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Emotion Regulation, Happiness, and the Neuroplasticity of the Brain

Richard J. Davidson, PhD

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The Buddhists have had a more than 2,500-year tradition of cultivating virtuous qualities of mind, and we believe important lessons can be learned from the experiential and introspective science they have conducted. It is in the spirit of that collaboration and dialogue that we began to do our work, which is still in the embryonic stage in this area. Just this past October, we were in Dharamsala, India, for a meeting on neuroplasticity with the Dalai Lama. His Holiness had been devoting a considerable amount of his personal time to interacting with scientists. In fact, he told us that other than causes that are directly related to Tibet, he spends more time with scientists than with any other group. This is a testament to the extraordinary curiosity and interest he has in fostering this dialogue. These meetings are small, intimate gatherings in the Dalai Lama's headquarters in Dharamsala, India. They last for 5 days, and the Dalai Lama is present for the entire time. Much of the meeting is spent in very intensive dialogue with His Holiness, as he examines and queries us with very pointed questions, and interrupts us constantly and appropriately.

The central issues we would like to discuss comprise 3 major points: The first is that people differ in their levels of happiness, and these differences are associated with different underlying biological characteristics; the second is that emotion regulation plays a key role in modulating these differences in happiness, and we will give you a feel

for how we can actually perform hard-nosed empirical research on emotion regulation; and the third point is that happiness can be regarded as the product of skills that can be enhanced through mental training, and such training can induce positive changes in the brain. One of the vehicles that we believe promotes these kinds of more positive mental states is meditation.

There appear to be differences among people in what has been called "happiness set points." We tend to return to these set points following changes in our circumstances. As I said earlier, these changes are associated with different patterns of brain function. Now, the word "happiness" is being used here as a proxy for a whole set of positive characteristics which we, in Western bio-behavioral science, have really only begun to appreciate, but have been articulated with considerably more precision in the Buddhist canons.

Resilience is an issue that we have been particularly interested in, and our work and the work of a number of other scientists is beginning to suggest that some exposure to adversity may be required to cultivate resilience. Being exposed to adversity may promote the conditions in which the positive skills of regulating emotion may be cultivated. Human beings are endowed with the capacity to voluntarily regulate emotion, and this competence may be the key to understanding why some people are resilient and other people are vulnerable. Finally, there is the role of mental training in happiness.

I want to remind the reader, in case he or she needs reminding, that happiness is an inalienable right. In 1776, Thomas Jefferson told us that the pursuit of happiness is a right that is granted in our Declaration of Independence.

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Now happiness can also be a matter of life or death. A recently published epidemiological study from the Netherlands simply asked a very large sample of people about their relative degrees of happiness. The study examined the extent to which, over a long interval of time (roughly 20 years), these ratings predicted suicide. It turns out that people who reported themselves to be very unhappy had more than a 10-fold increase in suicide rates. So relative degrees of happiness are critical.

Some might ask what "happiness" is. We will use the definitions of others as a starting point. Dr Martin Seligman, a psychologist at the University of Pennsylvania, described happiness as encompassing 3 components: one is pleasure or positive emotion; a second is engaged, goal-directed pursuits; and the third is meaning, or having a connection to some larger purpose.

How valuable is happiness? Do social and economic conditions significantly affect happiness? What do such findings imply? Some epidemiological data based on extremely large sample sizes use admittedly very coarse self-report measures; nevertheless, such data are telling. The first question is, "Does marriage buy you happiness?" These data, based on tens of thousands of subjects, show that at the point when one gets married, there is a large increase in happiness or life satisfaction relative to the 5-year period prior to marriage. But, and here is the rub, if we look at 5 years after marriage, we find that levels of happiness have receded to the point where they are actually slightly below what they were just prior to marriage! What about widowhood? You take a big hit, but you quickly return to baseline. What about that important and powerful motivator in our culture—money? The data for the gross domestic product (GDP) plotted from 1946 to 1996 in the United States show us that, as a culture, our country has been doing extremely well economically, at least before the last 6 or 7 years. But when we look at the percentage of people who report themselves to be very happy, that is absolutely flat across this time period. So levels of reported happiness do not appear to track the economic changes that have been occurring in this country.

What does all of this suggest? Can happiness be enhanced, or are we all stuck at our respective set points? How can we better measure happiness? What are the underlying constituents? Our dialogue with Buddhism has taught some of my colleagues and me that we are not stuck, that there is a way out. The path to finding the way out, to actually improving genuine levels of happiness, can be found in some of the traditions that have existed for thousands of years before our science was developed. Considering emotion regulation as a key to well-being, we think this regulation can be either voluntary or automatic. By "voluntary emotion regulation," we mean the intentional cultivation of changes in one's emotions, whereas "automatic emotion regulation" proceeds in the relative

absence of effortful processing and is often a non-conscious mode of regulating emotions. We believe that "voluntary emotion regulation" can induce changes in brain circuits that underlie emotion, and that the intentional cultivation of certain forms of positive emotion may have beneficial effects on mental and physical health.

These suggestions are based upon empirical work using modern brain-imaging methods. In our laboratory, we have developed a paradigm to study voluntary emotion regulation. For example, we present an emotional picture to a person and instruct him or her to voluntarily down-regulate a negative emotion if we are presenting a negative emotional picture (we train participants prior to the experiment). We may present a picture of a person who is diseased or perhaps mutilated (a picture we often show is a baby with a tumor growing out of its eye). One of the dominant responses we see to those kinds of images, at least from undergraduate students in our culture, is disgust. We then instruct the participants to reappraise the situation. We basically ask them to look at the same picture with an aspiration that the suffering of the individual depicted in the picture be relieved and that the outcome be positive. This is the kind of cognitive strategy we teach people in order to down-regulate negative emotions. We recently used a magnetic resonance imaging (MRI) scanner to look at changes that occur in the brain in response to these instructions after we presented negative emotional pictures. We predicted that changes would occur in the amygdala, which is critically important for threat detection and for certain kinds of emotional learning, particularly negative emotional learning. The MRI showed a diminished response in the amygdala when subjects were trained to down-regulate their negative emotion compared to a control condition or a condition where they were asked to enhance the negative emotion.

Now, some people are good at voluntarily regulating their negative affect, and others are not so good at it. We asked ourselves which area of the brain might be associated with this change in the amygdala and discovered that it's the ventromedial prefrontal cortex, an area of the brain that has been critically implicated in extinction learning and other features of emotional regulation. We also know that this area has extensive anatomical reciprocity with the amygdala. If we look at the relation between the signal in the amygdala and the signal in the ventromedial prefrontal cortex when subjects are instructed to down-regulate negative emotion compared to a control condition, they are very tightly coupled. This means that individuals showing high levels of activation in the ventromedial prefrontal cortex during the down-regulation condition are showing low levels of activation in the amygdala, and vice versa. These data imply that the ventromedial prefrontal cortex may be an area of the brain that is strengthened by emotion-regulation training.

Another question that interests us is whether these individual differences in emotion regulation have any bearing on other kinds of regulatory processes that may occur outside the laboratory and are potentially important for physical health. In these same subjects, for 7 consecutive days, 6 times a day, we obtained saliva samples to extract cortisol, a hormone released by the adrenal gland and controlled by the hypothalamic pituitary adrenal axis. It turns out that if we look at individual subjects, there is a lot of variability. And other research shows that individuals who have a flatter slope of their cortisol across the day have worse outcomes compared to those who have a steeper slope. Those who have a flatter cortisol slope have a larger waist circumference, perform more poorly on explicit memory tasks, have lower perceived social support, etc. Some very recent work from Dr David Spiegel at Stanford University shows that in women with metastatic breast cancer, those who have a flatter cortisol slope actually die sooner.

We looked at the relation between the signals that we measure in the MRI scanner and the slope of cortisol, and found that individuals who are good emotion regulators (who have more activation in their ventromedial prefrontal cortexes) have a steeper cortisol slope. Those who have less activation in the amygdala when they are down-regulating emotion also have a steeper cortisol slope. So these phenomena that we measure in the laboratory are integrally related to what occurs in the real world.

We have provided a foundation for discussing the impact of training the mind on brain signals that are associated with emotion. Matthieu Ricard, one of the individuals who has been not just a subject but also a collaborator, has been a Tibetan Buddhist practitioner since the late 1960s. He also has a PhD in molecular biology from the Pasteur Institute, so he has extensive science training and was a co-author on the article that we recently published in the *Proceedings of the National Academy of Sciences*. One of the central focal points in that article was about changes in his own brain. The work that we've done with monks and other adept practitioners has been importantly informed by their own input. These are individuals who are very different from ordinary subjects, and have provided a wealth of information and expertise.

Let me share a few snippets of data, some of which have been published and some which have not. One of the things we decided to do was start simply, because this is such new work and there is still so much that we have to learn. So in these initial studies, we used a very simple block design where we asked the practitioners to meditate for very short periods of time, and we alternated the meditation periods with a neutral state. These practitioners told us this is something they can do, and we wanted to start by studying a practice that is central to the Dalai Lama's mission, which involves the voluntary cultivation

of compassion. This is something that practitioners in this tradition do on a regular basis and believe is critically important. In Matthieu's own words, he says what he was doing in this experiment: "Here what we have tried to do for the sake of the experiment is to generate a state in which love and compassion permeate the whole mind with no other consideration, reasoning, or discursive thoughts." This is sometimes called *pure compassion* or *non-referential compassion*. According to the reports of these individuals, they are able to generate this state on command. This ability is based upon years of practice, which often began with visualizing an individual who was suffering and then wishing, or having the aspiration, that the suffering be relieved. But then they can develop the practice to the point where the actual object falls away, and that is why it is called *non-referential*. It's just pure compassion, and we actually thought that for experimental purposes it would be better to start with that, where we wouldn't have the confounding influences of different individuals that different practitioners may be imagining, and so forth. We thought that for methodological reasons it would actually be cleaner to do it this way. We have done both electroencephalogram (EEG) studies and fMRI (functional MRI) studies. In the recent article we published on this work, we went to great lengths to show that the effects we described are not purely due to muscle changes. About 30% of the effect may be due to muscle, but the remainder of the changes in EEG that we observed resulted from changes in the gamma frequency range in the brain. There is a massive increase in gamma synchrony between frontal and parietal brain regions that is typically sustained for long periods of time in the adept practitioners. The controls were all individuals who were interested in meditation, and we trained them in the same practices, which they practiced for 1 week before we tested them. Compared with the adepts, the controls showed comparatively much more modest changes.

There are numerous opinions about what kind of controls to use, and there are many kinds of control groups that we wish to use in the future. There are limitations to the control group that we used here, but this was our first effort. A conservative estimate of the number of hours of meditation practice across their lifetimes is from about 12,000 to 55,000 hours. There was a relatively strong relation between the number of hours of practice and the percentage of change in the gamma signal that we saw across practitioners. In our fMRI studies of compassion meditation, we are able to see more detailed regions of the brain that change because fMRI has much better spatial resolution compared with EEG (though EEG has better temporal resolution). Our fMRI data reveal activation in motor regions of the brain. We also see activation in frontal regions, and the activation tends to be more left-sided, which corroborates some of

the work we have done previously.

One of the questions that the reader may ask is whether these training effects were related to pre-existing differences. In a randomized control trial with another kind of meditation in novices, we have shown that we do get effects, longitudinally over time, that are related to the training and are not just pre-existing differences.

We can aptly sum up the importance of this work by quoting the Dalai Lama, who said, "The systematic training of the mind, the cultivation of happiness, the genuine *intertransformation* by deliberately selecting and focusing on positive mental states and challenging negative mental states is possible because of the very *structure and function* of the brain. But the wiring in our brains is not static, not irrevocably fixed. Our brains are also adaptable."