-compassion and self-regulation – rather than in their experience of the stressor's controllability.

Following this experimental study, the authors subsequently examined predictors and moderators of the beneficial physiological outcomes associated with self-compassion meditation (Arch et al., 2016). Specifically, they sought to determine what role two stress vulnerability traits (social anxiety, rumination) and two resiliency traits (self-compassion, nonattachment, i.e., the Buddhist notion of release from mental fixations) might have in moderating the effects of brief self-compassion meditation training on sAA and HF-HRV (vs. control conditions). Results showed that relative to the control groups, higher reported baseline nonattachment (i.e., lower attachment) within the self-compassion group predicted lower TSST-related increase in sAA and lower self-reported anxiety than did lower baseline nonattachment (e.g., higher attachment). In contrast, levels of nonattachment did not influence sAA outcomes for the two control groups compared to the self-compassion group. However, trait rumination was significantly more influential in predicting sAA increases within the control groups compared to the self-compassion group. In summary, the physiological benefits of brief self-compassion training (relative to the two control conditions) were robust across various levels of baseline social anxiety and trait self-compassion but were moderated by baseline levels of nonattachment and rumination, such that participants with higher levels of attachment or rumination benefitted less from self-compassion training than those with lower levels of attachment or rumination. As participants with these baseline characteristics did not benefit equally, the authors concluded that individuals with higher levels of attachment or rumination might require a more extensive or tailored self-compassion training.

Whereas the aforementioned studies examined self-compassion training in non-clinical samples, Ascone et al. (2017) evaluated the physiological impact of a single session of self-compassion-focused guided imagery among 51 psychiatric patients (including 36 psychiatry inpatients and 15 outpatients) receiving treatment for paranoid ideation. Skin conductance levels (SCL) were measured throughout the experiment by a recording bracelet. Following baseline assessment, participants underwent a 3–5-min negative mood induction in which they recalled a recent social stressor that induced either fear or shame. Participants were then randomly assigned to either self-compassion imagery (n = 26) or control imagery (n = 25). In the intervention group, experimenters read from a standard script aloud for 10 min, instructing participants to create a mental image of a person or object that elicits compassion and warmth for the participants. In the control group, experimenters described a chair in the experiment room, matching the self-compassion imagery script in style and length. Compared to the control group, those receiving self-compassion imagery reported significant increases in happiness and self-reassurance, but there were no differences between conditions in SCL or symptoms of paranoia. Given that this experiment was conducted in a single session, the authors suggest that participants may not have experienced sufficient practice creating a self-compassionate mental image, resulting in increased effort during the intervention that impeded their ability to relax physiologically.

While these studies support the role of self-compassion in improving physiological markers of stress, more recent work has begun to elucidate the intervention processes that account for these physiological benefits. Specifically, one study sought to examine the precise intervention mechanisms that drive the beneficial physiological effects of self-compassion by randomizing 135 adults in equal numbers (n = 27 per condition) to five conditions including a loving-kindness meditation condition where compassion is directly instructed (direct compassion), a compassionate body scan condition where participants attend to bodily sensations with a sense of calm acceptance (indirect compassion), a positive-excitement condition, a self-critical rumination condition, and a neutral control condition (Kirschner et al., 2019). Thus, the study aimed to test whether self-compassion uniquely affects physiological responding, or whether it

confers these benefits only to the extent that it increases positive affect.

This study consisted of a single laboratory session where participants listened to one 11.5-min tape, which guided participants through an induction specific to their condition. For example, participants in the direct compassion loving-kindness condition were instructed to direct loving thoughts toward someone close to them and then to direct those same thoughts toward themselves (in the spirit of *metta* meditation), whereas those in the indirect compassion body scan condition were guided to direct kind attention to body sensations. Researchers tracked HF-HRV, SCL, and HR for the duration of the taped experimental inductions. Results from this brief intervention showed decreased HR throughout the entire audio exercise in the direct loving-kindness group and for the first 8 min in the compassionate body scan group, relative to the three comparison groups. Further, HF-HRV was elevated in both self-compassion groups throughout the exercise (except the final minute of the compassionate body scan) relative to the three comparison groups. Fewer robust differences were seen in SCL, though the loving-kindness group did show a significant decrease relative to the neutral control group for the first 7 min of the exercise.

Regarding mechanisms, this study found that HR fully mediated the relationship between the loving-kindness condition and self-reported self-criticism and partially mediated the relationship between the compassionate body scan condition and self-reported levels of both self-criticism and positive affiliative affect. Thus, inducing self-compassion may be beneficial in improving self-criticism and affiliative affect to the extent that it calms HR-based physiological arousal. In sum, the authors report that brief self-compassion inductions may confer physiological benefits in two ways: first, through activation of the parasympathetic positive affect system (HF-HRV), which corresponds to reduced stress and enhanced emotion regulation capabilities; and second, by increasing a positive sense of self while decreasing a negative sense of self. Importantly, these improvements cannot be attributed simply to increasing positive affect, suggesting that inducing self-compassion confers unique benefits in improving physiological markers of stress.

Beyond the use of physiological measures associated with stress, other work has extended our understanding of self-compassion into the study of physical pain. Luo et al. (2019) randomized 29 healthy adults to undergo both compassionate and neutral self-talk protocols in a randomized order to measure their impact on HF-HRV and pain ratings during a cold pain exposure. To accomplish this, these researchers first had participants generate four self-compassion statements, followed by the start of the experimental manipulation trials. For each trial, participants were presented with either a self-compassion (e.g., "I understand your pain") or neutral control (e.g., "The store is selling fruits") statement for 10 s that they were asked to read aloud. After 10 s, participants underwent a 3-min cold pain exposure by holding a bottle filled with iced water while recording pain ratings every 30 s. All four self-compassion statements along with four control statements were presented three times each, resulting in a total of 2 min of exposure to self-compassion statements and 2 min of exposure to control statements. Results showed that reported pain was significantly lower during the self-compassion statement trials compared to the control statement trials. In addition, HF-HRV during cold pain exposure was higher in the self-compassion trials as compared to the control trials. Further, higher levels of HF-HRV were more significantly associated with lower pain ratings during the self-compassion trials than in the control trials. This study thus extends past findings by showing that relative to a neutral control condition, very brief self-compassion in the context of thermal pain can improve both perceived physical pain and physiological markers of self-regulation.

The studies described above indicate that brief self-compassion interventions can improve physiological markers of stress in response to both physical pain and psychological stressors. Additional work has sought to examine the extent to which small adjustments in self-compassion

exercises bolster these outcomes. One such study by Petrocchi et al. (2016) tested whether repeating self-generated, self-compassionate phrases while looking at a mirror would improve outcomes as compared to not using a mirror, as is typically done. They recruited 86 adults from the general population and had each of them generate four phrases they would use to soothe or encourage a friend going through a difficult time. Participants then wrote about a recent situation during which they harshly criticized themselves out of shame or disappointment. The self-criticism writing exercise successfully increased HR and negative affect, while decreasing positive affect and HRV, suggesting that the researchers successfully induced a state of self-criticism. Participants then were randomized to one of three conditions for a 5-min experimental manipulation, including repeating their four encouraging phrases toward themselves while looking at themselves in a mirror (n = 30), repeating their four encouraging phrases toward themselves without looking into a mirror (n = 28), or looking at themselves in a mirror without repeating the phrases (n = 28). Self-report and ECG measures of HR and HRV were incorporated throughout all procedures. The group that recited self-compassionate statements while looking in the mirror showed significantly larger increases in HRV and reported more soothing positive affect relative to the two comparison groups. The relationship between condition and increase in soothing positive affect was partially mediated by an increased sense of common humanity, a facet of self-compassion. Overall, while the precise mechanisms are not fully understood, the authors purport that reciting self-compassionate phrases while looking into a mirror may improve outcomes by increasing the number of positive social signals being communicated, facilitating a sense of self-compassion that extends beyond verbal language, or seeing ourselves from an external, more objective point of view in a manner that reduces self-critical biases.

Summary of Experimental Studies on Self-Compassion and Stress Physiology

Overall, the limited number of laboratory studies that manipulate self-compassion show that such manipulations often result in improved physiological markers of stress, particularly those associated with sympathetic (e.g., sAA, HR) and parasympathetic (i.e., HF-HRV) nervous system responding. These improvements in physiological stress were observed in the context of both psychological and physical stress tasks. Thus, briefly trained or induced self-compassion appears to cultivate resilience in the face of diverse acute stressors.

Research has begun to explore mediators and moderators of the physiological benefits of induced self-compassion and to elucidate the specific approaches to inducing self-compassion that have the greatest effect on physiological self-regulation and stress response. Indeed, these beneficial effects can be bolstered with minor manipulations, such as reciting self-compassion phrases into a mirror as compared to not using a mirror (Petrocchi et al., 2016). Importantly, one study found that the beneficial effects of self-compassion training were not attributable solely to increased positive affect but rather were unique to self-compassion processes (Kirschner et al., 2019).

While these initial findings are promising, more work remains to be done in order to better understand the physiological benefits of briefly induced or trained self-compassion. For example, additional laboratory-based studies are needed to replicate and extend current findings, and particularly to clarify the potential effects of self-compassion training on skin conductance and cortisol, which are key indices of sympathetic and HPA axis activation, respectively. In addition, future studies can attempt to extend these findings into more vulnerable populations, including in clinical groups that are more likely to suffer from lower levels of self-compassion (Macbeth & Gumley, 2012).

Clinical Interventions Related to Stress and Mental Health

Expanding on brief manipulations in laboratory settings, eight studies examined the impact of lengthier clinical interventions in more naturalistic settings. Similar to most of the aforementioned work, these studies were predominantly conducted with healthy adult populations, although three focused on populations facing potentially heightened stress, recruiting individuals who had experienced early life adversity, parenting stress, or cancer biopsy (Pace et al., 2013; Poehlmann-Tynan et al., 2020; Wren et al., 2019). Interventions included at-home meditation practice using audio recordings as well as group-based self-compassion training, ranging in length from a relatively brief manipulation (2 weeks) to a 15-week course. Self-compassion was cultivated using several formal interventions, including Cognitively-Based Compassion Therapy (CBCT; Pace et al., 2009), Emotion Focused Training for Self-Compassion and Self-Protection (EFT-SC; Halamová et al., 2019), and Compassionate Mind Training (CMT; Gilbert, 2000, 2009, 2010), among others. In addition to self-reported outcomes, the following biomarkers were assessed: sAA and HR to assess sympathetic nervous system response, cortisol as a marker of the HPA axis, and HRV as an indicator of parasympathetic nervous system response. Additionally, immune system functioning was explored through IL-6, salivary C-reactive protein (CRP), and sIgA.

In one such early clinical intervention study, researchers examined the impact of CBCT training on IL-6 and cortisol in response to a TSST among 61 healthy university students ages 17–19 years (Pace et al., 2009). Recruited from a health education class, participants were randomized to take part in either CBCT (n = 33), compassion meditation training based on Tibetan Buddhist mind-training or *lojong* practices, or a health discussion group (n = 28) over the course of 6 weeks, totaling 12 intervention hours for both conditions. In contrast to mindfulness practices that encourage nonjudgmental awareness of thought processes and emotions, *lojong* practices first challenge individuals' preconceived thoughts and emotions toward others and then guide them to develop spontaneous feelings of empathy, love, and compassion toward all people, beginning with the self and expanding to include others whom individuals dislike or with whom they have conflicts. CBCT was designed to first teach attention and mindfulness techniques as a foundation, and then gradually shifted toward focusing on *lojong* meditations. In addition to 12 h of group training, CBCT participants were encouraged to practice exercises daily at home using audio recordings. The health discussion groups reviewed standardized topics related to mental and physical health among university students, and participants wrote weekly papers applying material to their lives to control for time and practice outside of class. To evaluate the impact of meditation training on physiological response to a novel stressor, participants completed the TSST between 8 and 10 weeks from the initiation of the study. Surprisingly, researchers did not find evidence for a main effect of compassion meditation on IL-6, cortisol, or self-reported subjective distress following the TSST. However, after examining variability in weekly meditation practice among participants, researchers conducted a median split analysis for high and low practice. Using this approach, significant correlations were found, demonstrating an inverse relationship between practice, IL-6, and distress. Specifically, a greater number of practice sessions per week was associated with lower immune response and subjective distress, a finding which highlights the importance of committed practice of compassion exercises in improving psychological and physical outcomes.

In a subsequent study, Pace et al. (2013) examined the impact of CBCT on salivary C-reactive protein (CRP) among 55 adolescents in the foster care system, seeking to understand the impact of compassion training in a population impacted by early life adversity. Adolescents in this trial were randomly assigned to either a 6-week CBCT intervention (n = 29) or a waitlist control (n = 26). CBCT participants attended class twice a week, completing a total of 12 intervention hours; additionally, they were encouraged to practice daily

exercises at home using an audio recording. To examine CRP, saliva samples were collected immediately upon awakening prior to and following the intervention. As with findings from Pace et al. (2009), no group differences were found for salivary CRP. However, when researchers examined a subset of adolescents with complete data on weekly practice time, an inverse relationship was found between number of practice sessions and morning salivary CRP levels across the 6-week study, such that more practice was associated with lower CRP levels. Consistent with previous findings (Pace et al., 2009), the authors concluded that participation in a CBCT class might not be enough to reduce markers of inflammation; instead, active at-home practice may be particularly important.

Like Pace et al. (2009, 2013), Poehlmann-Tynan et al. (2020) also employed CBCT to manipulate self-compassion, although the authors examined a different population potentially prone to higher stress levels – parents of young children. In a randomized preliminary efficacy study, 39 parents of children ages 9 months to 5 years 4 months were randomized to either CBCT (n = 25) or a waitlist control (n = 14). Parents in the CBCT condition completed eight weekly group sessions in addition to one full day retreat, totaling 20 intervention hours. Hair cortisol concentration (HCC) was analyzed for both parents and children at pre- and post-intervention assessments along with psychosocial measures of stress and parenting stress. Among parents in both CBCT and the waitlist control group, average HCC increased over time, with no significant difference between groups. Whereas no main effect of the intervention was found for parent HCC, there was a significant group difference in children's HCC. Specifically, among children of parents in the CBCT condition, average HCC decreased from pre- to post-intervention. Furthermore, the average HCC for children of parents on the waitlist control increased across the intervention, which the authors found surprising given that children's HCC tends to decrease with age after age 1 year.

Paralleling CBCT, another study tested the effects of group meditation training focused first on mindfulness training followed by self-compassion training. In this small, uncontrolled study, 31 healthy adults (90% female) participated in an 8-week group-based program (Bellosta-Batalla et al., 2018) derived from Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1990) and Compassion-Focused Therapy (CFT; Gilbert, 2010). Participants completed a 2-h group session each week for 8 weeks and were assessed at pre- and post-intervention on self-reported variables, sIgA, and salivary cortisol levels. Neither sIgA nor salivary cortisol levels changed significantly over the 8 weeks of the intervention. However, cortisol decreased significantly *within* the first and last intervention sessions, whereas sIgA levels increased within the last intervention session. Though at-home practice was not assessed, this small study suggests that compassion practice can immediately benefit stress- and immune-related biomarkers, similar to previous research (Pace et al., 2009, 2013). Given that this study was small and did not include a control group, results should be interpreted with caution.

Another more recently developed intervention, Emotion-Focused Training for Self-Compassion and Self-Protection (EFT-SCP; Halamová et al., 2019), aims not only to bolster self-compassion but also to explicitly reduce self-criticism by increasing protective anger, or an ability to stand up and assert oneself in response to self-criticism. In a quasi-experimental study evaluating EFT-SCP, 73 healthy university students were recruited and assigned to the following conditions by clustering based on year in school: (1) EFT-SCP (n = 19), (2) an active control consisting of expressive writing (n = 20), (3) or a no-treatment control condition (n = 34) (Halamová et al., 2019). During a baseline laboratory session, participants completed psychosocial measures followed by a 10-min audio-taped guided imagery task that began with 1-min of relaxation and then three, 3-min imagery tasks that intentionally cultivated sequential feelings of self-criticism, self-protection, and self-compassion. In the first imagery task, participants remembered a situation in which they felt self-criticism and were asked to describe their inner

self-critic. Second, participants imagined the part of them that would want to defend or protect them against their inner critic. Third, participants imagined the part of them that is self-compassionate and loving at times of difficulty and thought about how they might respond to their self-critic. HF-HRV (via root mean square of successive R-R intervals) was assessed during this imagery exercise. Following this session, students in the EFT-SCP condition completed a 12-week group course, totaling 1.5 intervention hours per week and consisting of experiential exercises designed to elicit self-compassion (e.g., self-compassionate body scan and breathing, imagining a safe place) and reduce self-criticism (e.g., imagining one's self-critical part to build awareness). In addition, EFT-SCP participants completed daily expressive writing tasks at home associated with that week's EFT-SCP content to cultivate self-compassion (e.g., writing a letter to yourself as a child expressing compassion, practicing self-compassion in front of the mirror) or lessen self-criticism (e.g., changing your self-critical dialogue). In contrast, students participating in the active control completed a weekly at-home expressive writing task. After 12 weeks, all participants returned to the laboratory to complete the audio-taped imagery exercise for a second time, during which HF-HRV was again assessed. Findings showed that compared to both control groups, HF-HRV for students in the EFT-SCP intervention condition increased significantly during the imagery exercise from pre- to post-test, specifically during the guided self-critical imagery task where participants described their inner self-critic and the guided self-compassion imagery task, in which participants took a self-compassionate perspective. This suggests that the EFT-SCP self-compassion training led to greater self-regulation in the context of both induced self-compassion and induced self-criticism.

Ko et al. (2018) also examined a group-based university course of self-compassion, randomly assigning 41 university students (ages 18–22 years) to either a 15-week academic Seminar on Compassion (n = 21) or a waitlist control group (n = 20). Content in this Seminar on Compassion included a range of self-compassion, compassion, and mindfulness meditation and related practices, reading and discussing biographical information on world leaders in compassion, and compassion teachings from diverse world religions. In this study, students completed a baseline laboratory session at the end of their fall semester and prior to beginning the compassion course, consisting of pre-intervention self-report measures as well as saliva collection to assess sAA. Students in the intervention group were then asked to attend the compassion course twice a week for 80 min per class throughout the semester, totaling 40 intervention hours. During the last week of the spring semester, post-intervention measures and saliva collection were again completed. Findings showed a significant group difference in sAA, such that sAA decreased among students taking the compassion course, whereas sAA increased among students in the waitlist control group.

Whereas the aforementioned interventions utilized group training, a few studies relied largely or solely on individual at-home practice of self-compassion exercises. One of these studies examined compassionate mind training (CMT), a component of Compassion-Focused Therapy (CFT; Gilbert, 2009, 2010), that emphasizes soothing breathing, attention and awareness, and guided imagery to develop compassionate images of others and self (Matos et al., 2017). Ninety-three healthy adults and university students (ages 18–43 years) were randomly assigned to participate in either a 2-week CMT training program (n = 56) or a waitlist control (n = 37). All participants completed a laboratory session at pre- and post-intervention. During these laboratory sessions, participants completed self-report measures, and resting HRV in the form of RMSSD was assessed over a 5-min relaxation period. In between the two laboratory sessions, participants in the CMT training program completed an initial 2-h group session where they learned CMT exercises and were provided with a manual outlining CMT theory as well as audio recordings of CMT exercises to facilitate at-home practice. Participants were invited to practice the exercises at home over

2 weeks and could independently decide whether to use the audio recordings to guide this practice. Following 2 weeks, all participants returned to the laboratory to complete the post-intervention assessment, again consisting of self-report measures and an assessment of resting HRV. As hypothesized, participants in the CMT condition demonstrated a significant increase in HRV from pre- to post-intervention, whereas there was no significant change in HRV over time for participants in the control condition. This study suggests that self-compassion can be practiced largely independently over a relatively short period of time, and still provide benefits for physiological self-regulation (in the form of increases in resting HRV).

Wren et al. (2019) also relied on at-home meditation practice, reporting on the physiological response to a loving-kindness meditation intervention among breast cancer patients. In this study, 56 participants underwent four assessments of diastolic and systolic BP and HR: (1) pre-biopsy and prior to randomization, (2) post-biopsy, (3) after learning of biopsy results if abnormal, and (4) 1-week post-surgery. All assessments of BP and HR were completed during laboratory sessions, except for the final two assessments, which were taken from patients' electronic medical records. Following the pre-biopsy assessment, patients were randomly assigned to receive one of the following conditions during a biopsy: (1) a loving-kindness meditation administered by audio recording ($n = 23$), (2) music from a genre that the patients selected ($n = 16$), or (3) usual care consisting of support from the biopsy team ($n = 17$). Following biopsy, patients in the loving-kindness and music conditions received condition-specific instructions for condition-specific at-home practice. Specifically, loving-kindness participants received an audio recording of loving-kindness meditation exercises, a rationale for daily practice, and instructions for at-home 20-min daily practice, whereas the music control group received an audio recording with their selected music genre, a rationale for the soothing effect of music, and instructions to listen every day at home for 20 min. Both the loving-kindness intervention and music groups participated in a scripted booster phone call to assess and solve practice barriers. Results indicated a significant group difference in HR for those in the loving-kindness meditation group compared to the two control groups, where HR remained stable over time for the intervention group but increased for both the music and usual care groups. Furthermore, the authors found that *within* the loving-kindness group, more time spent practicing loving-kindness meditation predicted a lower HR over time, reflecting findings from previous studies regarding the physiological benefits of more daily self-compassion practice (Pace et al., 2009, 2013). However, the authors did not find evidence for group differences in either diastolic or systolic BP.

In summary, more extended self-compassion interventions appear to improve some measures of physiological response to stress, particularly parasympathetic (e.g., sAA and HRV) and sympathetic (e.g., HR, though HR also reflects parasympathetic influence) system responses (Halamová et al., 2019; Ko et al., 2018; Matos et al., 2017; Wren et al., 2019). Whereas no group differences emerged from pre- to post-intervention on biomarkers assessing immune functioning (e.g., IL-6, salivary CRP, sIgA) or HPA axis stress response (e.g., cortisol; Bellosta-Batalla et al., 2018; Pace et al., 2009, 2013), two studies demonstrated the benefits on immune system functioning (e.g., IL-6, CRP; Pace et al., 2009, 2013) and sympathetic responding (e.g., HR; Wren et al., 2019) for individuals within self-compassion interventions who committed more to daily self-compassion practice. Additionally, one study demonstrated benefits of self-compassion training for children of parents undergoing self-compassion training, finding improved cortisol response among children with parents participating in a group-based self-compassion intervention (Poehlmann-Tynan et al., 2020). Thus, pending replication, self-compassion intervention studies point toward greater physiological benefits for those who practice more in their daily lives, an important but unsurprising finding, and extend to those who are being parented by the practitioner, suggesting the broader benefits of parenting training.

Ultimately, extant findings suggest that training in self-compassion can improve biomarkers associated with stress and immune response systems, likely reflecting greater physiological resilience. Caveats include the fact that research in this area is still emerging, and that most studies did not use acute stress or criticism paradigms to evaluate whether benefits extend to the contexts in which they are most needed. Future self-compassion intervention studies should extend the work of Pace et al. (2009) and Halamová et al. (2019) by examining more systematically whether more adaptive physiological responses following self-compassion training extend to a range of stressful contexts.

Conclusions

This chapter characterizes the growing literature on observational, laboratory, and intervention studies that evaluate the benefits of trait, briefly induced state, or more extensively trained self-compassion on physiological outcomes related to stress and immune functioning. Evidence derived from diverse methodologies show that self-compassion in multiple forms (trait, brief state, and enduringly trained self-compassion) can benefit autonomic and immune biomarkers associated with stress resilience and self-regulation. Most extant studies, however, have been conducted in healthy samples – an important focus for improving general population well-being. However, research has identified populations who are particularly low in self-compassion, including women (Neff, 2003a) and those with various symptoms of psychopathology (Macbeth & Gumley, 2012). Individuals undergoing acute or chronic stressors also represent appropriate targets for self-compassion training. In addition, adults with anxiety disorders, posttraumatic stress disorder, major depression, and other forms of psychopathology, as well as adults and children undergoing acute and chronic stressors, often evidence poorer autonomic regulation (Beauchaine & Thayer, 2015) and immune functioning (e.g., Danese & Baldwin, 2017), thus recommending them to interventions that help to improve such functioning. Thus, future research can build on the small body of physiologically focused self-compassion studies that target these more vulnerable populations (e.g., Arch et al., 2014; Wren et al., 2019) with the intention of including those who stand to benefit the most from training in self-compassion.

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