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Self-Regulation: The Role of Heart Rate Variability

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Many patients seek psychotherapy to address complaints related to self-regulation, such as when they experience their emotions and behaviors as being out of control. Self-regulation is the capacity to change or inhibit thoughts, emotions, impulses, or overt behaviors. Self-control and willpower are other terms for self-regulation. Ineffective self-regulation predicts poor physical and emotional health, and other life problems (Baumeister, Heatherton, & Tice, 1994; Tangney, Baumeister, & Boone, 2004). Improving one's ability to self-regulate is essential for improving overall mental and physical health. If we can help our patients learn strategies to improve self control, we will help them improve emotional stability and reduce impulsive and emotionally-driven behaviors, which will contribute to their functioning and overall life satisfaction.

Recent research has clarified that self-regulatory capacity is both a trait that varies among individuals and a state that varies considerably within individuals over short periods of time. For example, patients with borderline personality disorder generally have less ability to self-regulate than other people, but it is also true that their abilities fluctuate based on many factors, such as rest and nutrition. Like a muscle, short-term self-regulatory abilities temporarily diminish with sustained self-regulatory effort, but can be replenished with rest. Furthermore, there is evidence that the ability to self-regulate can improve with practice, just as muscle strength and endurance improve with physical training. Finally, there is evidence that self-regulatory fatigue has general implications. Many forms of effort can temporarily deplete the capacity for self control, and many forms of rest and self-care can replenish it.

Research studies have shown that prolonged self-regulatory effort temporarily decreases self-control abilities, making us more likely to fail at self-control in the near future. Furthermore, many forms of effort temporarily deplete our general abilities to self-regulate. The implication is that sustaining effort at one specific self-regulation task, such as suppressing thoughts, emotions, and memories, will temporarily decrease our ability to control other behaviors, such as engaging in physical exercise or resisting tempting foods (e.g., Bray et al. 2008). One study showed that resisting cookies decreased persistence on solving difficult word puzzles (Segerstrom & Solberg Nes, 2007).

Heart rate variability (HRV), defined as the beat-to-beat differences in heart rate, can be used as an indicator of self-regulatory capacity (Segerstrom & Solberg Nes, 2007). Generally, during inhalation the heart beats faster and during exhalation heart rate slows down. For example, during a typical resting state a normal person could have a peak of 80 beats per minute (bpm) during inhalation and a rate of 75 bpm at the end of the exhalation, a difference of 5 bpm. Research suggests that parasympathetic nervous system (PNS) activity is also correlated with HRV. For example, a larger inhale-exhale difference in heart rate indicates greater PNS activity and is associated with greater ability to resist temptations and persist with challenging tasks; however, only two studies have tested the correlation between HRV and self-regulation behaviors. Segerstrom and Solberg Nes (2007) and Reynard, Gevirtz, Brown, and Boutelle (2011) found that lower HRV at rest was correlated with less persistence with difficult and unsolvable anagrams. HRV is also an indicator of overall health and ability to recover from stress.

Many studies have also found that low HRV is associated with emotional dysregulation, the tendency for emotional reactions to occur too frequently and intensely. Emotional dysregulation can occur when a person faces stressful life events, is highly emotionally sensitive, or has difficulty tolerating emotions.

Greater HRV is associated with more ability to recover from stress. Also, recent emotional stress reduces HRV and the ability to resist temptations and persist with challenging tasks (Baumeister et al., 2005). For example, individuals with borderline personality disorder have lower HRV and more problems with emotion dysregulation and self-control than individuals with other disorders (Kuo & Linehan, 2009). Just as various stressors and forms of self-control temporarily reduce HRV and self-regulation capacity, many things can be done to replenish them. Short-term capacity for self-regulation can be replenished with glucose, rest, and positive emotions (Baumeister 2003; Gailliot & Baumeister, 2007). Research also shows that even a small boost in mood restores self-regulatory capacity. In one of these studies, participants who watched a short comedy video between the two challenging tasks persisted longer in the final task (Tice et al., 2007).

Research studies have also shown that many forms of practice in self-regulation can improve one's general ability to persist across a wide variety of tasks requiring self-control. Training in any specific act of self-control will strengthen many other acts of self-control (Muraven et al., 1999; Oaten & Cheng, 2007). For example, research participants who consistently exerted effort at time management also improved at many other behaviors that were not targeted, including eating healthier foods, increasing physical activity levels, and reducing tobacco and alcohol use (Oaten & Cheng, 2006). Similarly, regular physical exercise leads to an increase in general self-regulation abilities, reducing a wide variety of problem behaviors including unhealthy eating, angry behaviors, substance use, and impulsive spending (Oaten & Cheng, 2007). Considerable evidence indicates that regular physical exercise increases HRV, which might be the reason why it improves self-regulation. It is also likely that other interventions that increase overall levels of HRV may be effective at improving general self-regulation ability.

One effective strategy for increasing HRV is resonant frequency slow breathing. Slowing breathing to approximately six breaths per minute (one complete breath cycle lasting 10-12 seconds) is effective at reducing emotional arousal by increasing HRV and activating the PNS. Breathing usually occurs at a much faster rate. Not only does increased PNS activity decrease breathing rate, but intentionally slowing breathing rate also increases parasympathetic activity. Slow breathing also increases HRV, such that the peak heart rate during inhalation could be as high as 95 beats per minute (bpm) while the slowest rate during the exhalation being as low as 60 bpm (a difference of 35 bpm).

Breathing at a slower rate also increases the smoothness, or *coherence,* of heart rate fluctuations from breath-to-breath, and the synchrony of breathing, heart rate fluctuations, and blood pressure fluctuations. When this *cardio-respiratory synchrony* occurs, the peak of the inhalation occurs at almost the exact same moment as the peak of the heart rate increase and the lowest blood pressure. Slow breathing increases the inhale-exhale difference in blood pressure, in addition to increasing the inhale-exhale difference in heart rate. Coherence and synchrony are important indicators of autonomic nervous system balance and overall emotional and physiological harmony. Optimal slow breathing results in lowered blood pressure and heart rate, warm hands and feet, a decreased sweat response and a general sense of relaxation and wellbeing. Patients with poor self-regulation would benefit from daily practice of breathing at their resonant frequency (e.g., at least 15 minutes per day). Improved parasympathetic functioning and blood pressure regulation are likely to persist beyond slow breathing practice sessions when slow breathing creates the largest possible inhale-exhale differences in heart rate and blood pressure (Zucker et al., 2009).

Optimal breathing rate, known as *resonant frequency*, varies among individuals, and breathing at resonant frequency has a much greater psychological and physical health benefit than breathing at a rate even slightly slower or faster. Optimal breathing rate ranges from 4.5 to 7.0 breath cycles per minute. Overall, shorter people and women have an optimal breathing rate that is faster than for taller people. For example, the ideal rate for people five feet tall is about 6 breaths per minute, on average (ranging between 5.4 and 6.4 breaths per minute), whereas for people six feet tall the optimal rate is about 5.3 breaths per minute (ranging between 5.0 and 5.7) (Vaschillo, Vaschillo & Lehrer, 2006). The ideal way to find the precise optimal breathing rate for an individual is to use biofeedback equipment to identify the breathing rate that maximizes coherence, cardio-respiratory synchrony, and the inhale-exhale difference in heart rate. Biofeedback equipment helps patients learn optimal breathing by providing real-time feedback about natural heart rate fluctuations (HRV).

Many patients with poor self-regulation would likely benefit from daily practice of breathing at their resonant frequency using a breathing pacer, and eventually learn to breathe at their resonant frequency without the aide of a pacer or HRV feedback. Practicing without a pacer or biofeedback helps generalize this skill to many situations in the natural environment. Breathing pace can easily be verified using iPhone and other applications. It can also be measured simply by using a timer (e.g., a stopwatch) or a watch with a second hand. Biofeedback resources and free breathing pacers are available at: www.dbtsandiego.com/current_clients This resonant frequency slow breathing intervention is a promising therapeutic strategy for reducing emotional reactivity, and increasing HRV and general self-regulation capacity. Further research is needed, however, to evaluate its effectiveness.

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