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NEURAL EFFECTS OF COMPASSION TRAINING

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Abstract

Compassion is potentially an effective emotion-regulation strategy to face the suffering of self and others. The aim of this paper is to provide an evolutionary understanding of compassion and compassion training (CT) by examining the psychological, neural and behavioral effects of loving-kindness meditation and compassion meditation. The author presents various definitions of compassion and examines the physiological and neural processes behind it. Compassion seems to have evolutionary roots but can be limited due to inherited blocks and fears. Compassion is however trainable and can potentially bypass certain evolutionary-based biases. CT results in various significant psychological effects, most notably positive affect, increased (self) compassion, and mindfulness. Evidence is however inconsistent, especially in relation to active controls. Neural effects are significant yet inconsistent across different experimental conditions. CT without a concurrent task activates (1) the right somatosensory cortices (2) the parieto-occipital sulcus, and (3) the right anterior insula. In relation to the socio-affective video task, CT activates medial orbitofrontal cortex, ventral striatum/nucleus accumbens, putamen, and anterior parts of anterior cingulate cortex; regions related to positive affect, motivational reward and affiliation. These findings converge with the reviewed psychological literature. CT also results in increased altruistic and compassionate behavior towards others, even when it's costly to the self and under no-reciprocity conditions. Behavioral effects are mostly demonstrated in game-settings against active controls but also in one real-life situation. Together, the results suggest that CT is beneficial to individuals as well as inter-group relationships.

Keywords: Compassion, loving-kindness meditation, compassion meditation, neural effects of meditation.

Table of Content

Introduction 5

Method and Delimitations 7

Theoretical Considerations 10

Definitions of Compassion 10

Definitions of related terms. 13

Compassion Training 14

Evolutionary Perspective on Compassion 16

Evolutionary function of compassion. 16

Universality of compassion. 18

Displays of compassion. 19

Competing motivational systems and blocks to compassion. 20

Physiological processes involved in compassion 21

The quadratic vagal activity–prosociality hypothesis. 23

Neural processes involved in compassion. 24

Result 25

Psychological Effects of Compassion Training 25

Reviews on compassion training. 25

Meta-analyses on compassion training. 27

Social aspects of compassion training. 30

Neural Effects of Compassion Training 31

Neural effects without concurrent task. 31

Neural effects during the socio-affective video task. 34

Behavioral Effects of Compassion Training 35

Behavioral effects in game-settings. 36

Behavioral effects in real-life situations. 38

Discussion 39

Psychological Effects 39

Neural Effects 43

Behavioral Effects 46

Synthesis 49

Limitations of the Present Study 50

Conclusion 50

Future Studies 50

Introduction

Suffering is an integral and inescapable part of the human condition, regardless of one's class, life-situation, gender or creed. There are different ways of responding to the suffering of self and others; we can for example become detached and cynical or we can become overwhelmed by it. We can also find adaptive and constructive ways of confronting and managing suffering, and thus become more effective in preventing and reducing it (Skwara, King, & Saron, 2017).

Compassion is viewed by some as an effective emotion-regulation strategy that buffers against negative affect (elicited by others' suffering) by generating positive affect through reward-and affiliation-related brain circuitries (Preckel, Kanske, & Singer, 2018). Thus, compassion can potentially be a constructive response to suffering by enhancing emotional resilience and by serving as a coping strategy to prevent empathic distress; a maladaptive form of over-empathizing with others' affective state (Klimecki, Leiberg, Ricard, & Singer, 2014). Increasing our ability for compassion can therefore be argued to constitute a desirable path forward. Dalai lama might have set the tone for the need of more compassionate individuals when he stated that the cultivation of compassion is no longer a luxury, but a necessity if our species is to survive (Condon & Desteno, 2017).

Compassion is often defined as the feeling that arises when witnessing the suffering of another coupled by a subsequent desire to help (Goetz, Keltner, & Simon-Thomas, 2010). There has been a contemplative and philosophical interest in compassion since time immemorial because it plays such a central role in most world religions as well as secular ethics, but it was during the late 1990's that the phenomena became an object of scientific scrutiny by neuroscientist and psychologist (Kirby, Tellegen, & Steindl, 2017; Singer & Klimecki, 2014). Evolutionary thinkers argue that compassion emerged in human affairs since it serves an important function by motivating caretaking of offspring, by serving as an

attribute in mate selections processes and by promoting non-kin cooperation (Goetz et al., 2010). Despite its evolutionary roots among humans, the expression of compassion does not always occur automatically due to various blocks, fears and resistances. However, compassion is open to cultivation and regulation and has therefore the potential to become less biased and more inclusive in its application (Gilbert, 2015).

The scientific interest in compassion has resulted in a number of different empirically supported interventions that focus on developing compassion (Kirby et al., 2017). Loving-kindness meditation (LKM) and compassion meditation (CM) are two such interventions that are based on ancient Buddhist-based trainings whereby the meditator mentally sends well-wishing thoughts and intentions towards others and oneself or visualize relieving the suffering of others (Hofmann, Grossman, & Hinton, 2011). Since studies suggest that these forms of compassion trainings (CT) sensitize meditators to the suffering of others, and increase their tendency to feel compassion and act altruistically towards the sufferer (Weng et al., 2013), they have become popular among researchers and clinicians (Seppala et al., 2017). There are however few studies connecting the psychological, neural and behavioral aspects of CT, which is needed in order to understand the functioning and impact of the practices. Furthermore, if the various psychological and behavioral findings on CT could be substantiated by neuroscientific data, it would make the claims convergent across multiple scientific fields, and thus lend more reliability to the findings (Fox et al., 2016).

The aim of this paper is to examine compassion from an evolutionary perspective as well as offer a broader understanding of CT by examining the empirically validated effects of LKM and CM from a cognitive neuroscientific perspective. An evolutionary account can offer ultimate causal reasons for why compassion exists in the first place and thus shed understanding and appreciation of the function of compassion among humans. An examination of the effects of CT may deepen the understanding of the mechanisms and

consequences of practicing LKM and CM, and hence offer insights about their practical significance in relation to suffering and well-being. The research question is; *What are the psychological, neural and behavioral effects of CT?*

The paper begins with an explanation of how the study has methodologically been conducted and proceeds then to theoretical considerations by offering various definitions of compassion and CT. Then follows an examination of compassion from an evolutionary as well as physiological and neural perspective. Then follows results where the psychological, neural and behavioral effects of CT will be examined separately. Towards the end, a discussion follows with conclusions and limitations.

Method and Delimitations

In 2018 the author of the present paper scanned Google scholar (https://scholar.google.se/), Web of science (http://apps.webofknowledge.com/) and Worldcat discovery (https://his.on.worldcat.org/discovery) in order to find published, peer-reviewed original articles, meta-analyses and reviews focused on the effects of LKM and/or CM. Unless otherwise stated, CT in the present paper refers to LKM and/or CM. The search for articles was conducted by the use of search terms such as; compassion, loving-kindness meditation, metta (loving-kindness in Pali) and compassion meditation. The search for articles was facilitated by the Oxford handbook of compassion science (Seppala et al., 2017); which is the first handbook solely focused on the scientific study of compassion, altruism, and empathy. Since the handbook is the only (up-to-date) resource bringing the latest science on compassion together; it was used as a guide to find the latest and most relevant original articles focused on CT. The handbook is authored by top researchers in the field that offer a multidisciplinary and systematic take on compassion from a basic as well as clinical research point of view, in order to offer a deeper theoretical and empirical understanding of the

evolutionary, developmental, neurobiological, social, and clinical applications of compassion science.

No particular definition or theory of compassion was guiding the selection of articles. Rather, the aim was to find empirical studies focused on either novices being exposed to LKM or CM for the first time, studies focused on long-term meditators (LTM) (total amount of meditational experience ranging from 750h to 10000h, or 5 to 45 years), or studies comparing novices and LTMs. Studies combining CT with other interventions such as mindfulness or cognitive reappraisal were also selected as long as the CTs were used separately from the other interventions, so as to enable an analysis of the distinct effect of CT. Studies combining different meditation forms or other interventions without separating them into different groups or distinct blocks of time were excluded. The only exception for this are three meta-analyses (Galante, Galante, Bekkers, & Gallacher, 2014; Shonin, Van Gordon, Compare, Zangeneh, & Griffiths, 2015; Zeng, Chiu, Wang, Oei, & Leung, 2015) that will be used in the section covering psychological effects of CT. It should however be noted that these meta-analyses are predominantly focused on LKM and CM since they include; 1) predominantly studies that are exclusively based on LKM and CM and 2) to a much lesser degree studies that are based on multi-method programs that themselves are at least to 50% based on LKM and/or CM (an inclusion criteria). One meta-analysis (Galante et al., 2014) use the term kindness-based meditation (KBM) which refers to LKM, CM and forgiveness practices. With these exceptions in mind, the paper will focus on studies where LKM and/or CM have been used rather than studies focused on multi-exercise programs such as the mindful self-compassion program; cognitively-based compassion training; compassion cultivation training; cultivating emotional balance; and compassion focused therapy. Even though the procedures in LKM and CM include directing loving-kindness and compassion towards oneself, these forms of CTs are theoretically and procedurally different from the

construct of self-compassion which is composed of mindfulness, common humanity and kindness (Neff, 2016). Thus, studies predominantly focused on self-compassion will be excluded.

The length of CT interventions varied considerably among the studies, from one single dose of LKM lasting 7 min (Hutcherson, Seppala, & Gross, 2008) to entire meditation programs lasting between 4 to 12 weeks including weekly group sessions ranging from 10 to 120 minutes.

Both immediate and long-term effects of LKM/CM will be examined. In this paper, immediate effects refer to the ongoing changes occurring in the mind and brain. Neuroimaging studies sometimes refer to them as neural correlates, neural signatures, or just neural effects. Psychological studies sometimes use the term immediate emotions occurring during meditation separately from the daily positive emotions occurring during the days following meditation which refer to the more continuous, long-term, effects of meditation (Zeng et al., 2015). Neuroimaging studies sometimes use the term neuroplasticity to refer to more long-term effects, for example neural effects resulting from two weeks of CM practice (Weng et al., 2013). In the behavioral studies the CT effects were measured either immediately afterwards (Weng et al., 2013) or after 2-5 days (Leiberg, Klimecki, & Singer, 2011). The current paper will examine all these different types of effects. In order to interpret effect sizes, the author of the current paper will follow the recommended use of Cohen's d and Hedge's d of .20, .50, and .80 to mean small, medium, and large respectively (Cohen, 1992).

As to the psychological effects of CT, to enable a comprehensive examination of the field the focus was to find all existing meta-analyses and reviews on the topic (Galante et al., 2014; Hofmann et al., 2011; Kreplin, Farias, & Brazil, 2018; Shonin et al., 2015; Zeng et al., 2015). In order to further examine the effects of CT that relate more to the social aspects and

interpersonal relationships, two prominent studies were included (Kang, Gray, & Dovidio, 2013; Stell & Farsides, 2016).

As to the neural effects of CT, only neuroimaging studies using functional magnetic resonance imaging (fMRI) or positron emission tomography (PET) were selected because of their superior ability to locate specific brain regions. Due to limitations of space and time, studies using electroencephalography (EEG) to measure the electrophysiological activity during CT were excluded (Lee, Kulubya, Goldin, Goodarzi, & Girgis, 2018). The selected studies constitute a rather comprehensive list of their sort since they are based on one (and the only) meta-analysis examining the neuroimaging effects of CT (Fox et al., 2016). Furthermore, these studies are often mentioned in prominent and recent neuroimaging studies on meditation (Preckel, Kanske, & Singer, 2018; Weng et al., 2013) as well as in the Oxford handbook of compassion science (Seppala et al., 2017).

As to the behavioral effects of CT, the focus was to find studies examining the subsequent, empirically validated physical behavior of meditators. A comprehensive search at the above mentioned search engines as well as a chapter in the Oxford handbook of compassion science conducting an overview of the behavioral data on CT (Skwara et al., 2017), together confirmed that the selected studies can be seen as a quite comprehensive list of their sort.

Theoretical Considerations

Definitions of Compassion

Compassion is oftentimes understood as an affective state and hence defined as the feeling that arises when witnessing another's suffering coupled with a subsequent desire to help (Goetz et al., 2010). A number of researchers view compassion as an emotion and define it along similar lines (Batson & Shaw, 1991; Lazarus, 1991; Trivers, 1971). However, only

20% of emotion researchers agree that compassion is an emotion, compared to other emotions such as fear, anger, disgust and sadness where there is more than 80% agreement (Ekman, 2016).

In compassion-focused therapy literature (Gilbert, 2015) it is maintained that compassion cannot be reduced to simple definitions or emotions because it is a complex and evolved social mentality. Here compassion is defined as a sensitivity to suffering in self and others, with a commitment to try to alleviate and prevent it. Compassion is hence viewed as a motivational system consisting of two different psychologies; (1) engagement which consists of a sensitivity to suffering in self and others and (2) action which consists of a commitment to try to alleviate and prevent the suffering. The first psychology refers to the intention and act of turning towards suffering rather than avoiding or dissociating from it whereas the second psychology refers to an intention to acquire the needed wisdom to be able to prevent and alleviate the suffering and a willingness to act upon that wisdom. One can have one psychology of compassion without having the other as in the case of jumping into a river to rescue someone from drowning but not being able to swim. Furthermore, prevention requires foresight with a focus on the growth, optimization and flourishing potentials of the recipients whereas alleviation deals with immediate suffering. Compassion requires therefore certain competencies; which are all trainable for example through LKM (Gilbert, 2014).

The first psychology of compassion has to do with the ability to engage, stay with, and understand the sources of suffering, and it involves six competencies (Gilbert, 2014). (1) The motivation to care for others wellbeing refers to the willingness to turn towards suffering, rather than turning away from it. (2) Sensitivity, refers to the ability to notice rather than avoid stimuli that triggers caring motivation. (3) Sympathy, refers to the ability to emotionally connect with and be attuned to suffering, to allow oneself to be moved by suffering rather than dissociating from it and be cold. (4) Distress tolerance, is the ability to cope with others'

suffering. (5) Empathy, is divided into emotional empathy which is the ability to feel what others are feeling and cognitive empathy which is the ability to make use of perspective-taking or theory of mind-like skills to infer and reason about the nature of the suffering and its causes. (6) Non-judgement, refers to the ability to refrain from prejudice, condemnation and blaming. The second psychology of compassion refers to the development of wisdom, insight and practices into what is helpful and courage to act upon this wisdom and involves six competencies. (1) Attention, refers to the ability to know and learn what to pay attention to, like for example other potential helpers or even one's own inner resources. (2) Imagery, refers to the skillful use of one's imagination to enhance compassionate feelings and thoughts, as in compassion meditation for example. (3) Reasoning, refers to the cultivation of knowledge about how to best alleviate and prevent suffering. (4) Compassionate behavior, can either be passive as when we provide soothing, warmth and affiliative care, or active as in when we are performing courageous acts such as confronting injustice or being assertive or protective in challenging situations. (5) Sensory, refers to somatic awareness and body training that is helpful when cultivating compassion, such as breathing exercises and body postures. (6) Feelings of compassion, vary according to context and can therefore be anything from warm and gentle to exited and stressed as when saving someone from a burning house, or even transforming one's anger into action to prevent injustice. (Gilbert, 2015).

A recent review of the existing definitions of compassion concluded that there is a lack of consensus on definitions and a paucity of psychometrically robust ways of measuring the construct (Strauss et al., 2016). The purpose was to synthesize all the existing definitions of compassion from a broad range of Buddhist and western psychological traditions by integrating their common elements together into a single definition. The resulting proposal is that compassion should be understood as a cognitive, affective, and behavioral process that is composed of the following five elements that include both self- and other-compassion; 1)

recognizing suffering; 2) understanding the universality of suffering; 3) feeling empathy for the person suffering and connecting with the distress (i.e. emotional resonance); 4) tolerating uncomfortable feelings aroused in response to the suffering (for example anger, fear and distress) and by so doing remaining open to and accepting of the person suffering; and lastly 5) motivation to act in order to alleviate suffering. Each of these components are part of several published definitions of compassion but no single existing definition includes all five of them. Element 2 refers to the observation that compassion involves recognizing a commonality with the sufferer and an acknowledgement that as a fellow human being we too could find ourselves in a similar position (Strauss et al., 2016).

The integration of the most common conceptual elements of compassion into one single definition is much needed in the field of compassion science since a unifying definition could potentially serve as a foundation for a new comprehensive measure of compassion. This definition must however be empirically tested by examining whether the five elements turn out to be statistically distinct factors of an overarching construct of compassion; an endeavor yet to be undertaken (Strauss et al., 2016).

Definitions of related terms. Beyond compassion, there are other possible ways to respond to the suffering of others, such as pity, empathic concern, cognitive empathy, affective empathy, and empathic distress (Goetz et al., 2010).

Pity is similar to compassion but it lacks the inclination to help and contains the additional appraisal of feeling concern for someone considered inferior to oneself (Goetz et al., 2010) or at least feeling condescension towards the sufferer (Strauss et al., 2016).

Batson (Batson, 2017) defines empathic concern as an “other-oriented emotion elicited by and congruent with the perceived welfare of a person in need” (p.28). Conceptually speaking, empathic concern does not include the motivation to help but is instead hypothesized to cause altruistic motivation. Temporally then, motivation is distinct

from and subsequent to empathic concern whereas in compassion the motivation to help is included in the concept (Goetz et al., 2010).

Like compassion, empathy has also been defined as a multidimensional construct that can be divided into the more cognitively complex and effortful cognitive empathy and the phylogenetically older affective empathy. Cognitive empathy, also called theory of mind, perspective-taking, and mentalizing, has been defined as the ability to intellectually understand another person's state of mind by inferring and reasoning about their emotions, thoughts and beliefs. Affective empathy is often defined as being affected by and sharing the emotional state of another. Many definitions of compassion include both aspects of empathy but compassion also includes the additional element of a desire to act in order to alleviate suffering; an element not found in empathy alone (Goetz et al., 2010) . Additionally, compassion is felt exclusively in relation to suffering whereas empathy is pan-affective and may be applied towards a wide range of both positively and negatively valenced feelings such as suffering, fear, joy and anger (Preckel et al., 2018; Strauss et al., 2016). Affective empathy may lead to compassion but it's not guaranteed to do so, nor is affective empathy alone sufficient to gender compassion. In fact, affective empathy may instead lead to self-focused responses such as empathic distress, which is often defined as a maladaptive form of empathic sharing of others' emotions (usually negative emotions). Empathic distress is oftentimes detrimental because it results in ones' own suffering and may result in antisocial effects such as aggressive verbal behavior (Preckel et al., 2018).

Compassion Training

LKM is a form of mental training derived from the Buddhist tradition. The goal of LKM is to develop unconditional kindness toward others as well as the practitioner himself (Zeng et al., 2015). Other methods, such as inducing empathic concern in participant by instructing them in perspective-taking (Eisenberg & Miller, 1987) or having participant

listening to songs consisting of prosocial lyrics (Greitemeyer, 2009), can temporarily prime individuals to feel empathy in the presence of others' distress. LKM practice, however, aims to permanently alter the meditator's motivation and feelings towards other people and seeks to cultivate a more benevolent, friendly, connected and positive attitude towards others (Leiberg et al., 2011). Research on LKM has increased dramatically since 2008 when the first scientific studies of LKM were released (Fredrickson et al., 2017; Zeng et al., 2015).

The procedure in LKM is based on cultivating loving and kind intentions toward various people, including the meditator himself. Most commonly meditators sit cross-legged, close their eyes and, in the privacy of their mind, form key phrases, such as "may you be happy" and "may you be free from suffering" that they send to various targets. In order to facilitate the initial cultivation of kind intentions, the meditators may bring to their minds images of certain people they hold dear, or they may visualize a shining light that extends from their hearts towards various people. The procedure follows a sequence by starting with easier targets and then proceeding to ever more difficult ones. The meditator begins by sending well-wishing intentions towards the self, close (family members, partners etc.), neutral (strangers for example), and difficult persons (someone you have a conflict with for example) and ends by embracing all sentient being on earth (Zeng et al., 2015).

The Buddhist idea is that LKM leads to the cultivation of the four sublime attitudes called the four immeasurables; (1) loving-kindness (metta) is unconditional love and good will towards all; (2) compassion (karuna) is the intention and willingness to relieve suffering; (3) appreciative joy (mudita) is rejoicing when others are happy and successful, even when we are not happy or successful ourselves; and (4) equanimity (uppekha) is being calm and even-tempered (Zeng et al., 2015). These four attitudes together form the very foundation of the Buddhist ethical system. Furthermore, loving-kindness and compassion are said to be incompatible with anger, hatred, envy, and jealousy. (Hofmann et al., 2011). The aim is to

enable the meditator to volitionally generate a state of compassion and to cultivate an ability to tolerate the suffering of others without being overwhelmed or distressed. In fact, LKM enables the meditator to maintain a positive state of mind while in the presence of others' suffering. The initially generated state of loving-kindness can be applied towards other's suffering, and so be turned into compassion (Engen & Singer, 2015).

CM is very similar to LKM but adds the component of visualizing the suffering of others as well as the alleviation of the suffering. Typical phrases in CM are "may you be free from enmity", " may you be free from mental suffering, "may you be free from physical suffering";, and "may you take care of him/herself happily" (Hofmann et al., 2011). CM, like LKM includes the self as a target of the meditation.

Evolutionary Perspective on Compassion

Evolutionary function of compassion. Among the early evolutionary thinkers there was considerable debate about whether compassion and sympathy could be viewed as results of evolutionary forces, as Darwin himself thought when claiming that sympathy was the strongest of human instincts, or if these emotions are too self-costly for the individual to be in resonance with the theory of evolution (Goetz et al., 2010). Among more recent evolutionary thinkers however, it is argued that compassion is evolutionary rooted by motivating caretaking of offspring, by serving as attribute in mate selections processes, and by promoting non-kin cooperation. Compassion is therefore viewed as a distinct affective state, with a response profile differentiated from distress, sadness, and love, and serving as an adaptation to survival and reproduction-related situations. (Goetz et al., 2010). The present paper will offer an account of compassion from this evolutionary perspective. Next follow three evolutionary arguments for compassion.

The first argument is based on the fact that human infants are vulnerable for an extensive period of time and require therefore lot of parental investment in terms of their time

and energy (Goetz et al., 2010). Evolutionary adaptations of this sort by which parents can effectively respond to the distress of their offspring by providing caregiving, should be selected for in order for the parents to successfully pass on their genes to the next generation (Stellar et al., 2017). Empirical evidence in favor of this analysis suggests that attachment security in early age fosters later caregiving feelings and behaviors such as compassion whereas attachment related insecurity or anxiety suppresses compassionate caregiving (Mikulincer, Shaver, Gillath, & Nitzberg, 2005). Additionally, there is preliminary evidence suggesting that variability in compassionate responses to suffering is better explained by nurturing tendencies based on the impulse to care for and protect infants rather than by other possible mechanisms such as perceived similarity with the sufferer (Batson, Lishner, Cook, & Sawyer, 2005).

The second evolutionary argument for compassion is based on the process of mate selection (Goetz et al., 2010). To select and reproduce with a compassionate partner has obvious evolutionary benefits because such partners are more likely to devote more time, energy and resources in their offspring, more likely to provide physical care in terms of touch, affection and protection and more likely to co-create communities characterized by compassion and care which are more conduicive to the offspring. Furtermore, its also reasonable to assume that compassionate individuals tend to be more faitful towards their partners and more likely to commit to long-term monogamous relationships. Tendency towards compassion correlates highly with a secure attachment style (Shiota, Keltner, & John, 2006), signaling a healthy parenting style which in turn predicts better adjustement of offspring. Additionally, a study of mate preferences across 36 countries and 6 continents found that the trait kindness-understanding is very often ranked as a top characteristic in potential partners (Buss et al., 1990).

The third evolutionary argument for compassion is based on compassion being a facilitator of cooperation between non-kin by way of initiating, maintaining and regulating reciprocally altruistic relationships (Trivers, 1971). In favour of this analysis there is emprical evidence suggesting that compassion reduces the perceived psychological distance to others in need by increasing perceived self-other similarity in the giver, especially towards vulnerable and weak others (Oveis, Horberg, & Keltner, 2010). Additionally, compassion leads to helping behavior (Leiberg et al., 2011; Weng et al., 2013), greater generosity (Saslow et al., 2013), prosocial behavior towards strangers (Leiberg et al., 2011) and greater altruistic helping of victims (Weng, Fox, Hessenthaler, Stodola, & Davidson, 2015), even when the help is costly to the giver in terms of taking painful shocks in the place of another person (Batson, Duncan, Ackerman, Buckley, & Birch, 1981). Individuals prefer relationships with agreeable and compassionate others because these relationships predict trustworthy and cooperative behavior that tend to lead to mutually beneficial exchanges (Goetz et al., 2010).

Universality of compassion. Various observations suggest that compassion is universal across time and culture. Evidence suggests that something like compassion, i.e. prosocial behavior such as empathy and spontaneous acts of unselfishness, even when its costly to the self, is found in humans' closest primate relatives (Campbell & De Waal, 2011; De Waal & Suchak, 2010; Warneken & Tomasello, 2006) as well as dolphins and elephants (Spikins, Rutherford, & Needham, 2010). Chimpanzees routinely hug the loser of a fight and have been seen to show acts of selfless courage when trying to save an infant from drowning and dying themselves in the process (De Waal, 2008). There is also prehistoric archeological evidence suggesting that some form of compassion was present in early hominids, even as far back as 1.5 million year ago in Homo Ergaster, and 200 000 years ago in Neanderthals, in the form of deep collaborations, sharing of emotions, care of the ill and care beyond immediate relationships and time-frames. Evidence also suggests that early upper palaeolithic modern

humans provided extensive care for injured or incapacitated individuals (Spikins et al., 2010). Compassion is also communicated across different cultures by means of touch (Hertenstein, Keltner, App, Bulleit, & Jaskolka, 2006).

Displays of compassion. The evidence for a distinct display of compassion is mixed. Studies suggest that compassion is more reliably expressed through the medium of voice and touch compared to facial expressions and posture where the evidence is inconsistent (Goetz et al., 2010). In one study participants were asked to communicate different emotions trough brief, non-verbal vocal burst. Observers were able to reliably identify various prosocial vocal bursts 47% of the time; compassion alone was identified 24% of the time which is significantly greater than chance levels (8%) (Simon-thomas, Keltner, Sauter, Sinicropi-yao, & Abramson, 2009).

Touch seem to be a reliable way to reduce others' suffering since touch tends to; reduce cortisol (Francis & Meaney, 1999), activate reward areas such as orbitofrontal cortex and subgenual cingulate cortex in the brain (Rolls, 2000), and reduce activation in the neural systems associated with emotional and behavioral threat responses when pain is anticipated (Coan, Schaefer, & Davidson, 2006). Furthermore, touch seem to promote reciprocal altruism and cooperative bonds and has been shown to play an important role in securing compliance (Willis & Hamm, 1980) and promote cooperation with strangers in economic game-settings (Kurzban, 2001). Touch is thus one modality through which to express compassion and studies lend support to that claim (Goetz et al., 2010). In one study participants in different countries were asked to express 12 distinct emotions to other participant through a touch on the forearm, including sympathy, sadness, love and fear. Blind-sighted participants receiving touch were able to discern that sympathy was being expressed 48% of the time in Spain and 57% in the US; a significant result considering chance level is at 8%. Sympathy was usually expressed through longer and medium intensive stroking and patting. 53% of outside

observers were later able to discern that sympathy was being expressed in these exchanges by merely watching a film depicting a hand taking contact with someone's forearm (Judy, Michael, & Sophie, 2006).

Competing motivational systems and blocks to compassion. It should be noted however that compassion competes with other motivational systems and social mentalities that promote self-interest and seek self-expression and have the ability to turn off compassionate tendencies and therefore interfere with CT. The human brain has evolved with ancient motivational systems such as aggressive behavior and dominance seeking among conspecifics, sexual opportunism and group living and these can express themselves for example in the pursuit of status, sex, reproduction, food and power and control in social groups. Moreover, there are various fears, blocks and resistances to compassion such as in-group favoring over out-groups, having the sense that others don't deserve compassion, having fear that others will become too dependent, or fear of being overwhelmed or distressed by others' suffering (Gilbert, 2015). Studies also suggest that humans prefer to help happy and friendly people over sad and distressed people (Hauser, Preston, & Stansfield, 2014). These are some of the reasons why compassion does not always automatically express itself in the face of suffering.

Compassion is however open to cultivation and regulation by way of high-level cognitive processes, complex cultural and social practices and self-identity formation (Gilbert, 2015). Compassion can for example be trained over long-term by various meditational practices (Galante et al., 2014), by facilitating a prosocial orientation to relating (Kogan et al., 2014), by working with the parasympathetic nervous system to generate feelings of calm and safe (Porges, 2001), and by creating social contexts that promote and reward compassionate behavior. Evolutionary processes have equipped humans with a natural yet limited form of

compassion, but with practice compassion can become more inclusive and wise in its application (Gilbert, 2015).

Physiological processes involved in compassion. It has been suggested that the autonomic nervous system can be seen as an internal milieu that enables emotion-related action tendencies, as in the case of fear inducing a fight-or-flight response or compassion inducing an approach and caregiving response (Janig, 2003). Various arguments have been made which together suggest possible autonomic markers of compassion (Goetz et al., 2010).

For example, activation of the vagus nerve seem to decrease cardiovascular arousal, which in turn promotes emotion regulation and calmness in situations of distress. This way compassionate individuals can avoid becoming emotionally distressed and instead focus on the needs of other people (Kogan et al., 2014). Studies suggests that compassion, compared to distress, involves orientation towards the individual in need and involves approach-related behavior. The parasympathetic nervous system slows down the heart rate and has therefore been associated with an orienting response as well as a sustained outward attention; which is a core action tendency of compassion (Suess, Porges, & Plude, 1994). Experimental studies suggest that heart rate deceleration occur in situations that evoke compassion, whereas heart rate acceleration occur in situations that induce distress, in both children and adults (Eisenberg et al., 1988; Eisenberg, Fabes, Schaller, Miller, et al., 1991).

Furthermore, it seems that compassion and distress evoke different levels of skin conductance; a physiological measure of sympathetic autonomic nervous system arousal. For example, distress-inducing films evoke higher levels of skin conductance compared to compassion-inducing films (Eisenberg, Fabes, Schaller, Miller, et al., 1991; Eisenberg, Fabes, Schaller, Carlo, & Miller, 1991). Furthermore, higher skin conductance levels correlate with higher self-reported distress (Eisenberg, Fabes, Schaller, Miller, et al., 1991), with more

distress expressions (Eisenberg, Fabes, Schaller, Carlo, et al., 1991), as well as with gaze aversion during distressing films (Fabes, Eisenberg, & Eisenbud, 1993).

Other arguments suggest that compassion engages a branch of the autonomic nervous system; the vagus nerve, that is evolutionarily old in mammals and involved in social engagement and caregiving behaviors (Porges, 2001; Stellar, Cohen, Oveis, & Keltner, 2015). The vagus nerve is the tenth cranial nerve and is a component of the human social engagement system and regulates the vocal cords and interacts with the neural regulation of the ears, eyes, motor behaviors such as tactile contact, and a number of facial muscles involved in social communication and affiliation. For example, the vagus interacts with neural pathways that innervate facial muscles required for emotional expressions as in nodding the head and orienting the head and gaze toward others (Porges, 2001). Vagus nerve activity is inferred by measuring respiration-associated variability in the heart rate, or respiratory sinus arrhythmia (RSA). Dispositional vagal activity is measured by tonic RSA, or baseline level of RSA at rest, whereas situational vagal activity is measured by fluctuations in RSA relative to baseline during exposure to emotional stimuli (Beauchaine, 2001).

Studies confirm that tonic RSA is positively associated with trait-like compassionate responding. For example, boys with high tonic RSA are rated by both parents and teachers as more helpful and better emotion-regulators than boys with lower RSA (Eisenberg et al., 1994). Other studies show that children's tonic RSA is positively related to their self-reported levels of sympathy, both on the level of dispositions as well as in response to compassion-inducing films. Tonic RSA was also associated with less facial display of distress, self-reported distress and gaze aversion, and lowered skin conductance in response to the compassion-inducing film (Fabes et al., 1993). In another study individuals showed greater RSA during a compassion-induction compared to three control groups; neutral control, positive emotion control, and a prosocial emotion control not related to others suffering.

Furthermore, greater RSA during the compassion-induction compared with the neutral and control emotion group was associated with lower heart rate and respiration, and predicted self-reported feelings of compassion, compassion-related words, and nonverbal displays of compassion (Stellar et al., 2015).

Vagal activity seem to be related to many core processes required for prosociality such as positive emotions, sociability, greater connection to others, and emotion regulation (Kogan et al., 2014). Studies also suggest that vagal activity correlates with state-like episodes of compassion. Individuals exposed to compassion-inducing photographs showed higher levels of RSA than individuals exposed to pride-inducing photographs. Furthermore, controlling for tonic RSA, higher RSA while watching the compassion-inducing photographs were positively related to self-reported feelings of compassion and negatively related to feelings of pride (Goetz et al., 2010). Interestingly, a recent experimental study demonstrates that LKM, mediated by increased sense of social connection, increases vagal activity compared to a control group (Kok et al., 2013).

The quadratic vagal activity–prosociality hypothesis. A group of researchers have responded to the research on compassion by formulating the quadratic vagal activity–prosociality hypothesis, which is a theoretical framework for understanding vagus nerve involvement in prosociality (Kogan et al., 2014). Prosociality here refers to compassion, levels of trustworthiness, and general kindness. The claim is that moderate levels of vagal activity promote the greatest levels of prosociality since it strikes a balance between a necessary arousal to feel empathy for other's suffering and the necessary regulation to handle one's own negative emotions in order to be able to respond in a kind and compassionate fashion. Too low or very high vagal activity is then socially maladaptive and leads to lower levels of prosociality.

There is evidence in support of the hypothesis. For example, studies show a significant quadratic relationship (inverted U-shape) between vagal activity and two variables of prosociality; the degree of warm, prosocial relations with others and agreeableness. Same studies also demonstrate a quadratic relationship between vagal activity and prosocial positive emotion like compassion and gratitude, but no relationship, quadratic or otherwise, between vagal activity and non-prosocial positive emotions like joy for example. This suggests that the relationship between vagal activity and prosociality is not due to general positive emotions but due to positive prosocial emotions in particular. Target participants' vagal activity was also quadratically related to how observers (strangers) rated the participants level of prosociality. The authors suggest that vagus nerve activity, up to a point, is a core physiological correlate of prosociality which promotes compassion and care for others by regulating physiological systems that enable the experience of positive emotions, emotional expression, empathy for others, and the regulation of one's own distress. However, it should be noted that the demonstrated relationship is correlational and can therefore not reveal any causal patterns (Kogan et al., 2014).

Neural processes involved in compassion. There are studies suggesting that compassion has its own distinct neural network, and is on a neural level differentiated from both cognitive and affective empathy (Preckel et al., 2018). It seems that affective empathy tends to activate anterior insula (AI) and anterior middle cingulate cortex (aMCC). A meta-analysis concluded that a core network consisting of bilateral anterior insular cortex and medial/anterior cingulate cortex is associated with empathy for pain, and that these areas overlap with activation during directly experienced pain (Lamm, Decety, & Singer, 2011). Cognitive empathy tends to activate a network consisting of the temporal poles (TP), ventral temporoparietal junction (TPJ), superior temporal sulcus (STS), precuneus/posterior cingulate (PCC) and the medial prefrontal cortex (MPFC) (Preckel et al., 2018). Compassion on the

other hand tends to activate networks associated with reward and affiliation processes such as the nucleus accumbens (NAcc), ventral tegmental area (VTA), ventral striatum (VS), medial orbitofrontal cortex (mOFC), the subgenual anterior cingulate (sgACC), as well as putamen and pallidum (Klimecki, Leiberg, Lamm, & Singer, 2013; Klimecki et al., 2014; Klimecki, Leiberg, Ricard, & Singer, 2013; Preckel et al., 2018; Singer & Klimecki, 2014). More details about these studies can be found in the section covering neural effects of CT during the socio-affective video task.

However, certain researchers have raised concerns about the idea that compassion can be equated with a discrete brain circuit and proposes instead that the cultivation of compassion engages various motivational, affective and cognitive networks (Dahl, Lutz, & Davidson, 2016). For example, one study (Weng et al., 2013) demonstrated that CM practitioners' response to emotionally disturbing images was related to increased connectivity between the dorsolateral prefrontal cortex (DLPFC) and NAcc. DLPFC is often associated with cognitive functions, such as reappraisal, and NAcc is associated with the reward network and with positive affect; and together both areas are often associated with cognitive reappraisal (Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008). Hence, there is no consensus on the underlying neural networks of compassion.

Result

Here follows an examination of the psychological, neural and behavioral effects of CT.

Psychological Effects of Compassion Training

Reviews on compassion training. A review article (Hofmann et al., 2011) concluded that both LKM and CM seem to be effective in enhancing psychological functioning and seem to be highly promising methods for improving positive affect and for reducing stress and negative affect such as anxiety and mood symptoms. Increased psychological functioning

seem to occur even after a relatively short period of training time. In one study a one-time, 7 min-long LKM increased feelings of social connection towards strangers and positive feelings towards the self, both on implicit and explicit levels. These results were observed in comparison to a control group consisting of a neutral imagery task which controlled, for effects of exposure, relaxation, and cognitive activity (Hutcherson et al., 2008). The review findings are however preliminary since the scientific literature on the subject was limited at the time. Despite the limitations, the authors concluded that LKM and CM can optimally be combined with existing cognitive-behavioral treatments. They furthermore hypothesized that LKM may be particularly relevant for interpersonal problems such as anger control issues, and that both CM and LKM may be particularly relevant for the treatment of depression and relationship problems, such as marital conflicts, and for preventing burn-out among professional caregivers or others who must provide long-term care to friends or relatives (Hofmann et al., 2011).

A systematic review (Shonin et al., 2015) of Buddhist-derived LKM and CM intervention studies was conducted with the purpose to assess potential effects in the symptom severity of Diagnostic and Statistical Manual of Mental Disorders (DSM), axis 1 disorders in clinical samples. The review also assessed concomitants and risk factors for psychopathology such as thought suppression, emotional dysregulation, psychological distress, as well as psychopathology relevant biomarkers in non-clinical, healthy samples. 20 studies together comprising a total of 1,312 participants were reviewed. Participants demonstrated significant improvements in five different psychopathology-relevant domains; (1) positive and negative affect, (2) psychological distress, (3) positive thinking, (4) interpersonal relations, and (5) empathic accuracy. The authors concluded that CT may be used in the treatment of a broad range of mental health problems in both clinical and healthy adults as well as non-adult populations and may have particular utility in the prevention

and/or treatment of stress, mood disorders, anxiety disorders, emotional suppression, schizophrenia spectrum disorders, fear of self-compassion, and self-disparaging schemas. CT may also have utility in offender settings and for anger control problems (Shonin et al., 2015), a conclusion in line with a randomized, controlled study (RCC) where LKM, but not standard treatment, lead to reduced pain and psychological distress among 43 patients with persistent low back pain. Notably, effects were maintained at 3-month follow-up. Increased LKM on a given day was associated with less pain the same day and less anger the following day (Carson et al., 2005). Furthermore, the enhanced sense of social connectedness that results of LKM practice (Hutcherson et al., 2008) may function as a protection against life stressors and feelings of isolation, loneliness and low sense of purpose. Likewise, when paying attention to the needs and suffering of others, practitioners of LKM and CM are better equipped to add perspective to their own suffering. However, these review conclusions should be considered with caution since they are based on preliminary findings that ought to be replicated with larger samples and more stringent study designs (Shonin et al., 2015).

Meta-analyses on compassion training. A meta-analysis (Galante et al., 2014) reviewed and meta-analyzed the evidence from 22 randomized controlled studies focused on the effects of kindness-based meditations (KBM) on health and well-being against passive and active control groups in patients and the general population. KBM showed to be moderately effective in decreasing self-reported depression (Hedges's g: -0.61), however only against passive controls. The data on the reduction of anxiety, anger and stress is mixed, however relaxation seem to increase during meditation even though no such effect extending beyond the meditation practice itself has been found. KBM also moderately increased mindfulness (Hedges's g: 0.63), compassion (Hedges's g: 0.61), self-compassion (Hedges's g: 0.45) and perspective taking against passive controls. Furthermore, a trend of increased positive emotions could be detected. However, no equivalent increase could be detected for

more stable measures of well-being such as satisfaction of life or quality of life. CT significantly alters ideal affect since meditators tend to value low-arousal emotions (calmness) over high-arousal emotions (excitement) (Koopmann-Holm, Sze, Ochs, & Tsai, 2013).

No significant differences could be found for negative emotions (Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008; Koopmann-Holm et al., 2013). KBM seem to have a positive effect on affective learning since meditators tend to associate a larger proportion of neutral stimuli with positivity than passive controls (Hunsinger, Livingston, & Isbell, 2013), which in turn may have an effect on other psychological processes such as attitude formation. Meditators also show greater cognitive control than controls, as measured by the Stroop test (Hunsinger et al., 2013). Meditators demonstrate a significant reduction in outward direction of anger towards other people or objects through increased control (Carson et al., 2005) and meditators showed reduced fears of compassion (Jazaieri et al., 2013). However, no significant differences were found for forgiveness, empathy, or social connectedness.

As to comparisons against active controls the results were inconsistent. Compared to progressive relaxation KBM leads to more positive emotions (Hedges's g: 0.42) and compassion (Feldman, Greeson, & Senville, 2010) and compared to cognitive reappraisal KBM leads to more helping behavior (Weng et al., 2013). However, compared to mindfulness and concentrative meditation, there were no significant differences in compassion (Feldman et al., 2010) and helping behavior (Condon, Desbordes, Miller, & Desteno, 2013). No significant differences could be found between KBM and health discussion groups on measures such as stress, depression, compassion, helping behavior and connectedness, with the only exception being emphatic accuracy which was greater for KBM (Galante et al., 2014).

The authors (Galante et al., 2014) noted that many of the studies under review suffered from high attrition rates, small sample sizes and poor reporting, and consisted of low to moderate methodological quality. Furthermore, results based on self-reports should be interpreted with caution since they could be distorted by expectancy effects and social desirability bias considering that kindness and compassion are explicitly emphasized during interventions. It should also be noted that none of the studies explicitly measured adverse effects of CT. Despite the limitations and complexities involved, the authors concluded that overall KBM demonstrate encouraging yet inconsistent evidence in support for the health of individuals through its positive effects on well-being and for the health of communities through its positive effects on social interaction (Galante et al., 2014).

Another meta-analytic review was conducted based on empirical studies using LKM or CM with self-reported positive emotions (Zeng et al., 2015). The authors differentiated immediate positive emotions from long-term, daily positive emotions, and examined them separately. Included studies numbered 24 which together consisted a total of 1759 participants. A medium sized effect was found for daily positive emotions, in experiments applying randomized controlled trials (RCT) with wait-list controls as well as non-RCT. All of the 17 studies measuring follow-up results reported that the daily positive emotions that were gained were maintained post-meditation. However, of four studies comparing LKM/CM with active controls, only one study demonstrated a larger increase in daily positive emotions compared to concentration meditation (May, Weyker, Spengel, Finkler, & Hendrix, 2014) but not compared to mindfulness and theatre therapy (Koopmann-Holm et al., 2013), memory training (Leiberg et al., 2011), nor the positive emotion regulation program (Weytens, Luminet, Verhofstadt, & Mikolajczak, 2014). It is therefore unclear whether LKM and CM are more effective than other active interventions in generating daily positive emotions. (Zeng et al., 2015).

The results of the on-going practice of LKM and CM on immediate positive emotions were mixed, ranging from no significant differences to high effect sizes (Zeng et al., 2015). LKM and CM were for example superior to emotionally neutral controls such as neutral visualization (Hutcherson et al., 2008; Seppala, Hutcherson, Nguyen, Doty, & Gross, 2014), memory training (Klimecki, Leiberg, Lamm, et al., 2013) and mindfulness meditation (Feldman et al., 2010), and yielded more positive other-focused emotions compared to pride-induction (Seppala et al., 2014). However, there was no significant difference between LKM/CM when compared to a music control group (Wheeler & Lenick, 2014) or progressive relaxation (Feldman et al., 2010). Overall however, it seems that the on-going practice of LKM and CM seem to generate immediate positive emotions (Zeng et al., 2015). Interestingly, in studies with wait-list controls, LKM showed a larger effect size than CM.

The authors concluded that the scientific study of CT is in the beginning stages of the research, results should therefore be viewed as exploratory rather than definitive (Zeng et al., 2015).

Social aspects of compassion training. CT have demonstrated personal and psychological benefits but does it also have an effect on social and intergroup relations? The following two studies (Kang et al., 2013; Stell & Farsides, 2016) were not included in the previous meta-analyses and reviews and can therefore shed interesting light on the subject. One study suggests that LKM improves automatically activated, implicit attitudes toward stigmatized social groups such as homeless people and blacks (Kang et al., 2013). 107 participants, consisting of non-black, non-homeless adults with no prior experience of LKM, were randomly assigned to 3 different experimental conditions: 6-week long LKM practice, 6-week long loving-kindness discussion, or a waitlist control. Only in the LKM practice group were implicit biases reduced, as measured by the implicit association test. Explicit, conscious attitudes toward blacks and homeless people did however not improve as a result of

LKM. The authors conclude that LKM does not only enhance personal health but it can also be used as an intervention for promoting healthy intergroup relations. In another randomized controlled study (Stell & Farsides, 2016), consisting of 71 white, undergraduate students, a 7 min-long LKM directed to a member of a racial out-group was sufficient to reduce racial bias towards that out-group, as measured by the race implicit association test. The practice was however only effective in reducing bias towards the explicitly targeted group and did not impact implicit biases towards untargeted racial groups. The reduction in bias was mediated by other-regarding positive emotions, increased control and decreased automaticity of information processing.

Neural Effects of Compassion Training

Psychological effects can be seen as subjective markers of CT, but are there any significant, objective, neurobiological markers of the same?

Neural effects without concurrent task. There is only one meta-analysis that separately examines the functional neuroimaging results of CT (Fox et al., 2016). This is a review and meta-analysis of 25 functional neuroimaging investigations of four different categories of meditation, of which 6 experiments consist of LKM or CM. Included studies involved participants performing only meditation while in the scanner rather than other concurrent tasks. The meta-analysis used the method of activation likelihood estimation (ALE) in order to examine which patterns of brain activation can be detected; which then generated statistical maps demonstrating clusters in the brain where convergence between foci of activation or deactivation is greater than would be expected by mere chance. Three significant and consistent clusters of brain activation were found. The first cluster (1) was in the right somatosensory cortices (BA 2) which extended into the anterior inferior parietal lobe (BA 40); regions associated with somatosensory processing, the production of a unified sense of the body, empathy as well as perception of pain (Lamm et al., 2011). The second cluster (2)

was in the parieto-occipital sulcus (BA 23/31). The third cluster (3) was in the right anterior insula which have been associated with theory of mind and empathy (Lamm et al., 2011). Insula has generally been implicated with interoception (Craig, 2004; Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004; Farb, Segal, & Anderson, 2013), i.e. the ability to monitor and being consciously aware of one's internal somatic states such as the heart rate and respiration. However, the more anterior parts of the insula seem to be associated with conscious awareness of interoceptive input and the integration of this information with emotional states and higher-order goals (Craig, 2004; Critchley et al., 2004). The recruitment of insula also suggests the involvement of empathy (Lamm et al., 2011) and the cultivation of compassionate and prosocial responses to this distress (Fox et al., 2016). No significant deactivations were found for LKM/CM; suggesting that no particular brain regions are significantly de-engaged during CT. The overall adjusted mean effect size for LKM/CM was (Cohen's d: 0.44); approximately medium effect (Fox et al., 2016).

A supplementary meta-analysis was performed by including only investigations of LTM of LKM/CM, and hence excluding studies focused on short-term practitioners. This meta-analysis revealed almost identical results but spotted one additional small cluster of activation in the left somatosensory cortices, on the parieto-occipital sulcus (BA 23/31). Overall, it should however be noted that the results of the meta-analysis were based on the fewest experiments and smallest number of foci among the four different categories of meditation under scrutiny and has therefore lower statistical power (Fox et al., 2016).

The authors (Fox et al., 2016) noted that a few additional non-significant (i.e. sub-threshold) but notable clusters were found that warrant attention. For example, a cluster of activation in the anterior cingulate cortex (BA 24), a cluster in the superior portion of the left frontopolar cortex (BA 10) which extended somewhat into the dorsolateral prefrontal cortex (BA 9) as well. One of the included studies (Weng et al., 2013) for example had novices

practice CM via guided audio instructions for 30 min per day for 2 weeks (and a comparable control group consisting of reappraisal training). The increased altruistic behavior among CM practitioners co-occurred with increased neural activity in brain regions that are thought to correlate with the regulation of emotions and cognitive processes involving other people; namely the inferior parietal cortex (IPC) and DLPFC. The authors (Weng et al., 2013) believe that the co-activation of IPC and DLPFC reflect enhanced sustained attention and goal maintenance in order to extend help to other individuals. The co-activation also reflects the process of integrating information from neural systems that process external information and internal information; the former representing other individual's suffering and the latter representing the goal to help the sufferer. The meditators tended to approach rather than avoid other's suffering which requires some sort of emotion regulation strategy; and the findings suggest that a fronto-parietal executive control network serves that function. Meditators also exhibited increased connectivity between DLPFC and the NAcc which predicted greater altruistic redistribution only among meditators; an observation that may reflect regulation of internal information by increasing positive feelings towards sufferers. Meditators might use positive appraisal to face aversive stimuli (suffering) by enhancing the reward value of the sufferer's well-being and by anticipating a reward by helping the sufferer. Greater activation of IPC predicted increased altruistic behavior among compassion meditators but not among reappraisal trainees, which suggests that IPC could be seen as a neural marker of altruistic behavior induced by CM. The neural changes resulting from CT suggests that enhanced altruistic behavior may be attainable by enhancing neural mechanisms that support the understanding of others' states, greater fronto-parietal executive control, and up-regulation of positive affect. The authors conclude that their findings lend support to the idea that compassion and altruism are better viewed as trainable skills rather than as stable traits (Weng et al., 2013).

Neural effects during the socio-affective video task. How about studies where meditators are placed in the FMRI scanner and asked to use LKM as an emotion-regulation strategy while watching videos depicting suffering individuals? The following three studies (Engen & Singer, 2015; Klimecki, Leiberg, Lamm, et al., 2013; Klimecki et al., 2014) used the socio-affective video task; a validated test used to expose participants to the suffering of others through film clips depicting people in distressing situations (for example women crying after an earthquake).

In one study (Klimecki et al., 2014) 94 participants first received empathy training and thereafter LKM. The control group consisted of a memory task. Participants first practiced empathy-for-suffering for one day (6h) and then one hour each day for a week, and thereafter shifted to LKM with an identical time-frame. LKM reversed the increase in negative affect from the previous empathy training back to the initial baseline in the same individuals. LKM also lead to an increase in positive affect, both in situations of suffering as well as everyday situations, despite the fact that the participants were exposed to equally distressing videos as in the previous empathy training. Reported emotions of warmth, concern and kindness tended to increase neural activity in pregenual anterior cingulate cortex, ventral striatum as well as medial orbitofrontal cortex. These areas form together a neural network that is distinct and different from the network activated in the empathy training. This finding is in line with a previous study examining neural plasticity induced by short-term (one day course of 6h and an average of 6h at-home practice) LKM training compared to a memory control group. The difference was however that negative affect did not decrease in meditators. LKM activated putamen, pallidum, the ventral tegmental area as well as the medial orbitofrontal cortex (Klimecki, Leiberg, Lamm, et al., 2013). The authors refer these areas as the compassion network which has experimentally been linked to affiliation (Strathearn, Fonagy, Amico, & Montague, 2009), positive affect (Kringelbach & Berridge, 2009) and reward processing

(Haber & Knutson, 2010). A meta-analysis of 171 FMRI studies reporting cingulate cortex activation (Beckmann, Johansen-berg, & Rushworth, 2009) concluded that reward processing is associated with more anterior activation in the cingulate cortex, a finding that converges with the pgACC involvement in compassion. Furthermore, the anterior parts of the cingulate cortex are also strongly interconnected with VS and OFC. The researchers concluded that LKM can be used as an effective coping strategy to prevent burnout and empathic distress, as well as counteract the effects of too much empathizing (Klimecki et al., 2014).

Another study (Engen & Singer, 2015) included 15 LTM of LKM from the Nyingma tradition of Tibetan Buddhism; a tradition specialized on the cultivation of compassion, loving-kindness and altruism. LTMs had at least 40000h of meditational experience. The meditators were asked to either deploy a passive view, or positive reappraisal or LKM in order to modulate their emotional responses while being exposed to the socio affective video test. Both forms of emotion regulation strategies were effective in regulating affect but LKM predominantly increased positive affect whereas positive reappraisal predominantly decreased negative affect. LKM, compared to both passive-viewing and positive reappraisal, showed increased activation in areas associated with affiliation, positive affect and reward processing, namely VS/NACC, globus pallidus, rgACC, pgACC, and vmPFC. Interestingly VS/NACC was also activated prior to stimulus presentation; a finding consistent with the view that compassion involves a volitional and stimulus-independent generation of positive affect. The authors make the claim that the underlying mechanisms in compassion-based emotion regulation are the neural systems associated with the generation of positive affect (Engen & Singer, 2015).

Behavioral Effects of Compassion Training

CT seem to result in various psychological and neural effects. However, can these changes translate into actual helping behavior.

Behavioral effects in game-settings. One study (Mccall, Steinbeis, Ricard, & Singer, 2014) examined LTMs with an average of 40000 hours of meditational practice, including CT. LTM were subjected to unfair treatment in a game-setting but chose to punish the perpetrator less severely than controls. However, when the LTMs witnessed others being unfairly treated they punished the perpetrator in equal amounts as the controls. LTM also reported feeling less anger in response to unfair treatment than controls, even though both groups' ratings of unfair perpetrator behavior were equal. Furthermore, LTMs were more likely to recompense the victims and because LTMs felt less angered by unfair behavior towards themselves, they were less likely to punish the same behavior. It was concluded that LTM were more focused on norm reinforcement and restoration of equity and less focused on vengeful, retributive justice (Mccall et al., 2014).

In a study using the same dictator game, CM practitioners exhibited more altruistic behavior towards a victim after witnessing an unfair social interaction compared to reappraisal controls (Weng et al., 2013). Participants practiced CM by the use of internet-based audio files for 30 min per day for two weeks. However, it should be noted that altruism was not measured at pre-training, baseline levels. It was concluded that pure mental training may well generalize to behavioral domains by affecting social behavior outside of the training context.

Earlier studies have presented evidence of momentary instruction-based inductions of empathic concern for a specific person leading to increased prosocial behavior towards the same person immediately after the induction (Eisenberg & Miller, 1987). Newer studies have moved beyond these earlier studies by demonstrating long-term effects as well (Leiberg et al., 2011). One such study used the Zurich prosocial game (ZPG) because it enables the analysis of prosocial behavior across several trials with high ecological validity. ZPG analyzes helping behavior in a more valid manner compared to the dictator game since it takes into account

factors such as reciprocity, helping cost, and distress cues. LKM (six-hour practice) practitioners demonstrated more helping behavior, both when it was costly and non-costly to themselves, compared to participants who received short-term memory training. The effects on prosocial behavior were relatively long-lasting since the post-test was conducted two to five days after the training. The results also occurred in a different physical place than the training itself and the meditators and recipients of help had never met before. In terms of subjective experiences, participants reported less negative feelings, more positive feelings and an enhanced sense of compassion (Leiberg et al., 2011).

Helping behavior under no-reciprocity conditions, but not helping behavior in reciprocity conditions, was related to differences in training hours in meditation (Leiberg et al., 2011). It was suggested that this points to a difference between compassion-based and norm-based prosocial behavior. It seems that LKM influences both forms of behavior but influences the compassion-based prosocial behavior to a larger extent. Helping after already having been helped oneself should depend more on feelings of obligation to reciprocate the behavior whereas helping without the possibility of reciprocation should depend more on feelings of compassion rather than cold, norm-based calculations. These results fit well with other studies suggesting that both fairness- and compassion-based motivation may result in cooperation, but the former tend to result in punishment when norms are transgressed. Compassion-based motivation on the other hand, in situations of defection, can counteract desires for revenge and prevent the occurrence of iterative non-cooperation (Singer & Steinbeis, 2009).

Another study examined more closely different, potential sub-types of altruistic behavior resulting from CM by looking separately at altruistic helping of victims and altruistic punishment of transgressors (Weng et al., 2015). Compassion could after all result in punishment towards transgressors, which could be seen as a way to ensure that social norms

are followed, and a way to decrease suffering by protecting the victims. The study demonstrated that two weeks of CM (7h total) lead to more altruistic helping of anonymous victims compared to an active control group consisting of a reappraisal task. Furthermore, altruistic redistribution was driven more by a motive of helping than a motive of punishing. CM had no effect on punishment behavior towards transgressors. Interactions took place in the Helping game where the compassion group spent 1.87 times more money than the reappraisal group to altruistically provide help to the recipients. Compassion meditators increased the equality between the dictator and recipient by 29% and spent an average of 1.14 dollars, whereas the reappraisal group increased the equality by 15% and spent an average of 0.61 dollars (Weng et al., 2015).

Behavioral effects in real-life situations. What are the behavioral effects of CT in ecologically valid, real-life situations? One of the very few studies examining prosocial behavior in this manner trained participants in an 8-week program consisting of one mindfulness group and one CM group (Condon et al., 2013). The participants were placed in a test situation where everyone, including the actors, were blind to the hypothesis of the experiment as well as the experimental condition. Participants were asked to show up in a room under the disguise of a cognitive test. Two female actors sat in a designated waiting area taking hold of two of the available three chairs. Upon arriving to the waiting area, the participants sat down in the remaining chair. After the participant had been sitting for 1 min, a third female actor, acting out the role of the sufferer appeared with crutches and a walking boot. The sufferer was visibly wincing while walking and made sure to stop just at the chairs. She then audibly sighed in discomfort and leaned back against a wall.

Results showed that meditators offered their seats to the sufferer (50%) more frequently than the wait-list controls (15%), in fact by a probability ratio of five (odds ratio: 5.33) (Condon et al., 2013). However, it should be noted that there was no difference in

compassionate responding between mindfulness and CT, despite the fact that the mindfulness condition was deliberately made devoid of any compassion components. It was concluded that both compassion and mindfulness meditation can enhance compassionate responding beyond the influence of participant expectations and demand characteristics (Condon et al., 2013). Interestingly the same authors replicated the results in another study without CM, instead only using mindfulness meditation and an active control group based on a cognitive skill task. Mindfulness meditators gave up their seats more frequently (37%) than the active control group (14%) (Lim, Condon, & Desteno, 2015).

Discussion

The aim of this paper was to examine compassion from an evolutionary point of view and to address the psychological, neural and behavioral effects of CT.

Psychological Effects

Several different significant psychological effects of CT were found, especially compared to passive controls, but quite inconsistently compared to active controls. Two meta-analyses (Galante et al., 2014; Zeng et al., 2015) and two reviews (Hofmann et al., 2011; Shonin et al., 2015) concluded that CT in general increases positive affect, but no equivalent increase could be detected for more stable measures of well-being such as satisfaction of life or quality of life (Galante et al., 2014). CT generates more positive emotions than for example progressive relaxation (Feldman et al., 2010) and concentration meditation (May et al., 2014) but not more than other active controls. A more refined analysis detected a medium effect size on long-term daily positive emotions, but the results were mixed for immediate positive emotions, ranging from non-significant to high effect sizes (Zeng et al., 2015). CT seems to promote low-arousal and prosocial emotions such as peacefulness, relaxation and kindness rather than high-arousal emotions such as excitement (Galante et al., 2014; Zeng et al., 2015);

a finding in line with studies showing CT alters ideal affect towards low-arousal emotions (Koopmann-Holm et al., 2013).

Some studies conducted follow-up measures, and reported maintained therapeutic effects, even at three-month follow-up (Carson et al., 2005), suggesting the potential for long-term effects. Furthermore, meta-analytic evidence showed that all studies measuring follow-up results in a meta-analysis reported that increased daily positive emotions were maintained post-meditation (Zeng et al., 2015). It is however unclear how long the demonstrated effects can last without continuous practice. The effects could after all return to baseline levels. In order to understand how much practice is needed for long-term effects, future studies should control for this by rigorous pre-post measurements over longer time-frames.

Furthermore, LKM may generate more positive emotions than CM (Zeng et al., 2015), not surprisingly since LKM includes cultivation of warm, positive feelings for self and others, sometimes even envisioning others smiling. CM on the hand includes envisioning the suffering of others (Zeng et al., 2015), studies even report that meditators cry during CM practice (Lutz, Greischar, Perlman, & Davidson, 2009). LKM simply emphasizes positive emotions more than CM; useful knowledge for clinicians and coaches when selecting and adapting their methods to various people with different needs.

Compared to passive controls, CT also showed moderate effects for mindfulness, compassion, perspective taking and self-compassion, and compared to active controls more cognitive control (Galante et al., 2014). However, compared to health discussion groups, there were no significant differences on measures such as stress, depression, compassion, helping behavior and connectedness, except for emphatic accuracy which was higher for CT (Galante et al., 2014). The relative lack of positive results in comparison to active controls suggests that at least some of the effects of CT are possibly of a nonspecific nature rather than from the specific mental procedure itself, pointing to factors such as participants taking time out from

their regular schedule, receiving caring attention, or taking positive action (Galante et al., 2014). It has also been suggested that didactic components beyond the mere guidance of meditation itself might play a role since sometimes various Buddhist ideas are being taught to the meditators; such as the metaphysical concept of interconnection between self and others and the ultimate spiritual significance of compassion (the ideal of bodhisattva) (Zeng et al., 2015). Interestingly, a recent study demonstrated that exposure to mere loving-kindness-language (without any meditation practice) increases sensitivity to others pain and reduces sensitivity to own pain (Williams, Poljacik, Decety, & Nusbaum, 2018). Thus, people interested in optimizing the results of meditation might consider incorporating some of these contextual factors in to their practice.

The effects of CT on pro-social and other-focused positive emotions (Zeng et al., 2015), enhanced sense of social connectedness (Hofmann et al., 2011; Shonin et al., 2015) coupled with less expressed anger towards people and objects (Carson et al., 2005), is likely to promote healthy and meaningful social relationships. Furthermore, CT seems to reduce implicit biases towards stigmatized groups (Kang et al., 2013; Stell & Farsides, 2016), and can thus promote healthy intergroup-relationships. These results suggest that CT may, to some degree, bypass evolutionarily based impulses of favoring in-groups over out-groups. These findings may be of value to policy makers, education providers and activists interested in facilitating harmonious relationships among different racial and socio-economic groups.

Both reviews (Hofmann et al., 2011; Shonin et al., 2015) suggested that CT leads to decreased negative affect, and pointed to studies where anger, pain and psychological distress decreased (Carson et al., 2005). It was even suggested that CT may be used in the treatment of various mental health problems in both clinical and healthy adults. Furthermore, meta-analytic results showed moderate effect size for decreased self-reported depression, but the results for anxiety, anger and stress were mixed, and no meta-analytic difference could be

found for negative affect (Galante et al., 2014). Since the reviews (Hofmann et al., 2011; Shonin et al., 2015) on mental health problems were qualitative and were to a large degree non-convergent with the meta-analytic findings reported in this paper, it is reasonable to remain very cautious about the claimed beneficial effects on psychopathology. Furthermore, the general lack of results against active controls gives no reason to believe that CT alone should be used to treat psychopathology, especially since there are already existing evidence-based therapeutic modalities for this purpose. More research is simply needed before any firm conclusions can be drawn here. However, the various positive effects of CT coupled with significant decreases in depression, and outward directed anger, and fears of compassion (Galante et al., 2014), jointly suggests that CT may play a role in the prevention of certain mental health problems or be used in conjunction with other evidence-based modalities to optimize therapeutic effects. Furthermore, decreased fears of compassion suggest that CT may potentially overcome typical blocks to compassion such as beliefs that others don't deserve compassion because they might become dependent.

It should be noted that none of the reviewed studies examined adverse effects of CT. CT could after all bring negative feelings, thoughts and memories to the awareness of the meditator. It's reasonable to assume that for certain individuals, an intense focus on the suffering of self and others could lead to empathic distress, and in the worst case possibly to feelings of panic. Possible adverse side effects are especially important to consider when CT is being administered to individuals with mental health problems. It gives reasons to speculate that individuals with mental health problems might want to begin with LKM which is more focused on the generation of positive feelings rather than CM which emphasizes suffering to larger degree.

Neural Effects

Meta-analytic evidence (Fox et al., 2016) demonstrated that CT without a concurrent task shows three significant clusters of brain activation; (1) the right somatosensory cortices which extended into the anterior inferior parietal lobe, (2) the parieto-occipital sulcus, and (3) the right anterior insula. These results are contrary to findings of distinct neural networks for compassion and empathy which claim that the anterior insula is only engaged in the empathy network but not in compassion network (Preckel et al., 2018). The Meta-analysis suggest instead that CT includes elements of empathy by engaging the anterior insula, at least during CT without a concurrent task. Moreover, somatosensory areas and the inferior parietal lobe have been implicated in empathy, especially while viewing pictures of body parts in painful situations (Lamm et al., 2011). These findings give credence to definitions of compassion that include empathy (Gilbert, 2014; Strauss et al., 2016). Excluding short-term meditation studies did not alter the results significantly, suggesting that the neural effects for both novices and LTMs seem to be similar. Furthermore, CT demonstrated a medium effect size, meaning that the neural effects of CT results in approximately one-half standard deviation increase in brain activity compared to baseline conditions, which points to practical significance of results (Ferguson, 2009).

In three different studies (Engen & Singer, 2015; Klimecki, Leiberg, Lamm, et al., 2013; Klimecki et al., 2014) where meditators deploy LKM as an emotion-regulation strategy when confronting the suffering of others in a video task, a non-overlapping neural network is activated. This network consists of medial orbitofrontal cortex, ventral striatum/NACC as well as putamen, and anterior parts of ACC. These regions have been associated with positive affect (Kringelbach & Berridge, 2009), motivation and reward (Beckmann et al., 2009; Haber & Knutson, 2010) and affiliation (Strathearn et al., 2009), a finding that fits well with the reported feelings of warmth, concern and kindness by the meditators as well as meta-analytic

evidence regarding positive feelings (Zeng et al., 2015). Since positive affect was present before exposure to stimuli, the authors suggest that the regulatory mechanism behind LKM might consist of a stimulus-independent, internal generation of positive affect which counteracts the negative emotions elicited by witnessing others' suffering (Engen & Singer, 2015). Thus, it is suggested that LKM can serve as an effective coping strategy to prevent burnout and empathic distress, and might even reverse the increase in negative affect derived from empathizing with suffering (Klimecki et al., 2014). These findings may have utility for professionals working with caring for suffering individuals, such as physicians and nurses suffering from high stress levels and burnouts.

However, these results do not convergence with the results of the neuroimaging meta-analysis (Fox et al., 2016). The different results might reflect the fact that the meta-analysis was exclusively focused on actual meditation (with eyes closed) during the scanning session whereas the other studies (Engen & Singer, 2015; Klimecki, Leiberg, Lamm, et al., 2013; Klimecki et al., 2014) were focused on LKM being used as an emotion-regulation strategy (with eyes open) to confront videos depicting suffering individuals. In the former case, the meditators were solely engaged with the meditational operations in the privacy of their own minds whereas in the latter case the meditators were not visualizing but were instead watching a distressing video and simultaneously sending well-wishing intentions to the suffering individuals in the same video. Nonetheless, the procedure in the latter case is somewhat similar to the procedure used in CM, where the meditator visualizes the suffering of others and then tries to alleviate the suffering by well-wishes. The non-convergent results are therefore puzzling. It should however be noted that the meta-analysis (Fox et al., 2016) found brain clusters of activation just below the agreed upon significance threshold level; most notably in the ACC, frontopolar cortex as well as ventromedial prefrontal cortex; results that

converge with the socio-affective video task studies (Engen & Singer, 2015; Klimecki, Leiberg, Lamm, et al., 2013; Klimecki et al., 2014).

The inconsistent neuroimaging results points to the existing disagreement on the neural mechanism behind the generation of compassion. One group of researchers (Engen & Singer, 2016) maintain that the route to compassion goes via motivational and affective neural circuits whereas another group (Dahl et al., 2016) maintain the route goes primarily via circuits underlying cognitive appraisal and perspective taking, and that motivation and affect should be seen as an outcomes of CT rather than mechanisms thereof. Meta-analytic evidence gives limited support to the cognitive explanation since CT (without a concurrent task) activates for example inferior parietal lobe, a region implicated in reappraisal (Dahl et al., 2016). However, three other studies (Engen & Singer, 2015; Klimecki, Leiberg, Lamm, et al., 2013; Klimecki et al., 2014) gives more support to the motivational and affective route to compassion, since the CT during the socio-affective video task engages medial orbitofrontal cortex, ventral striatum/NACC as well as putamen, and anterior parts of ACC. This paper cannot resolve the disagreement, thus further research is much needed in order to pin down the specific neural circuits underlying compassion.

The varying results might also reflect a wider concern regarding meditation studies, namely overshadowing (Fox et al., 2016). When experienced meditators are asked to practice LKM or CM for a short period of time in a brain scanner, their traditional meditative background and the emphasis they have placed on various mental techniques over several years of practice is likely to influence how they actually perform the targeted form of meditation; and this in turn might influence the associated neural effects under examination. For example, in many studies the objects are Tibetan monks who have often practiced both LKM/CM as well as mindfulness meditation for as much as 40000 hours (Engen & Singer, 2015). The portion of LKM relative to total hours of meditation is not always presented in the

studies, and when it is, the issue of overshadowing still remains. Another issue is that the meta-analysis (Fox et al., 2016) grouped LKM and CM together rather than analyzing them separately. The mental procedures of LKM and CM are after all somewhat different in that CM emphasizes suffering more by visualizing the suffering of others and the self, whereas LKM emphasizes positive feelings more by generating feelings of warmth and well-wishing towards others and the self. This is in line with the results of another meta-analysis (Zeng et al., 2015) which points out that LKM seem to be somewhat more effective than CM in generating positive affect.

Behavioral Effects

There is preliminary evidence suggesting that CT may lead to compassionate behavior towards others, in both game-settings as well as real-world situations. All studies under review confirmed this claim but the evidence is stronger within game-settings where 4 independent studies confirm that CT generates more compassionate and altruistic behavior compared to controls (Leiberg et al., 2011; Mccall et al., 2014; Weng et al., 2013, 2015). More specifically, CM practitioners exhibited more compassionate behavior than cognitive reappraisal practitioners (Weng et al., 2013, 2015), LKM practitioners more than short-term memory training practitioners (Leiberg et al., 2011), and LTMs of LKM more than novices (Mccall et al., 2014).

Interestingly one study (Leiberg et al., 2011) could demonstrate behavioral effects of LKM five days after the period of practice, suggesting that LKM has the potential to cause relatively long-term effects outside of the meditational context. Further studies are however needed to corroborate this single finding. Furthermore, compassionate behavior resulted even when it was costly to the self and under no-reciprocity conditions, and towards individuals who were not targeted in the meditation itself but were complete strangers to the meditators (Leiberg et al., 2011). This suggests the possibility that the behavioral effects of CT; (1) need

not depend entirely on self-benefit calculations but can occur even when the giver must make a sacrifice in order to help another or cannot expect the help to be reciprocated (2) need not be limited to the specific targets of the meditation but can have a spill-over effect by including others, even strangers. Moreover, it seems that meditation induced altruistic behavior is driven more by a motive of helping than a motive of punishing (Mccall et al., 2014; Weng et al., 2015) and that meditators tend to feel less angered by unfair treatment compared to controls (Mccall et al., 2014). This suggest that CT can potentially generate compassionate behavior even towards transgressors. Behavioral results give reason to suggest that CT may potentially overcome various fears and blocks to compassion, such as the belief that others don't deserve help, especially when its costly to the self, or that help should only be extended when reciprocity is expected. Some authors (Leiberg et al., 2011) concluded that CT increases prosocial behavior probably via mechanisms related to changes in meditators manner of thinking and feeling about other people; including a more general positive, friendly and benevolent attitude. Fittingly, participants reported a heightened sensitivity towards others, feelings of internal safety and being more openhearted towards others. However, other additional mechanisms behind CT may also cause prosocial behavior, such as increased relaxation and feelings of oneness.

Studies linking meditation, brain activity, and behavioral effects are rare (Fox et al., 2016) but one study (Weng et al., 2013) demonstrates that those with greater brain activation in IPC and DLPFC; brain areas associated with social cognition and emotion regulation, were also more likely to engage in altruistic behavior. Greater IPC activation in particular predicted more altruistic behavior in meditators but not in active controls, suggesting that IPC engagement could be a unique neural marker for altruism induced by CM. Interestingly, increased altruistic behavior was also related to increased connectivity between DLPFC and NACC; a finding convergent with other studies pointing out the important role of positive

emotions in CT (Engen & Singer, 2015; Klimecki, Leiberg, Lamm, et al., 2013; Klimecki et al., 2014). The study (Weng et al., 2013) provides preliminary evidence that two weeks of CM practice results in functional neuroplasticity which in turn is related to meaningful behavioral outcomes.

One study, probably the only of its kind, confirmed that CT results in compassionate behavior in ecologically valid, real-life situations, even five times more so compared to passive controls (Condon et al., 2013). The behavioral effects are strikingly significant since the social situation was designed to strengthen the bystander effect and could therefore have resulted in less helping behavior due to the involved social pressure. The presence of the two actors and their total indifference towards the sufferer could have likely lead to a diffusion of responsibility and norm enhancement. Thus, it seems that CT has the potential to overcome the bystander effect.

It is however puzzling that the active control group, consisting of mindfulness meditators, exhibited equal measures of compassionate behavior as the CM group, considering that CM is explicitly focused on generating compassion whereas mindfulness is focused on generating non-judgmental awareness of the present moment. These results converge with a meta-analysis (Galante et al., 2014) reporting similar results between CT and mindfulness and concentrative meditation on measures such as helping behavior and compassion; suggesting that compassionate and helping behavior may be generated by meditations other than CT. It has been suggested that CM most likely increase compassionate behavior through empathic processes and prosocial emotions, whereas mindfulness meditation most likely increase compassionate behaviors by way of a number of other mechanisms such as enhanced attention to all forms of stimuli and a reduced self-related affective bias (Lim et al., 2015). Additionally, a recent review (Skwara et al., 2017) claimed that many teachers of CT and mindfulness either explicitly or implicitly communicate values

of both compassion and non-judgmental attitudes in their trainings. Hence it is possible that both CT and mindfulness meditation, in both contextual and procedural terms, oftentimes include components of each other, and are therefore not easily differentiated.

Overall, preliminary evidence suggests that compassion seem to be a trainable skill with potential behavioral transfer in the real world (Weng et al., 2013). Interestingly, experimental studies suggest that the altruistic behavior (resulting from CT) leads to a pay-it-forward effect among the recipients of compassion. Grateful recipients of aid show an increase in their own tendency to subsequently provide help to others, even to complete strangers and even when the help is costly to themselves (Bartlett & Desteno, 2006; Desteno, Bartlett, Baumann, Williams, & Dickens, 2010). There is hence a potential society wide impact of CT in schools, organizations, and workplaces.

Synthesis

It is argued that compassion serves an evolutionary function by motivating caretaking of offspring, by serving as an favorable attribute in mate selections processes, and by promoting non-kin cooperation (Goetz et al., 2010). It can then be argued that the demonstrated positive effects of CT may enhance the evolutionary fitness of practitioners. After all, practitioners seem to be more likely to feel and behave more compassionately, even towards strangers and out-groups, and therefore most likely towards in-groups such as family. Compassion engenders more compassion by creating trust and affiliation between people, thus enhancing the well-being of all involved. Neuroimaging studies (Engen & Singer, 2015; Klimecki, Leiberg, Lamm, et al., 2013; Klimecki et al., 2014) lend support to the psychological claim that CT generates compassion, positive emotions and affiliation towards the sufferer. The demonstrated positive effects of CT, suggest that compassion can indeed be viewed as an effective emotion-regulation strategy to confront the suffering of self, and others, with benefits to both the giver and the recipient.

Limitations of the Present Study

This paper included a large number of different types of studies, with varying experimental conditions, aims, methodologies and measurement tools. The wide scope of studies can be considered a methodological weakness since not all studies are necessarily comparable, like for example mediation with and without a concurrent task. However, the wide scope offers a very broad range of data from psychological, neural and behavioral studies, enabling an overlook and comparison not undertaken before. Furthermore, the paper presents a qualitative review of studies rather than a statistical meta-analysis, which would yield more accurate and valid conclusions.

Conclusion

CT results in various significant psychological effects, most notably positive affect, and increased compassion, self-compassion, and mindfulness. Neural effects are significant yet inconsistent across different experimental conditions. CT also results in increased altruistic and compassionate behavior towards others, mostly in game-settings but also in one real-life situation. These findings can be used by clinicians and others using CT to reduce suffering and enhance well-being.

Future Studies

Future studies should clarify precisely for whom CT is suitable and under which circumstances, and how CT can be combined with other modalities to work optimally. Potential adverse effects should also be studied more closely, since CT may trigger negative memories and feelings. Moreover, CT often includes different components such as group meditation practice, didactic instruction, individual writing and reflection, group discussion and an ethical framework. In order to find the active ingredient of CT, researches should control for the separate, additive and interactive effects of these components on CT relevant

outcomes. Studies should also attempt to link the demonstrated physiological aspects of CT with neurobiological findings.

Furthermore, the scientific study of CT should move beyond mere cartography of brain activation or separate psychological self-reports, and instead progress towards a systematic, cross-disciplinary contemplative science based on randomized, actively controlled studies using larger sample sizes. This paper, limited as it may be, may inspire others to better connect the psychological, neural and behavioral aspects of CT and aim towards a unified framework explaining the mechanisms by which CT causes positive effects.

References

Bartlett, M. Y., & Desteno, D. (2006). Gratitude and prosocial behavior: Helping when it costs you. *Psychological Science*, *17*(4), 319–326.

Batson, C. D. (2017). The empathy-altruism hypothesis: What and so what? In E. M. Seppala, E. R. Simon-thomas, S. L. Brown, M. C. Worline, D. Cameron, & J. R. Doty (Eds.), *The oxford handbook of compassion science* (pp. 27–40). New York: Oxford University Press.

Batson, C. D., Duncan, B. D., Ackerman, P., Buckley, T., & Birch, K. (1981). Is Empathic Emotion a Source of Altruistic Motivation? *Journal of Personality and Social Psychology*, *40*(2), 290–302.

Batson, C. D., Lishner, D. A., Cook, J., & Sawyer, S. (2005). Similarity and Nurturance : Two Possible Sources of Empathy for Strangers. *Basic and Applied Social Psychology*, *27*(March 2013), 15–25.

Batson, C. D., & Shaw, L. L. (1991). Evidence for altruism. *Psychological Inquiry*, *2*(2), 107–122.

Beauchaine, T. (2001). Vagal tone, development, and gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology*, *13*(2), 183–214.

Beckmann, M., Johansen-berg, H., & Rushworth, M. F. S. (2009). Connectivity-based parcellation of human cingulate cortex and its relation to functional specialization. *The Journal of Neuroscience*, *29*(4), 1175–1190. https://doi.org/10.1523/JNEUROSCI.3328-08.2009

Buss, D. M., Abbott, M., Angleitner, A., Asherian, A., Biaggio, A., Blanco-Villasenor, A., … Yang, K. S. (1990). International preferences in selecting mates: A Study of 37 Cultures.

Journal of Cross-Cultural Psychology, *21*(1), 5–47. https://doi.org/10.1177/0022022190211001

Campbell, M. W., & De Waal, F. B. M. (2011). Ingroup-outgroup bias in contagious yawning by chimpanzees supports link to empathy. *PLoS ONE*, *6*(4), 19–22. https://doi.org/10.1371/journal.pone.0018283

Carson, J. W., Keefe, F. J., Lynch, T. R., Carson, K. M., Goli, V., Fras, A. M., & Thorp, S. R. (2005). Loving-kindness meditation for chronic low back pain: Results from a pilot trial. *Journal of Holistic Nursing*, *23*(3), 287–304. https://doi.org/10.1177/0898010105277651

Coan, J. A., Schaefer, H. S., & Davidson, R. J. (2006). Lending a hand: Social regulation of the neural response to threat. *Psychological Science*, *17*(12), 1032–1039. https://doi.org/10.1111/j.1467-9280.2006.01832.x

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1038/141613a0

Condon, P., Desbordes, G., Miller, W. B., & Desteno, D. (2013). Meditation increases compassionate responses to suffering. *Psychological Science*, *24*(10), 2125–2127. https://doi.org/10.1177/0956797613485603

Condon, P., & Desteno, D. (2017). Enhancing compassion: Social psychological perspectives. In E. M. Seppala, E. R. Simon-thomas, S. L. Brown, M. C. Worline, D. Cameron, & J. R. Doty (Eds.), *The oxford handbook of compassion science* (pp. 287–298). New York: Oxford University Press.

Craig, A. D. (2004). Human feelings: Why are some more aware than others? *Trends in Cognitive Sciences*, *8*(6), 239–241. https://doi.org/10.1016/j.tics.2004.04.004

Critchley, H. D., Wiens, S., Rotshtein, P., Öhman, A., & Dolan, R. J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience*, *7*(2), 189–195.

https://doi.org/10.1038/nn1176

Dahl, C. J., Lutz, A., & Davidson, R. J. (2016). Cognitive processes are central in compassion meditation. *Trends in Cognitive Sciences*, *20*(3), 161–162. https://doi.org/10.1016/j.tics.2015.12.005

De Waal, F. B. M. (2008). Putting the Altruism Back into Altruism : The Evolution of Empathy. *The Annual Review of Psychology*, *59*, 279–300. https://doi.org/10.1146/annurev.psych.59.103006.093625

De Waal, F. B. M., & Suchak, M. (2010). Prosocial primates: selfish and unselfish motivations. *Philosophical Transactions of the Royal Society B*, *365*(1553), 2711–2722. https://doi.org/10.1098/rstb.2010.0119

Desteno, D., Bartlett, M. Y., Baumann, J., Williams, L. A., & Dickens, L. (2010). Gratitude as Moral Sentiment : Emotion-Guided Cooperation in Economic Exchange. *Emotion*, *10*(2), 289–293. https://doi.org/10.1037/a0017883

Eisenberg, N., Fabes, R. A., Bustamante, D., Mathy, R. M., Miller, P. A., & Lindholm, E. (1988). Differentiation of vicariously induced emotional reactions in children. *Developmental Psychology*, *24*(2), 237–246.

Eisenberg, N., Fabes, R. A., Murphy, B., Karbon, M., Maszk, P., Smith, M., … Suh, K. (1994). The relations of emotionality and regulation to dispositional and situational empathy-related responding. *Journal of Personality and Social Psychology*, *66*(4), 776–797.

Eisenberg, N., Fabes, R. A., Schaller, M., Carlo, G., & Miller, P. A. (1991). The relations of maternal practices and characteristics to children's vicarious emotional responsiveness. *Child Development*, *62*(6), 1393–1408.

Eisenberg, N., Fabes, R. A., Schaller, M., Miller, P., Carlo, G., Poulin, R., … Shell, R.

(1991). Personality and socialization correlates of vicarious emotional responding. *Journal of Personality and Social Psychology*, *61*(3), 459–470.

Eisenberg, N., & Miller, P. A. (1987). The relation of empathy to prosocial and related behaviors. *Psychological Bulletin*, *101*(1), 91–119. https://doi.org/10.1037/0033-2909.101.1.91

Ekman, P. (2016). What Scientists Who Study Emotion Agree About. *Perspectives on Psychological Science*, *11*(1), 31–34. https://doi.org/10.1177/1745691615596992

Engen, H. G., & Singer, T. (2015). Compassion-based emotion regulation up-regulates experienced positive affect and associated neural networks. *Social Cognitive and Affective Neuroscience*, *10*(9), 1291–1301. https://doi.org/10.1093/scan/nsv008

Engen, H. G., & Singer, T. (2016). Affect and motivation are critical in constructive meditation. *Trends in Cognitive Sciences*, *20*(3), 159–160. https://doi.org/10.1016/j.tics.2015.11.004

Fabes, R. A., Eisenberg, N., & Eisenbud, L. (1993). Behavioral and physiological correlates of children's reactions to others in distress. *Developmental Psychology*, *29*(4), 655–663.

Farb, N. A. S., Segal, Z. V., & Anderson, A. K. (2013). Attentional modulation of primary interoceptive and exteroceptive cortices. *Cerebral Cortex*, *23*(1), 114–126. https://doi.org/10.1093/cercor/bhr385

Feldman, G., Greeson, J., & Senville, J. (2010). Differential effects of mindful breathing, progressive muscle relaxation, and loving kindness meditation on decentering and negative reactions to repetitive thoughts. *Behaviour Research and Therapy*, *48*(10), 1002–1011. https://doi.org/10.1016/j.brat.2010.06.006.Differential

Ferguson, C. J. (2009). An effect size primer: A guide for clinicians and researchers. *Professional Psychology: Research and Practice*, *40*(5), 532–538.

https://doi.org/http://dx.doi.org/10.1037/a0015808

Fox, K. C. R., Dixon, M. L., Nijeboer, S., Girn, M., Floman, J. L., Lifshitz, M., … Christoff, K. (2016). Functional neuroanatomy of meditation: A review and meta-analysis of 78 functional neuroimaging investigations. *Neuroscience and Biobehavioral Reviews*, *65*, 208–228. https://doi.org/10.1016/j.neubiorev.2016.03.021

Francis, D. D., & Meaney, M. J. (1999). Maternal care and the development of stress responses. *Current Opinion in Neurobiology*, *9*(1), 128–134. https://doi.org/10.1016/S0959-4388(99)80016-6

Fredrickson, B. L., Boulton, A. J., Firestine, A. M., Van Cappellen, P., Algoe, S. B., Brantley, M. M., … Salzberg, S. (2017). Positive Emotion Correlates of Meditation Practice: a Comparison of Mindfulness Meditation and Loving-Kindness Meditation. *Mindfulness*, *8*(6), 1623–1633. https://doi.org/10.1007/s12671-017-0735-9

Fredrickson, B. L., Cohn, M. A., Coffey, K. A., Pek, J., & Finkel, S. M. (2008). Open hearts build lives: Positive emotions, induced through loving-kindness meditation, build consequential personal resources. *Journal of Personality and Social PsychologySocial Psychology*, *95*(5), 1045–1062. https://doi.org/10.1037/a0013262.Open

Galante, J., Galante, I., Bekkers, M.-J., & Gallacher, J. (2014). Effect of kindness-based meditation on health and well-being: A systematic review and meta-analysis. *Journal of Consulting and Clinical Psychology*, *82*(6), 1101–1114. https://doi.org/10.1037/a0037249

Gilbert, P. (2014). The origins and nature of compassion focused therapy. *British Journal of Clinical Psychology*, *53*(1), 6–41. https://doi.org/10.1111/bjc.12043

Gilbert, P. (2015). The Evolution and Social Dynamics of Compassion. *Social and Personality Psychology Compass*, *9*(6), 239–254.

Goetz, J. L., Keltner, D., & Simon-Thomas, E. (2010). Compassion: An Evolutionary Analysis and Empirical Review. *Psychological Bulletin*, *136*(3), 351–374. https://doi.org/10.1037/a0018807

Greitemeyer, T. (2009). Effects of songs with prosocial lyrics on prosocial behavior: Further evidence and a mediating mechanism. *Personality and Social Psychology Bulletin*, *35*(11), 1500–1511. https://doi.org/10.1177/0146167209341648

Haber, S. N., & Knutson, B. (2010). The reward circuit: Linking primate anatomy and human imaging. *Neuropsychopharmacology*, *35*(1), 4–26. https://doi.org/10.1038/npp.2009.129

Hauser, D. J., Preston, S. D., & Stansfield, R. B. (2014). Altruism in the wild: When affiliative motives to help positive people overtake empathic motives to help the distressed. *Journal of Experimental Psychology: General*, *143*(3), 1295–1305. https://doi.org/10.1037/a0035464

Hertenstein, M. J., Keltner, D., App, B., Bulleit, B. A., & Jaskolka, A. R. (2006). Touch communicates distinct emotions. *Emotion*, *6*(3), 528–533. https://doi.org/10.1037/1528-3542.6.3.528

Hofmann, S. G., Grossman, P., & Hinton, D. E. (2011). Loving-kindness and compassion meditation: Potential for psychological interventions. *Clinical Psychology Review*, *31*(7), 1126–1132. https://doi.org/10.1016/j.cpr.2011.07.003

Hunsinger, M., Livingston, R., & Isbell, L. (2013). The impact of loving-kindness meditation on affective learning and cognitive control. *Mindfulness*, *4*(3), 275–280. https://doi.org/10.1007/s12671-012-0125-2

Hutcherson, C. A., Seppala, E. M., & Gross, J. J. (2008). Loving-kindness meditation increases social connectedness. *Emotion*, *8*(5), 720–724. https://doi.org/10.1037/a0013237

Janig, W. (2003). The autonomic nervous system and its coordination by the brain. In R. J. Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), *Handbook of Affective Sciences* (pp. 135–186). New York: Oxford University Press.

Jazaieri, H., Thupten, G., Kelly, J., Cullen, M., Doty, J. R., Gross, J. J., … Goldin, P. R. (2013). Enhancing compassion: A randomized controlled trial of a compassion cultivation training program. *Journal of Happiness Studies*, *14*(4), 1113–1126. https://doi.org/10.1007/s10902-012-9373-z

Judy, M., Michael, S., & Sophie, G. (2006). Touch communicates distinct emotions. *Emotion*, *6*(3), 48–50. https://doi.org/10.1007/978-3-319-41855-1

Kang, Y., Gray, J. R., & Dovidio, J. F. (2013). The nondiscriminating heart: Lovingkindness meditation training decreases implicit intergroup bias. *Journal of Experimental Psychology: General*, *143*(3), 1–8. https://doi.org/10.1037/a0034150

Kirby, J. N., Tellegen, C. L., & Steindl, S. R. (2017). A meta-analysis of compassion-based interventions: Current state of knowledge and future directions. *Behavior Therapy*, *48*(6), 778–792. https://doi.org/10.1016/j.beth.2017.06.003

Klimecki, O. M., Leiberg, S., Lamm, C., & Singer, T. (2013). Functional neural plasticity and associated changes in positive affect after compassion training. *Cerebral Cortex*, *23*(7), 1552–1561. https://doi.org/10.1093/cercor/bhs142

Klimecki, O. M., Leiberg, S., Ricard, M., & Singer, T. (2013). Differential pattern of functional brain plasticity after compassion and empathy training. *Social Cognitive and Affective Neuroscience*, *9*(6), 873–879. https://doi.org/10.1093/scan/nst060

Klimecki, O. M., Leiberg, S., Ricard, M., & Singer, T. (2014). Differential pattern of functional brain plasticity after compassion and empathy training. *Social Cognitive and Affective Neuroscience*, *9*(6), 873–879. https://doi.org/10.1093/scan/nst060

Kogan, A., Oveis, C., Carr, E. W., Gruber, J., Mauss, I. B., Shallcross, A., … Cheng, C. (2014). Vagal activity is quadratically related to prosocial traits, prosocial emotions, and observer perceptions of prosociality. *Journal of Personality and Social Psychology*, *107*(6), 1051–1063.

Kok, B. E., Coffey, K. A., Cohn, M. A., Catalino, L. I., Vacharkulksemsuk, T., Algoe, S. B., & Fredrickson, B. L. (2013). How positive emotions build physical health: Perceived positive social connections account for the upward spiral between positive emotions and vagal tone. *Psychological Science*, *24*(7), 1–10. https://doi.org/10.1177/0956797612470827

Koopmann-Holm, B., Sze, J., Ochs, C., & Tsai, J. L. (2013). Buddhist-inspired meditation increases the value of calm. *Emotion*, *13*(3), 497–505. https://doi.org/10.1037/a0031070

Kreplin, U., Farias, M., & Brazil, I. A. (2018). The limited prosocial effects of meditation: A systematic review and meta-analysis. *Scientific Reports*, *8*(1), 2403. https://doi.org/10.1038/s41598-018-20299-z

Kringelbach, M. L., & Berridge, K. C. (2009). Towards a functional neuroanatomy of pleasure and happiness. *Trends in Cognitive Sciences*, *13*(11), 479–487. https://doi.org/10.1016/j.tics.2009.08.006

Kurzban, R. (2001). The social psychophysics of cooperation: Nonverbal communication in a public good game. *Journal of Nonverbal Behavior*, *25*(4), 241–259. https://doi.org/10.1023/A:1012563421824

Lamm, C., Decety, J., & Singer, T. (2011). Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. *NeuroImage*, *54*(3), 2492–2502. https://doi.org/10.1016/j.neuroimage.2010.10.014

Lazarus, S. R. (1991). *Emotion and adaptation*. Oxford, England.: Oxford University Press.

Lee, D. J., Kulubya, E., Goldin, P., Goodarzi, A., & Girgis, F. (2018). Review of the neural oscillations underlying meditation. *Frontiers in Neuroscience*, *12*. https://doi.org/doi: 10.3389/fnins.2018.00178

Leiberg, S., Klimecki, O., & Singer, T. (2011). Short-term compassion training increases prosocial behavior in a newly developed prosocial game. *PLoS ONE*, *6*(3). https://doi.org/10.1371/journal.pone.0017798

Lim, D., Condon, P., & Desteno, D. (2015). Mindfulness and compassion: An examination of mechanism and scalability. *PLoS ONE*, *10*(2), 1–8. https://doi.org/10.1371/journal.pone.0118221

Lutz, A., Greischar, L. L., Perlman, D. M., & Davidson, R. J. (2009). BOLD signal in insula is differentially related to cardiac function during compassion meditation in experts vs. novices. *NeuroImage*, *47*(3), 1038–1046. https://doi.org/10.1016/j.neuroimage.2009.04.081

May, C. J., Weyker, J. R., Spengel, S. K., Finkler, L. J., & Hendrix, S. E. (2014). Tracking longitudinal changes in affect and mindfulness caused by concentration and loving-kindness meditation with hierarchical linear modeling. *Mindfulness*, *5*(3), 249–258. https://doi.org/10.1007/s12671-012-0172-8

Mccall, C., Steinbeis, N., Ricard, M., & Singer, T. (2014). Compassion meditators show less anger, less punishment , and more compensation of victims in response to fairness violations. *Frontiers in Behavioral Neuroscience*, *8*, 1–10. https://doi.org/10.3389/fnbeh.2014.00424

Mikulincer, M., Shaver, P. R., Gillath, O., & Nitzberg, R. A. (2005). Attachment, caregiving, and altruism: Boosting attachment security increases compassion and helping. *Journal of Personality and Social Psychology*, *89*(5), 817–839. https://doi.org/10.1037/0022-

3514.89.5.817

Neff, K. D. (2016). The self-compassion scale is a valid and theoretically coherent measure of self-compassion. *Mindfulness*, *7*(1), 264–274. https://doi.org/10.1007/s12671-015-0479-3

Oveis, C., Horberg, E. J., & Keltner, D. (2010). Compassion, pride, and social intuitions of self-other similarity. *Journal of Personality and Social Psychology*, *98*(4), 618–630. https://doi.org/10.1037/a0017628

Porges, S. W. (2001). The polyvagal theory: Phylogenetic substrates of a social nervous system. *International Journal of Psychophysiology*, *42*(2), 123–146. https://doi.org/10.1016/S0167-8760(01)00162-3

Preckel, K., Kanske, P., & Singer, T. (2018). On the interaction of social affect and cognition: empathy, compassion and theory of mind. *Current Opinion in Behavioral Sciences*, *19*, 1–6. https://doi.org/10.1016/j.cobeha.2017.07.010

Rolls, E. T. (2000). The orbitofrontal cortex and reward. *Cerebral Cortex*, *10*(3), 284–294. https://doi.org/10.1093/cercor/10.3.284

Saslow, L. R., Willer, R., Feinberg, M., Piff, P. K., Clark, K., Keltner, D., & Saturn, S. R. (2013). My Brother's Keeper?: Compassion Predicts Generosity More Among Less Religious Individuals. *Social Psychological and Personality Science*, *4*(1), 31–38. https://doi.org/10.1177/1948550612444137

Seppala, E. M., Hutcherson, C. A., Nguyen, D. T., Doty, J. R., & Gross, J. J. (2014). Loving-kindness meditation: a tool to improve healthcare provider compassion, resilience, and patient care. *Journal of Compassionate Health Care*, *1*(5), 2–9. https://doi.org/10.1186/s40639-014-0005-9

Seppala, E. M., Simon-thomas, E. R., Brown, S. L., Worline, M. C., Cameron, D., & Doty, J.

R. (Eds.). (2017). *The oxford handbook of compassion science*. New York: Oxford University Press.

Shiota, M. N., Keltner, D., & John, O. P. (2006). Positive emotion dispositions differentially associated with Big Five personality and attachment style. *Journal of Positive Psychology*, *1*(2), 61–71. https://doi.org/10.1080/17439760500510833

Shonin, E., Van Gordon, W., Compare, A., Zangeneh, M., & Griffiths, M. D. (2015). Buddhist-derived loving-kindness and compassion meditation for the treatment of psychopathology: A systematic review. *Mindfulness*, *6*(5), 1161–1180. https://doi.org/10.1007/s12671-014-0368-1

Simon-thomas, E. R., Keltner, D. J., Sauter, D., Sinicropi-yao, L., & Abramson, A. (2009). The voice conveys specific emotions: Evidence from vocal burst displays. *Emotion*, *9*(6), 838–846. https://doi.org/10.1037/a0017810

Singer, T., & Klimecki, O. M. (2014). Empathy and compassion. *Current Biology*, *24*(18), R875–R878. https://doi.org/10.1016/j.cub.2014.06.054

Singer, T., & Steinbeis, N. (2009). Differential roles of fairness- and compassion-based motivations for cooperation, defection, and punishment. *Annals of the New York Academy of Sciences*, *1167*, 41–50. https://doi.org/10.1111/j.1749-6632.2009.04733.x

Skwara, A. C., King, B. G., & Saron, C. D. (2017). Studies of training compassion: What have we learned; What remains unknown. In E. M. Seppälä, E. Simon-Thomas, S. L. Brown, M. C. Worline, D. C. Cameron, & J. R. Doty (Eds.), *The oxford handbook of compassion science* (pp. 219–236). New York: Oxford University Press.

Spikins, P. A., Rutherford, H. E., & Needham, A. P. (2010). From homininity to humanity: Compassion from the earliest archaics to modern humans. *Time and Mind*, *3*(3), 303–325. https://doi.org/10.2752/175169610X12754030955977

Stell, A. J., & Farsides, T. (2016). Brief loving-kindness meditation reduces racial bias, mediated by positive other-regarding emotions. *Motivation and Emotion*, *40*(1), 140–147. https://doi.org/10.1007/s11031-015-9514-x

Stellar, J. E., Cohen, A., Oveis, C., & Keltner, D. (2015). Affective and physiological responses to the suffering of others: Compassion and vagal activity. *Journal of Personality and Social Psychology*, *108*(4), 572–585. https://doi.org/10.1037/pspi0000010

Stellar, J. E., Gordon, A. M., Piff, P. K., Cordaro, D., Anderson, C. L., Bai, Y., … Keltner, D. (2017). Self-Transcendent Emotions and Their Social Functions: Compassion, Gratitude, and Awe Bind Us to Others Through Prosociality. *Emotion Review*, *9*(3), 200–207. https://doi.org/10.1177/1754073916684557

Strathearn, L., Fonagy, P., Amico, J., & Montague, P. R. (2009). Adult attachment predicts maternal brain and oxytocin response to infant cues. *Neuropsychopharmacology*, *34*(13), 2655–2666. https://doi.org/10.1038/npp.2009.103

Strauss, C., Lever Taylor, B., Gu, J., Kuyken, W., Baer, R., Jones, F., & Cavanagh, K. (2016). What is compassion and how can we measure it? A review of definitions and measures. *Clinical Psychology Review*, *47*, 15–27. https://doi.org/10.1016/j.cpr.2016.05.004

Suess, P. E., Porges, S. W., & Plude, D. J. (1994). Cardiac vagal tone and sustained attention in school-age children. *Psychophysiology*, *31*(1), 17–22.

Trivers, R. L. (1971). The evolution of reciprocal altruism. *The Quarterly Review of Biology*, *46*(1), 35–57.

Wager, T. D., Davidson, M. L., Hughes, B. L., Lindquist, M. A., & Ochsner, K. N. (2008). Prefrontal-subcortical pathways mediating successful emotion regulation. *Neuron*, *59*(6), 1037–1050. https://doi.org/10.1016/j.neuron.2008.09.006

Warneken, F., & Tomasello, M. (2006). Altruistic helping in human infants and young chimpanzees. *Science*, *311*(5765), 1301–1303. https://doi.org/10.1126/science.1121448

Weng, H. Y., Fox, A. S., Hessenthaler, H. C., Stodola, D. E., & Davidson, R. J. (2015). The role of compassion in altruistic helping and punishment behavior. *PLoS ONE*, *10*(12), 1–20. https://doi.org/10.1371/journal.pone.0143794

Weng, H. Y., Fox, A. S., Shackman, A. J., Stodola, D. E., Caldwell, J. Z. K., Olson, M. C., … Davidson, R. J. (2013). Compassion training alters altruism and neural responses to suffering. *Psychological Science*, *24*(7), 1171–1180. https://doi.org/10.1177/0956797612469537.Compassion

Weytens, F., Luminet, O., Verhofstadt, L. L., & Mikolajczak, M. (2014). An integrative theory-driven positive emotion regulation intervention. *PLoS ONE*, *9*(4), 1–11. https://doi.org/10.1371/journal.pone.0095677

Wheeler, E. A., & Lenick, N. W. (2014). Brief compassion meditation and recall of positive-emotion words. *Journal of Articles in Support of the Null Hypothesis*, *11*(2), 11–20. Retrieved from www.jasnh.com

Williams, P. B., Poljacik, G., Decety, J., & Nusbaum, H. C. (2018). Loving-kindness language exposure leads to changes in sensitivity to imagined pain. *Journal of Positive Psychology*, *13*(4), 1–5. https://doi.org/10.1080/17439760.2017.1315648

Willis, F. N., & Hamm, H. K. (1980). The use of interpersonal touch in securing compliance, *5*(1), 49–55.

Zeng, X., Chiu, C. P. K., Wang, R., Oei, T. P. S., & Leung, F. Y. K. (2015). The effect of loving-kindness meditation on positive emotions: A meta-analytic review. *Frontiers in Psychology*, *6*(NOV), 1–14. https://doi.org/10.3389/fpsyg.2015.01693