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Article

A Neurofeedback Intervention Program to Improve Teachers' Mental Well-Being

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Abstract: Most of the educational interventions proposed so far in the field of mental well-being in education usually address just students. In this study, we focused on teachers as the Covid-19 pandemic reiterated the importance of their mental well-being during demanding times. We investigated whether neurofeedback (NF) training can increase optimism, self-esteem, life satisfaction, and the ability to cope with stressful events, reflecting on the research literature that emphasizes these four factors, which affect the ability to be confident in dealing with uncertainty and distress. Forty teachers aged 35-55 participated in the study. The test group took part in 12 NF training sessions, and the control group was not treated. Our findings indicate that compared to the control group, measures of optimism, self-esteem, life satisfaction, and coping with stressful events improved significantly in the test group. To the best of our knowledge, this is the first attempt to test a mental welfare intervention program for teachers through NF. This study responded to a call to develop teacher intervention programs using physiological measurement and technological innovations to improve their mental health and allow them to cope better with stressful teaching conditions.

Keywords: mental well-being; neurofeedback; school teachers; optimism; self-esteem; stress

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1. Introduction

Teachers' satisfaction from stress and burnout has been the focus of many studies for years. Teachers' challenges and difficulties in the new "normal educational environment" following the COVID-19 pandemic triggered more stress, burnout, and emotional exhaustion (Dabrowski, 2020; Lagat, 2021). Recent studies have investigated teachers' characteristics of positive mental health, namely optimism, and its correlation with satisfaction, stress, and burnout. Studies reported that teachers' optimism correlates with less perceived workload (Marcionetti & Castelli, 2022) and may affect both their well-being and their levels of productivity and performance (Atmaca et al., 2020).

Teachers' positive mental health is an important variable that adversely affects students' achievements and significantly improves professional outcomes, such as induced feelings of stress and burnout. Therefore, we addressed optimism, self-esteem, life satisfaction, and the ability to cope with stressful situations since studies indicate that they are among the main psychological assets that directly and indirectly affect stress and emotional exhaustion. They make a person more persistent and confident when faced with uncertainties, hence less vulnerable to distress, and may be improved (Carver et al., 2010; Özdemir & Kerse, 2020; Reyes et al., 2019).

Studies in the reported literature tested educational environments designed to encourage mental well-being (McLean et al., 2020). However, to the best of our knowledge, just a few studies investigated interventions that aimed to develop well-being assets among teachers through an internal psychological procedure (Falecki & Mann, 2021).

Also, it seems that no intervention has yet been suggested to use Brain-Computer-Interfaces (BCI) for this purpose. Thus, we developed this intervention to study whether teachers' optimism, ability to cope with stressful situations, life satisfaction, and self-esteem could be improved by a neurofeedback brain training protocol.

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2. Neurofeedback: Brain Training

Neurofeedback (NF), also termed electroencephalogram (EEG) biofeedback, combines psychology, technology, and neuroscience**.** Neurofeedback trains the person to control his brain. Its contemporary goals include clinical (e.g., ADHD, obsessive-compulsive disorder - OCD, anxiety, depression) and non-clinical (e.g., peak performance) applications. Studies found that several sessions of neurofeedback brain training protocol improved functional state and enhanced everyday life performance (Dobrushina et al., 2020).

Neurofeedback is a gradual learning process aiming to regulate patterns of brain activity. Computer software and electrodes placed on the trainee's scalp and analysis of the trainee's electrical signals allows for real-time watching of the activity wave in the trainee's brain on the computer screen. The software's feedback is presented to the trainee according to the set targets, in audio-visual form, and "teaches" the trainee how to regulate his brain patterns. The repetition of providing immediate feedback on particular brain activity leads to strengthening neuronal connections, which we attempt to improve. Although it is not necessarily possible to correct the frequency of alterations through such training, many studies show a substantial reduction in the symptoms (Weber et al., 2020).

Our study did not address the clinical state but followed the trend of neurofeedback applications with healthy participants, commonly called the 'optimal' field (Gruzelier et al., 2014). Previous studies indicated that NF enables better coping with stressful situations and improves concentration and memory capabilities (Gruzelier et al., 2010). Specific advantages of NF training over other treatment options (e.g., medication) were found, including its non-invasive intervention process and the endurance of the effects that are evidentially stable for years after the end of the training period (Weber et al., 2020).

2.1. Neurofeedback Protocols

In this study, we used the neurofeedback (NF) procedure most frequently: the frequency/power NF protocols. This technique typically includes using surface electrodes to change the amplitude or speed of specific brainwaves in specific brain locations (Marzbani et al., 2016). The training plan (protocol) involves two domains: the site of the electrode (scalp areas responsible for the target area in which we look for a change) and the range of frequency for the training (Rubin, 2011).

Various brain sites (e.g., frontal, temporal, parietal) and diverse EEG bands (alpha, beta, theta) are related to different mental states. Notably, few studies found protocols effective for the same goals. For example, to reduce anxiety, one may up-train alpha in the parietal lobe or down-train high beta in the right temporal lobe (Rubin, 2011). In the following sections, we will discuss these two domains of NF protocols: frequency and site.

2.2. Brainwave Frequency

Brainwave frequency components are commonly categorized into delta (less than 4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–30 Hz), and gamma (30–100 Hz), where each represents a particular physiological function. One can observe Delta waves in the EEG signal when a person is asleep; theta waves when a person is sleepy; alpha waves when a person is relaxed but awake; low-beta (beta1, 13-15 Hz) waves when a person is calm; beta2 (16-19 Hz) waves when a person is alert, and high-beta (beta3, 20-30 Hz) in a stressful state.

Various training protocols allow for reinforcing or inhibiting specific brain waves. There are two classical directions in NF training, either focusing on low frequencies (alpha, theta) to strengthen relaxation or on high frequencies (beta1,2) for reinforcing activation and inhibiting distractibility (Marzbani et al., 2016). The most commonly used NF protocols are alpha, beta, theta/beta, and alpha/theta ratio.

Among the anti-stress protocols, beta2 and the eyes closed Alpha/Theta (A/T training) protocols have been used for a long time for relaxation and mood improvement purposes for optimal performance effects in healthy participants. Alpha oscillations (8–12 Hz) correspond to a state of

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resting wakefulness among healthy individuals (Nicholson et al., 2020). Studies indicate that the Alpha mood generates a calm and pleasant situation of creative activity and relaxation. Participants with the NF protocol of uptraining alpha showed personality changes, expressed in being more warm-hearted, emotionally stable, relaxed, and satisfied, as well as feeling better about themselves after training (Raymond et al., 2005). Moreover, when relaxing-target training sessions were combined with theta (4–8 Hz) and high-beta (22–37 Hz) inhibitors, results indicated reduced anxiety (Gruzelier et al., 2014).

Recent NF protocols developed from contemporary neuroscience include upper-alpha training (10-13 Hz) using the eyes-open protocol. Some experimental findings support upper-alpha as a promising NF parameter correlated to "evoking emotions" that is worth further investigation, whereas theta/alpha, theta/beta1, or theta/beta2 feedback is already established in therapy (Phneah & Nisar, 2017; Zoefel et al., 2011). As explained herein, our study used the upper alpha protocol combined with theta and high-beta3 inhibitors.

2.3. Brain Sites

Electrodes (placed on the scalp) can record the cortical activities of the brain regions that are adjacent to them. Studies have shown that the placements correlate with the corresponding cerebral cortical areas (Marzbani et al., 2016). NF practitioners use a standardized method to place the electrodes, named "10-20", using letters and numbers (e.g., C4, F3) to refer to the placement sites.

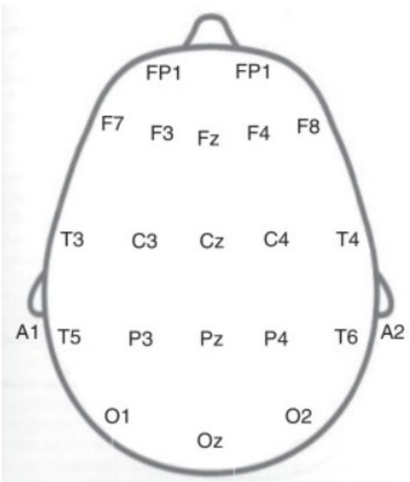

Figure 1. The standardized method to place electrodes on the scalp – "10-20".

Several brain regions have been linked to socio-emotional processing, particularly the amygdala and orbital portions of the prefrontal cortex. However, Studies pay less attention than deserved to a third region between the orbital frontal cortex and the amygdala, the temporal pole (Olson et al., 2007). This region is highly interconnected with the amygdala and orbital frontal cortex. Researchers refer to it as the paralimbic region. It is involved in the sensory and limbic processing of emotional states (Nicholson et al., 2020) and is considered necessary for emotional regulation.

The right temporal lobe appears to be associated with emotion and socially relevant memory that is associated with mood changes and seems to be the site of recollection of episodic personal memories. In contrast, the left temporal lobe is more associated with semantic memory. The right temporal site (T4 by the 10-20 placement method) tends to exhibit more significant decreases in PTSD symptoms than the left temporal (T3) placement (Gapen et al., 2016). Ribas et al. (2016) identified a pattern related to high beta waves, indicating stressfulness – more elevated in the right temporal lobe (T4) than in the left temporal lobe (T3), indicating the activation of the amygdalae and the hypothalamus to warn of danger.

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3. Psychological assets and their related NF protocols

In this study, we investigated optimism, self-esteem, life satisfaction, and coping with stressful situations since they, directly and indirectly affect one's persistence and confidence in facing uncertainties and distress. Some recent studies point to their relation to brain activity.

3.1. Optimism

Studies found that optimism serves an adaptive function, enhancing proactive behaviors while diminishing stress and anxiety (Erthal et al., 2021; Scheier et al., 1989). When the optimal state is balanced, reality-anchored optimism helps get the most out of opportunities (Caprara et al., 2010a, b; 2012). In this study, we investigated whether the right temporal lobe NF training would lead to increased optimism based on research that points to the correlation between right lobe function and brain training to levels of optimism (Raymond et al., 2005; Urry et al., 2004).

3.2. Self-Esteem

Self-esteem is the individual's perception of the self in a positive or negative attitude. Self-esteem is closely related to a person's basic life view (optimism or pessimism) and ability to cope with difficulties and challenges. A person with high self-esteem believes in his ability to influence his environment. Since his heightened sense of competence, he feels safe and valuable (Hecht, 2013). The pessimist tends to be self-critically insecure in facing life's challenges and feels less useful (Heinonen et al., 2005; Neff & Vonk, 2009).

Studies suggest that the sense of self manifests in the right temporal lobe. Studies (Mckay et al. 2010) argue that avoidance behaviors characterize individuals with lower self-esteem and under activity, pessimism, and depression. Hence training the brain for this target would trigger its activation. Following a left > right asymmetry principle, this could be achieved by increasing the alpha levels and lowering the beta levels in the right temporal lobe (Davidson, 2005; Mckay et al., 2010).

We thus hypothesized that neurofeedback up-training alpha and down-training high beta in the right temporal lobe would correlate positively with self-esteem.

3.3. Ability to Cope with Stressful Situations

Individuals with high levels of optimism report low levels of psychological stress (Creed, Patton & Bartum, 2004) and can cope better with stressors and crises (Scheier, Carver & Bridges, 1994). We investigated whether uptraining alpha would lead to better coping with stressful situations based on findings showing that alpha is associated with alert relaxation and reduced anxiety in healthy participants (Gruzlier et al., 2014; Marzbani et al., 2016).

3.4. Life Satisfaction

Whereas affect measures reflect short-term reports of subjective well-being and show situational variability, life satisfaction relates to relatively stable, long-term subjective well-being judgments (Kong et al., 2015). Studies linked higher life satisfaction to higher self-esteem, better physical and psychological health, fewer stressful life events, and fewer negative affect (Kong et al., 2015).

Kong et al. (2015) investigated the structural neural correlates of life satisfaction and found that life satisfaction correlates with the regional gray matter volume in the right cortex. Several studies have shown statistical improvements in quality of life, including life satisfaction, following NF alpha-theta training (Hershaw et al., 2020; Reddy et al., 2014). Therefore, we assumed that right-side alpha training would improve life satisfaction.

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4. Method

4.1. Participants

We recruited the participants in this study through social networks as a convenient sample of teachers. We invited primary-school teachers without clinical backgrounds in anxiety or depression to participate in the research and explained the method.

Sixty-seven males and females approved the consent form. Initially, 36 teachers were randomly assigned to participate in the experimental group. Still, only 20 females participated in the statistical analysis (4 performed only in the first stage of pre-treatment measures, six left after the second session, four after the fifth session, and two after the sixth session). In the experimental group (n=20), the participants were between 35 and 48 years (M = 41.20, SD = 4.70). Additional 20 female teachers were assigned to the control group (untreated), aged 35-45 years (M = 40.00, SD = 3.38).

4.2. Procedure

The control group received no intervention. The experimental group received 14 NF training sessions, 40 minutes for 12 weeks. An active electrode was placed at T4, referenced to the left ear lobe. Training targets aimed at increasing the upper alpha (10-13 Hz) and decreasing the upper theta (20-28 Hz). We used the Bioexplorer NF software (CyberEvolution, Inc.) for the training session interface. When the trainee's alpha wave increased, and the high beta wave decreased, we played an animation on the screen for the trainee to watch. When the animation stopped, the participants could notice their brain waves were not meeting the targets. Each NF training session consisted of steps of 5 minutes animation programs, and after each step, the participants had a 2 minutes interval of rest to avoid fatigue and keep concentration.

4.3. Measurements

Participants filled out the following psychological questionnaires:

- We measured *subjective satisfaction with life* by the Satisfaction With Life Scale (SWLS) (Larsen et al., 1985). It consists of 5 items (e.g., "I am satisfied with my life"; "If I could live my life over, I would change almost nothing"), rated on a 7-point Likert-type scale (α Cronbach = .90).
- We measured *optimism* by the Life Orientation Test (LOT) (Scheier & Carver, 1985), which includes 12 items (e.g., "I always see the good side of things"; "I hardly expect things to work out in my favor"), rated on a 5-point Likert-type scale (α Cronbach = .78).
- We measured *self-esteem* by the Rosenberg Self Esteem Scale (RSES) (Rosenberg, 1965), which consists of 12 items (e.g., "I can do things as well as most other people"; "I take a positive attitude toward myself"), rated on a 7-point Likert-type scale (α = .86).
- We measured *the ability to cope with stressful situations* using The Connor Davidson Resilience Scale questionnaire (CD-RISC) (Connor & Davidson, 2003). It includes 25 items on a 5-point Likert-type scale (e.g., "I consider myself a strong person"; "Under stressful situations, I focus and think clearly") (α = .0.91).

5. Results

The means and SD of the research variables were calculated for each group in the two-time measures (Table 1).

Table 1. Means and standard deviation of research variables for each group in both time measurements.

Variable	Experiment group		Control group	
	T1 Mean (SD)	T2 Mean (SD)	T1 Mean (SD)	T2 Mean (SD)
Optimism	2.60 (.43)	2.87 (.43)	3.17 (.41)	2.96 (.41)

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Life satisfaction	4.85 (.87)	5.03 (1.13)	5.53 (.64)	5.00 (1.00)
Self-esteem	4.25 (.91)	4.49 (1.00)	4.45 (.84)	4.47 (.88)
Resilience factors	3.66 (.53)	3.84 (.48)	3.85 (.41)	3.78 (.46)

We performed *T-tests* for independent groups to investigate whether there were differences at time points: T1 (before training), T2 (after training), and the control group. The only significant difference was that the control group reported higher optimism levels than the experimental group.

We then performed four Two-Way Mixed ANOVA analyses with each "group" (experimental, control) to compare variables and time points at T1 (before training) and T2 (after training) within variables. We tested whether the level of optimism, life satisfaction, self-esteem, and coping skills increased after NF training. The results indicated that:

- *Optimism*: We found a significant main effect in Time ($F(1,37) = 46.64$, $p < .001$, $\acute{\eta}^2_p = .56$), but not in Group ($F(1,37) = .058$, p = n.s, $\acute{\eta}^2_p = .002$). However, we revealed an interaction ($F(1,37) = 24.18$, $p < .001$, $\acute{\eta}^2_p = .39$) that indicated increased levels of teachers' optimism in the experimental group over time. In contrast, there were no significant differences in the control group between the time measurements.
- *Life satisfaction*: We found a significant main effect in Time ($F(1,38) = 24.55$, $p < .001$, $\acute{\eta}^2_p = .39$), but not in Group ($F(1,38) = .36$, p = n.s, $\acute{\eta}^2_p = .01$). However, we revealed a significant interaction ($F(1,38) = 29.28$, $p < .001$, $\acute{\eta}^2_p = .43$) over time in increased levels of teachers' life satisfaction in the experimental group, whereas there were no significant differences in the control group between time measurements.
- *Self-esteem*: We did not find a significant main effect in Time ($F(1,38) = 2.74$, $p = .11$, $\acute{\eta}^2_p = .07$) or group ($F(1,38) = .21$, p = n.s, $\acute{\eta}^2_p = .006$). However, we found a close to significant interaction ($F(1,38) = 3.68$, $p = .06$, $\acute{\eta}^2_p = .09$), which indicated increased levels of teachers' self-esteem in the experimental group over time. In contrast, there were no significant differences in the control group between time measurements.
- The *ability to cope with stressful situations:* We found a close to significant main effect for Time ($F(1,38) = 3.05$, $p = .08$, $\acute{\eta}^2_p = .07$), but not in the group ($F(1,38) = .17$, p = n.s, $\acute{\eta}^2_p = .005$). However, significant interaction ($F(1,38) = 10.71$, $p = .002$, $\acute{\eta}^2_p = .22$) indicated increased teachers' ability to cope with stressful situations in the experimental group over time. In contrast, there were no significant differences in the control group between time measurements.

The four Two-Way Mixed ANOVA analyses confirmed that teachers' optimism, life satisfaction, self-esteem, and ability to cope with stressful situations increased after NF training. In contrast, the control group had no differences in these variables.

6. Discussion

Scholars have stressed that any school-based approach to promoting mental health should begin with teachers' mental health (Beshai et al., 2016). However, most of the interventions constantly proposed for mental health in school address students, and only a few address teachers' well-being.

In this study, we investigated a neurofeedback procedure on teachers under unusual stress, especially since the Covid-19 pandemic wake. Pidgeon (2021) suggested the term "Corona wear" and examined the correlation between the pandemic and three other factors: resilience, social support, and optimism. Among them, only optimism has significantly predicted Corona-wear. Thus, he emphasized the importance of interventions to increase optimism and reduce the Corona-wear.

Following these recommendations, we tested an intervention program that uses neuroscience-based technology to improve the level of optimism, satisfaction in life, self-esteem, and the ability to deal with stressful situations among teachers. Similar intervention programs have been designed mainly to develop an awareness of similar factors and practical coping methods. In a recent meta-analysis of positive psychological interventions (Carr et al., 2021), the authors have found that these intervention programs generally have a low to medium effect on stress levels. Therefore, Russo (2021) recommends the inclusion of technologies aiming to increase an individual's awareness of biological processes (e.g., brain waves, heart rate, muscle tension) to better assist in reducing adverse symptomatology and empowering positive ones.

In our study, we joined other recent studies that call for the use of technology for psychological interventions (Przybylko et al., 2021). Among studies that recommend this venue is van Agteren's (et al., 2021) study that developed a software application to raise the sense of meaning, satisfaction with life, and positive emotion and found improvement in these measures. Such is Andersson's (2020) study that investigated a Mindfulness-focused intervention for teachers using a software program. He found improvement in several health metrics following the intervention program. In his view, the advantages of technology in this kind of intervention are that it increases engagement and persistence and allows personalization.

Hepburn and his colleagues (Hepburn et al., 2021) also investigated a teachers' intervention program on well-being issues and stress. They emphasized that besides the interventions aimed at teachers as a group, it is also essential to design and test individually tailored interventions for teachers.

Thus, our research joins these efforts and contributes to these recommendations by testing a neurofeedback protocol. One should remember that neurofeedback protocols require extensive research to better adjust for different populations, cultures, and genders. The literature describes differences between groups by demographic variables, such as perseverance in the intervention program. As noted above, more female teachers agreed to participate in this study, and they may have initially agreed to participate in the long training sessions in our study since they suffer more from stress (Pidgeon, 2021) or are more willing to persevere in neurofeedback treatment (Ward et al., 2019). Although no gender differences were reported in NF treatment, some researchers recommend further investigating gender variables and the correlation with NF training (Ward et al., 2019).

Additionally, other aspects of using technology with teachers need to be studied. For example, neurofeedback devices are still expensive. Studies need to investigate their economic and time cost-effectiveness further. Fear of exposure to personal physical metrics cannot be ignored and needs further understanding.

We suggest considering these concerns and reservations in developing future NF interventions with teachers and students. Nonetheless, our research is a step toward implementing other physiological-based interventions, such as magnetic stimulation (TMS) (Sharot et al., 2012). It clarifies the potential and prospects of technology in such interventions. However, one should consider the concern and objections as regards invasive protocols.

The current research suggests using NF to improve mental well-being, reflecting on Przybylko's (2021) call for a new NF paradigm of cross-cultural and universal interventions. Tabibnia (2020) offered a model that distinguishes between three brain activity channels relevant to improving well-being.

1. a channel aimed at reducing negative emotions and stress responses from the amygdala and hypothalamus;
2. a channel aimed at strengthening positive emotions triggered by brain reinforcement and motivation mechanisms;
3. a channel aimed to improve self-transcendence through brain mechanisms that reduce rumination in brain areas considered to increase self-reflectivity.

She sought intervention programs compatible with each channel, including Computer Based Training (CBT), and social support. However, her review did not include neurofeedback. The reason may lie in the trendiness of neurofeedback in education that brings some to apply caution in applying neuroscience to education or psychology. Many still emphasize that when selecting a neurofeedback protocol for an educational setting, one should carefully examine the suitability of the protocol for specific purposes and populations.

7. Conclusions

To the best of our understanding, the contribution of our research is the conceptualization of optimism in an applied setting that suggests a unique protocol for NF training. We hope that a better understanding of the correlation between brainwave activity and its impact on various well-being factors will help us understand how they may assist in dealing with other stressors – not only in the educational system. We hope the NF training method will broaden ways to nurture psychological assets. We hope that future research will continue to examine this protocol for other psychological factors. We also hope that future longitudinal studies will follow our results and better assess the validity and impact of our findings.

References

Atmaca, Ç., Rızaoglu, F., Türkdogan, T., & Yaylı, D. (2020). An emotion-focused approach in predicting teacher burnout and job satisfaction. *Teaching and Teacher Education*, *90*, 103025 https://doi.org/10.1016/j.tate.2020.103025

Andersson, R., (2020). Effects of a Mobile Phone-based Mindfulness Intervention for Teachers, and how Mindfulness Trait Correlates with Stress, Wellbeing, Burnout, and Compassion. Akademin för hälsa och välfärd, Högskolan Halmstad. https://5dok.org/document/ky6m0jnq-effects-mindfulness-intervention-teachers-mindfulness-correlates-wellbeing-compassion.html

Beshai, S., McAlpine, L., Weare, K., & Kuyken, W. (2016). A non-randomized feasibility trial assessing the efficacy of a mindfulness-based intervention for teachers to reduce stress and improve well-being. *Mindfulness*, *7*(1), 198-208.

Caprara, G. V., Alessandri, G., & Barbaranelli, C. (2010a). Optimal functioning: Contribution of self-efficacy beliefs to positive orientation. *Psychotherapie, Psychosomatik, Medizinische Psychologie*, 79, 328–330.

Caprara, G. V., Steca, P., Alessandri, G., Abela, J. R. Z., & McWhinnie, C. M. (2010b). Positive Orientation: Explorations on what is common to life satisfaction, self-esteem, and optimism. *Epidemiologia E Psichiatria Social*, *19*, 63-71.

Caprara, G. V., Alessandri, G., Eisenberg, N., Kupfer, A., Steca, P., & Caprara, M. G. (2012). The positivity scale. *European Journal of Psychological Assessment*, *24*, 701-712.

Carver, C. S., Scheier, M. F., & Segerstrom, S. C. (2010). Optimism. *Clinical Psychological Review Journal*, *30*, 879–889.

Carr, A., Cullen, K., Keeney, C., Canning, C., Mooney, O., Chinseallaigh, E., & O'Dowd, A. (2021). Effectiveness of positive psychology interventions: a systematic review and meta-analysis. *The Journal of Positive Psychology*, *16*(6), 749-769.

Connor, K. M., & Davidson, J. R. (2003). Development of a new resilience scale: The Connor-Davidson resilience scale (CD-RISC). *Depression and Anxiety*, *18*(2), 76-82.

Creed, P. A., Patton, W., & Bartrum, D. (2004). Internal and external barriers, cognitive style and the career development variables of focus and indecision. Journal of Career Development, 30, 277-294.

Dabrowski, A. (2020). Teacher well-being during a pandemic: Surviving or thriving? *Social Education Research*, *2*(1), 35-40. https://doi.org/10.37256/ser.212021588

Davidson, R. J. (2005). Well-being and affective still: Neural substrates and biobehavioural correlates. In Huppert, F. A., Baylis, N. & Keverne, B. (Eds). *The Science of Well- Being* (pp. 107-139). United Kingdom: Oxford University Press.

Dobrushina, O. R., Vlasova, R. M., Rumshiskaya, A. D., Litvinova, L. D., Mershina, E. A., Sinitsyn, V. E., & Pechenkova, E. V. (2020). Modulation of intrinsic brain connectivity by implicit electroencephalographic neurofeedback. *Frontiers in Human Neuroscience*, *192*.

Erthal, F., Bastos, A., Vilete, L., Oliveira, L., Pereira, M., Mendlowicz, M., & Figueira, I. (2021). Unveiling the neural underpinnings of optimism: a systematic review. *Cognitive, Affective, & Behavioral Neuroscience*, *21*(5), 895-916.

Falecki, D., & Mann, E. (2021). Practical applications for building teacher well-being in education. *Cultivating Teacher Resilience*, *175*.

Hecht. D. (2013). The neural basis of optimism and pessimism. *Institute of Cognitive Neuroscience*, *22*(3), 173-199.

Heinonen. K., Räikkönen, K. & Keltikangas-Järvinen, L. (2005). Self-esteem in early and late adolescence predicts dispositional optimism-pessimism in adulthood: A 21-year longitudinal study. *Personality and Individual Differences*, *39*, 511-521.

Hepburn, S. J., Carroll, A., & McCuaig, L. (2021). Exploring a Complementary Stress Management and Well-being Intervention Model for Teachers: Participant Experience. *International Journal of Environmental Research and Public Health*, *18*(17), 9009.

Hershaw, J. N., Hill-Pearson, C. A., Arango, J. I., Souvignier, A. R., & Pazdan, R. M. (2020). Semi-automated neurofeedback therapy for persistent postconcussive symptoms in a military clinical setting: a feasibility study. *Military Medicine*, *185*(3-4), e457-e465.

Gapen, M., van der Kolk, B. A., Hamlin, E., Hirshberg, L., Suvak, M., & Spinazzola, J. (2016). A pilot study of neurofeedback for chronic PTSD. *Applied Psychophysiology and Biofeedback*, *41*(3), 251-261.

Gruzelier, J. I., Foks, T., Steffert, M. J & Chen, T. R. (2014). Beneficial outcome from EEG-neurofeedback on creative music performance, attention and well-being in school children. *Biological Psychology*, *95*, 86-95.

Kong, F., Ding, K., Yang, Z., Dang, X., Hu, S., Song, Y., & Liu, J. (2015). Examining gray matter structures associated with individual differences in global life satisfaction in a large sample of young adults. *Social Cognitive and Affective Neuroscience, 10*(7), 952-960.

Lagat, K. T. (2021). Factors Affecting Teachers' Resiliency Amidst the COVID-19 Pandemic. *Recoletos Multidisciplinary Research Journal, 9*(1), 133-145.

Larsen, R. J., Diener, E. D., & Emmons, R. A. (1985). An evaluation of subjective well-being measures. *Social Indicators Research, 17*(1), 1-17.

Marcionetti, J., & Castelli, L. (2022). The job and life satisfaction of teachers: A social cognitive model integrating teachers' burnout, self-efficacy, dispositional optimism, and social support. *International Journal for Educational and Vocational Guidance, 1-23*.

Marzbani, H., Marateb, H. R. & Mansourian, M. (2016). Neurofeedback: a comprehensive review on system design, methodology and clinical applications. *Basic Clin Neurosci, 7*(2),143e58. https://doi.org/10.15412/J.BCN.03070208

McLean, L., Abry, T., Taylor, M., & Gaias, L. (2020). The influence of adverse classroom and school experiences on first year teachers' mental health and career optimism. *Teaching and Teacher Education, 87*, 102956.

Mckay, R., Arciuli, J., Atkinson, A., Bennett, E. & Pheils, E. (2010). Lateralisation of self-esteem: an investigation using a dichotically presented auditory adaptation of the Implicit Association Test. *Cortex, 46*, 367-373.

Neff, K. D. & Vonk, R. (2009). Self-compassion versus global self-esteem: two different ways of relating to oneself. *Journal of Personality and Social Psychology, 77*,23-50.

Nicholson, A. A., Ros, T., Densmore, M., Frewen, P. A., Neufeld, R. W. J., Théberge, J., Jetly, R., & Lanius, R. A. (2020). A randomized, controlled trial of alpha-rhythm EEG neurofeedback in posttraumatic stress disorder: A preliminary investigation showing evidence of decreased PTSD symptoms and restored default mode and salience network connectivity using fMRI. *NeuroImage: Clinical, 28*(1), 1-15. https://doi.org/10.1016/j.nicl.2020.102490

Olson, I. R., Plotzker, A., & Ezzyat, Y. (2007). The enigmatic temporal pole: a review of findings on social and emotional processing. *Brain, 130*(7), 1718-1731.

Özdemir, S., & Kerse, G. (2020). The effects of COVID-19 process on health care workers: Analysing of the relationships between optimism, job stress and emotional exhaustion. *International and Multidisciplinary Journal of Social Sciences, 9*(2), 178-201. http://doi.org/10.17583/rimcis.2020.5849

Phneah, S. W., & Nisar, H. (2017). EEG-based alpha neurofeedback training for mood enhancement. *Australasian Physical & Engineering Sciences in Medicine, 40*(2), 325-336.

Pidgeon, D. (2021). *COVID Burnout: A New Phenomenon?* Doctoral dissertation, Dublin, National College of Ireland.

Przybylko, G., Morton, D. P., & Renfrew, M. E. (2021). Addressing the COVID-19 mental health crisis: a perspective on using interdisciplinary universal interventions. *Frontiers in Psychology, 12*, 1102.

Rosenberg, M. (1965). Rosenberg self-esteem scale. *Journal of Religion and Health*. https://doi.org/10.1037/t01038-000

Scheier, M. F., & Carver, C. S. (1985). The Self-Consciousness Scale: A revised version for use with general populations 1. *Journal of Applied Social Psychology, 15*(8), 687-699.

Scheier, M. F., Matthews, K. A., Owens, J. F., Magovern, G. L., Lefbver, R. C., Abott, R. R. & Carver, C. S. (1989). Dispositional optimism and recovery from coronary artery bypass surgery. The beneficial effects on physical and psychological well-being. *Journal of Personality and Social Psychology, 57*, 1024-1040.

Scheier, M. F., Carver, C. S., & Bridges, M. W. (1994). Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem). A revaluation of the Life Orientation Test. *Journal of Personality and Social Psychology, 67*(6), 1063–1078. https://doi.org/10.1037/0022-3514.67.6.1063

Sharot, T., Kanai, R, Marston, D., Korn, C. W. & Dolan, R. J. (2012). Selectively altering belief formation in the human brain. *Proceedings of the National Academy of Sciences of the United States of America, 109*, 17058-17062.

Tabibnia, G. (2020). An affective neuroscience model of boosting resilience in adults. *Neurosci Biobehav Rev, 115*, 321-350.

Urry, H. L., Nitschke, J. B., Volsci, I., Jackson, D. C., Dalton, K. M. & Mueller, C. J. (2004). Making a life worth living: Neural correlates of well-being. *Psychological Science, 15*, 367-372.

Raymond, J., Sajid, I., Parkinson, L. A., & Gruzelier, J. H. (2005). Biofeedback and dance performance: A preliminary investigation. *Applied Psychophysiology & Biofeedback, 30*(1), 65-74. https://doi.org/10.1007/s10484-005-2175-x

Reddy, R. P., Rajeswaran, J., Bhagavatula, I. D., & Kandavel, T. (2014). Silent epidemic: The effects of neurofeedback on quality-of-life. *Indian Journal of Psychological Medicine, 36*(1), 40-44.

Reyes, M. E., Dillague, S. G., Fuentes, M. I., Malicsi, C. A., Manalo, D. C., Melgarejo, J. M., & Cayubit, R. F. (2019). Self-esteem and optimism as predictors of resilience among selected Filipino active duty military personnel in military camps. *Journal of Positive Psychology & Wellbeing, 4*(1), 15-25.

Ribas, V. R., Ribas, R. D. M. G., & Martins, H. A. D. L. (2016). A curva da aprendizagem de peter van deusen em neurofeedback. *Dementia & Neuropsychologia, 10*(2), 98-103.

 doi:10.20944/preprints202401.2137.v1

Rubin, O. (2011). *Neurofeedback.* Beit Alim Publishing (in Hebrew).

Russo, G. M. (2021). The Efficacy of Neurofeedback in the Treatment of Individuals with Anxiety-Spectrum Disorders: A Meta-Analysis. Doctoral dissertation, The University of Mississippi.

van Agteren, J., Bartholomaeus, J., Steains, E., Lo, L., & Gerace, A. (2021). Using a technology-based meaning and purpose intervention to improve well-being: a randomized controlled study. *Journal of Happiness Studies, 22*(8), 3571-3591.

Ward, K. P., Porter, N. A., & Wood, D. S. (2019). The effectiveness of neurofeedback in an outpatient setting: A multilevel modeling approach. *Research on Social Work Practice, 29*(8), 939-948.

Weber, L. A., Ethofer, T., & Ehlis, A. C. (2020). Predictors of neurofeedback training outcome: A systematic review. *NeuroImage: Clinical, 27*, 102301.

Zoefel, B., Huster, R. J, & Hermann, C. S. (2011). Neurofeedback training of the upper alpha frequency band in EEG improves cognitive performance. *NeuroImage, 54*, 1427-1431.