Heart-Brain Coherence: Relationship Between High Coherence Ratio and Reading Anxiety Among Iranian EFL Learners[1]

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Abstract

Based on psychophysiological research, coherent heart-brain interaction can change afferent cardiac signal pattern sent to the brain. Accordingly, the present study aimed at facilitating the emotion-cognition interaction through HeartMath Institute self-regulated emotional techniques to investigate the efficacy of heart-brain coherence on reading anxiety reduction that significantly enhances attention, memory, comprehension, and efficiency in learning. Participants were 63 Iranian university and high school students. In order to enable the participants to self-generate high psychophysiological state and optimal heart rate variability (HRV), TestEdge program, a biofeedback remedy that teaches students skills to self-regulate negative emotional learning impediments, was administered. Findings indicated that the combination of intentional heart focus with the generation of sustained positive feelings increased heart-brain coherence and resulted in a beneficial mode of psychophysiological state. This heart-brain coherence affected and controlled the HRV patterns significantly among the participants on average which, in turn, reduced reading anxiety. Particularly, this study found significant differences among the EFL students with high, mid, and low levels of coherence and their reading anxiety level.

***Keywords*:** Heart-Brain Coherence; Heart-Rate Variability (HRV); Reading Anxiety; TestEdge Program

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1. Introduction

According to the teachings of divine religions and some Roman or Persian philosophers such as Aristotle and Avicenna, the heart has been referred to as both physical and nonphysical and the center of wisdom and emotions. One of the verses of Holy Quran (Hajj: 46) reveals not only the duty but also the place of the heart. Therefore, one interpretation is that The Lord is talking about the physical heart, not the metaphorical heart called soul. Recently, the MRI neuroimaging suggests that the brain is deeply affected by the emotional processes (Immordino & Damasio, 2007). It has been shown that the heart transmits complex patterns of neurological and electromagnetic information to the different parts of the brain which create a main component of the physiological backdrop. This ultimately determines our cognitive and emotional experience (Appelhans, & Luecken, 2006; Armour, 2003, 2007; Bradley, McCraty, Atkinson, Tomasino, Daugherty, & Arguelles, 2010; McCraty, 2001, 2003a, 2003b, 2005, 2011; McCraty & Rees, 2009; Rozman, McCraty, & Goelitz, 1998; Thayer & Lane, 2009) This understanding signifies that changes in emotional states cause heart rate variability (HRV), which is an index of regulated emotional responding and one of the most valuable research tools in examining the interactions between emotion and cognition. McCraty (2003b) defines HRV as "naturally-occurring, beat-to-beat changes in heart rate, which are reflective of heart-brain interactions and autonomic nervous system dynamics" (p. 2).

The purpose of the present study was to investigate the effectiveness of self-regulated emotional techniques on heart-brain coherence and reading anxiety. Having a better understanding of the effect of HeartMath techniques may also assist educational researchers and teachers in their abilities at providing the best possible training to their students. Furthermore, knowing the relationships of how the HeartMath tools and techniques affect individuals' anxiety levels can prove valuable for both teachers and the students in their work. The design of the present study was one-comparison-group-pretest-posttest design (Best & Kahn, 2006). Self-regulation techniques were considered as independent variables and HRV and reading anxiety were taken into account as dependent variables. The following questions were addressed to fulfill the purpose of this study.

1. Does the implementation of self-regulated techniques increase EFL students' heart-brain coherence ratio?
2. Is there any significant relationship between heart-brain coherence and reading anxiety?

2. Literature Review

2.1. Emotional Learning

Although many educational systems pay much attention to students' cognitive skills from the moment they enter the kindergarten classroom, very little emphasis is placed on emotional intelligence (EI; Colman, 2015) and management of their inner conflicts and unbalanced emotions they bring with them everyday to school. Coleman defines EI as the ability to monitor one's or people's emotions to differentiate between various emotions to guide thinking and behavior that drive leadership performance. Learning failure frequently cooccurs with emotional problems, poor self-concept, and negative affect (Nelson, Benner, & Rogers-Adkinson, 2003; Novosel, 2012). Emotional learning offers a very timely and much-needed aid to schools in making a reality of their main mission (McCraty & Childre, 2003; Markham, 2004).

Whereas it was formerly maintained that emotions originated only in the brain, McCraty (2004) explains that emotions can be more accurately described as a product of the heart and brain acting together. Research in neurocardiology has proved that the heart acts as a complicated and wise center that can encode and process information to learn, remember, and make decisions (Ardell, 1994; Armour & Ardell, 2004; Amour & Kember, 2004). Gould, Cameron, Daniels, Woolley, and McEwen (1992) suggest that, in the hippocampus, cell proliferation is reduced in subgranular zone (SGZ) of the dentate gyrus because of negative emotions, whereas positive emotions and antidepressant treatments increase it. As Wolpow, Johnson, Hertel, and Kincaid (2011) state, exposure to stressful situations decreases the function of corpus callosum (i.e., the bridge between two hemispheres) and cerebral cortex with increase in heart rate leading to deficiency in learning. One sensitive tool which provides a noninvasive measure of neurocardiac function and autonomic nervous system dynamics is the HRV analysis (Appelhans & Luecken, 2006; Tiller, McCraty, & Atkinson, 1996).

2.2. Self-Regulated Learning and Heart-Brain Coherence

According to Dörnyei (2005), learners are active in learning processes. To control their learning, they move from other-regulation to self-regulation (Lantolf, 2006). This is the confirmation of research in neurobiology and psychophysiology which explains that learning emotional self-regulation techniques significantly improves attention, memory, intelligibility, and reasoning (Bradley, Atkinson, Tomasino, Rees, & Galvin, 2009; Schore, 1994). Researchers have shown that the heart has a crucial role in affecting our emotional experience and regulating the autonomic nervous system (Armour, 2007; Bradley et al., 2007; Bradley et al., 2010;

Childre, & Rozman, 2005; Kim, 2011); therefore, compassionate qualities of the heart such as positive thinking and self- care can be learned to reduce anxiety (Wolpow et al., 2011).

Neurologists like Childre and Martin (1999) found that the "rhythmic beating patterns of the heart are transformed into neural impulses that directly affect the electrical activity of the higher brain centers" (p. 11). It could either facilitate or restrain the brain's electrical activity. Based on the field theory and holographic principles (Laszlo, 1995), in addition to the principles of the systems theory (Kafatos & Nadeau, 1990), intuitive perception gains entrance to a field of energy where information about future events is set spectrally. Dalton (2013) refers to different HRV applications: synchronizing alpha waves of the brain with the heart rhythms, regulating autonomic nervous system, and cognitive development. Based on research on heart intuition or psychophysiology of emotions focusing on information perception out of our consciousness (Pearsall, 1999) and responding to emotionally relevant information or heart intelligence (McCraty & Rees, 2009) and through presenting electrophysiological evidence (Arguelles, McCraty, & Rees, 2003; McCraty, Atkinson, & Bradley, 2004; McCraty, 2005; McCraty, Atkinson, Tomasino, & Bradley, 2009), the Institute of HeartMath has shown that self-regulating techniques that combine intentional heart focus with the creation of maintained positive feelings lead to a helpful state of psychophysiological coherence. This heart-brain coherence affects and controls HRV patterns which are more ordered during positive emotional states whereas irregular during negative feelings indicating that the signals of the two branches of the autonomic nervous system do not synchronize with each other (Bradley et al., 2007; Childre & Rozeman, 2005; McCraty, 2001, 2005, 2011; Reich, 2009).

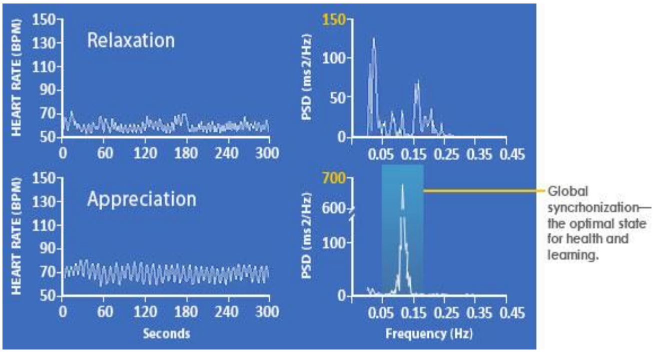

Figure 1. HRV Patterns During Different Emotional States (McCraty & Childre, 2003, p. 6)

The neurological heart-brain interaction can be measured through analyzing HRV measures from electrocardiograms. The normal HRV indicates the synergistic action of the two branches of autonomic nervous system. The IHM main purpose is reducing the level of stress and achieving a better performance by monitoring heart rhythms through applying TestEdge program and emWave technology. The first intervention is focusing on positive emotions through self-regulation techniques to increase heart-brain coherence. HRV data are collected and translated into graphics by a software program, emWave Desktop, to show if our physical, emotional, and cognitive, systems are in synchronization or out of synchronization.

2.3. Affective Factors: Reading Anxiety

It has been shown that the heart plays a critical role in regulating the autonomic nervous system and reducing the effect of our negative emotional experience on the brain (Armour, 2007; Bradley et al., 2010; Kim, 2011). The MRI neuroimaging suggests that the cognitive functions of brain are both deeply affected by and subsumed within the processes of positive and negative emotions (Immordino & Damasio, 2007). For example, anxiety decreases the function of corpus callosum and cerebral cortex leading to deficiency in language development and reasoning, as well as problems in regulating our emotions (Wolpow et al., 2011). To assist in managing our emotions, conscious effort to practice individual self-regulating techniques on a regular basis is required. Learning these techniques can significantly enhance learning.

Differing from trait anxiety, language anxiety as a kind of state anxiety and permanent kind of personality arouses in a particular situation (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). It has a negative effect on learning (Horwitz, Horwitz, & Cope, 1986; MacIntyre & Gardner, 1991b) and, according to Ellis (2008), it can be the result of difficulties with learning, rather than their causes. The nature of reading is complex and L2 reading is, further, complicated which needs to coordinate attention, perception, memory, and comprehension through various reading skills (Carrell & Grabe, 2002; Sellers, 2000). Reading anxiety, which is somehow distinct from language anxiety, is related to reading L2 texts (Saito, Horwitz, & Garza, 1999). There is a negative relationship between reading anxiety and L2 performance, that is, anxious students recall less content of the text (Erbe, 2007; Hsu, 2004; In'nami, 2006). Whereas most discussions of language anxiety have centered on the difficulties with oral performance, Saito et al. (1999) discuss the possibility of anxiety in response to reading and offer Foreign Language Reading Anxiety Scale (FLRAS). To find out the relationship between heart-brain coherence and reading anxiety, this scale has been used to elicit students' self-reports of reading anxiety.

Historically, in some philosophical schools of thought, for example, according to Aristotle and Avicenna, the heart was regarded as the center of wisdom.

Today, MRI neuroimaging findings provide evidence that the brain is profoundly affected by the heart and emotions. Psychoneurologists have also reported great cognitive and emotional changes in their patients' behavior after receiving the new heart (Pearsall, 1999)—the patients behaved more similar to their heart donators. Moreover, in the Holy Quran, in more than 100 verses, it is mentioned that the heart is responsible for our thoughts and behaviors. For example, in verse 46 of Hajj, not only the duty but also the place of the heart is emphasized: in our breasts. Therefore, it can be claimed that it is about the physical not the metaphorical heart. All of these evidences prompted the current researchers to undertake this research on the role of amazing heart, specified in teaching students self-regulated emotional techniques that promote acquisition of skills requisite for better student learning performance.

3. Methodology

3.1. Participants

The participants, ranging in age from 16 to 25, were 43 both male and female Iranian university students at Islamic Azad University and 20 female students of Tehran Farzanegan High School, differing in the level of reading performance. Each participant was compared with himself or herself not with others; therefore, reading proficiency level was not considered as a variable in this study.

3.2. Materials and Instrumentation

The passages of the book *Mosaic 1* (Wegmann & Knezevic, 2008) were selected as the reading materials. To examine the reading difficulty of pretest and posttest passages, Fry Graph Readability Formula (1968) was used. All the passages had almost the same grade difficulty measure of the readability.

The following instruments were used in this study: (1) Student Activity Guide (Novosel, 2012) to present the understanding of treatment, (2) an adapted form of Self-Care Checklist (Wolpow et al., 2011) to help the participants deal with their anxiety, (3) IHM self-regulation techniques like Cut-Thru (Childre & Martin, 1999; Childre & Rozman, 2002), Freeze-Frame, Heart Lock-In (Childre, 1998; McCraty & Childre, 2003), and Neutral Tool (Childre & Rozman, 2005) to facilitate managing emotions and focusing on the heart to make changes in the patterns of afferent cardiac input sent to the brain, (4) an emWave desktop instrument (a software) to record the participants' HRV and level of coherence, and (5) the FLRAS (Saito et al., 1999) to elicit the participants' self-reports of reading anxiety.

3.3. Procedure

The main behavioral objective of this study was to make the participants aware of identifying their emotions and attempting to be released from negative feelings to achieve more psychophysiological coherence. Following Novosel (2012), an adapted 180-min lesson plan was used. At first, with the help of Student Activity Guide (Novosel, 2012), the new concepts and key words were defined. Then, to deal with anxiety, the Self-Care Checklist (Wolpow et al., 2011) strategies were introduced. Then, the steps of the IHM self-regulation techniques were practiced. These techniques are entangled with (1) shifting away the focus from the mind to the area around the heart for, at least, 10 s while breathing normally, (2) recalling a positive thing or feeling to neutralize any anxiety, and (3) listening to the heart based on heart intuition to identify and reprogram the subconscious emotional memory pathways to increase coherence (Childre & Rozman, 2002; Reich, 2009). All was performed by the interactive modeling of these techniques. Examples of the lessons, activities, and objectives of the schedule are listed in Table 1:

Table 1. *Self-Regulation Lesson Plan (Adapted From Novosel, 2012, p. 74)*

Lessons	Activities	Objectives
1	Providing information on terminology and self-regulation techniques (45 min)	The students will be familiar with the definitions of key words in addition to self-regulation techniques requisite to understanding treatment.
2	Guided practice: HRV screen & coherence coach (30 min)	The students will demonstrate steps of self-regulation techniques and functions of HRV screen.
3	Group practice (30 min)	The students will name the steps of self-regulation techniques via oral response.
4	Modeling and guided practice (30 min)	The students will demonstrate the steps of self-regulation techniques.
5	Program Overview: (45 min)	The students will identify terminology and concepts.

To indicate the level of participants' psychophysiological coherence and reading anxiety, pretest and posttest were administered on the coherence level ratio and FLRAS. To collect and translate the HRV patterns of each participant into graphics, a pulse sensor plugged into the USB of a computer was clipped to their earlobe. The more coherence was achieved, the smoother heart rhythm patterns became. A tricolored bar graph (i.e., green, blue, and red) showed the degree of attained coherence: high, medium, and low coherence:

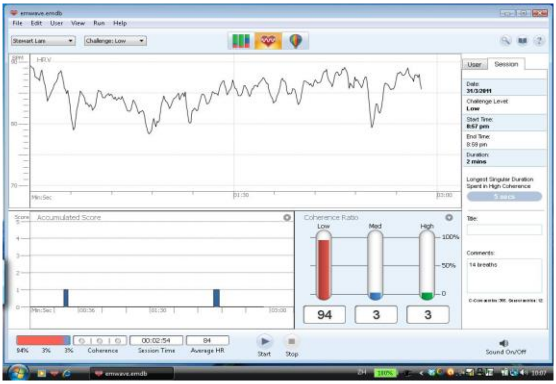

Figure 2. Heart Rate Variability Monitor

Figure 3. The USB Port

Figure 4. Earlobe Puls Sensor

4. Results

A nonparametric test (i.e., Wilcoxon Signed Ranks Test) and three separate path models were run to analyze the data. Checking the normality of the data, the results indicated that the ratios of kurtosis and skewness over the respective standard errors were acceptable, except for the high coherence ratio of pretest. Therefore, a nonparametric Wilcoxon test was used to answer the first research question.

4.1. Research Question # 1

Based on the results of Wilcoxon Signed Ranks Test run on the participants' high coherence ratio (see Table 2), there was a higher positive mean rank in the difference between the pretest and the posttest (*MR* = 32.35), meaning that the participants' high coherence ratio was higher on the posttest in comparison with the pretest:

Table 2. *Mean and Sum of Ranks; High Coherence Ratio of Pretest and Posttest*

		N	Mean Rank	Sum of Ranks
PostHC - PreHC	Negative Ranks	5[a]	16.01	80.00
	Positive Ranks	56[b]	32.35	1812.00
	Ties	2[c]		
	Total	63		

a. PostHighCoh < PreHighCoh
b. PostHighCoh > PreHighCoh
c. PostHighCoh = PreHighCoh

Furthermore, the results showed a significant difference between the pretest and the posttest of high coherence ratio and the participants' mean rank on the posttest was higher (p = .000, Z = -6.21, r = .858, showing a large effect size):

Table 3. *Wilcoxon Signed Rank Test Statistics*[a]

	PostHC - PreHC
Z	-6.219[b]
Asymp. *Sig*. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks

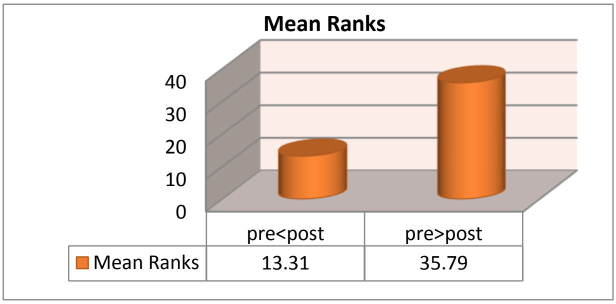

Figure 5. Mean Ranks: Pretest and Posttest High Coherence Ratio

4.2. Research Question # 2

The second research question asked if heart-brain coherence affected stress relief and reading anxiety or not. Three separate path models were tested in order to probe the second research hypothesis. The logic behind running path models was that the higher the heart coherence ratio (HCR), the lower the reading anxiety. In other words, it was hypothesized that the path model for the low HCR should show the highest contribution to reading anxiety whereas the high HCR should have the lowest or even negative effect on reading anxiety.

4.2.1. Path model of low heart coherence ratio (HCR)

Path model 4.2.1 displays the relationships between the pretest and the posttest of the low HCR and the pretest and the posttest of reading anxiety. It was hypothesized that the low HCR on the pretest correlated with the low HCR on the posttest, both of which, in turn, affected reading anxiety. The regression weights displayed on the arrows are analogous to standardized regression weights (Beta) in an ordinary regression model. The results indicated that:

A. If the posttest of the low HCR increased by 1 full *SD*, the posttest of reading anxiety increased by .58 *SD* (*p* = .000). That is to say, if the low HCR becomes lower, the reading anxiety will increase.

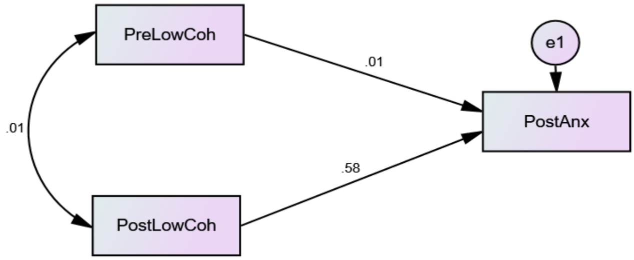

Figure 6. Path Model 4.2.1 Effect of the Low HCR on Reading Anxiety

B. Also, the results indicated that the pretest of the low HCR had a negligible effect on the posttest of reading anxiety (Beta = .007, *p* = .942), that is, if pretest of the low HCR increased by 1 full *SD*, the posttest of reading anxiety increased by .017 *SD*.

Table 4. *Non(standardized) Regression Weights; Low HCR on Posttest of Reading Anxiety*

			Unstandardized Estimate	S.E.	C.R.	*p*	Standardized Estimate
PostAnx	<---	PreLowCoh	.017	.241	.072	.942	.007
PostAnx	<---	PostLowCoh	.816	.147	5.546	.000	.576

C. The pretest of the low HCR had a negligible correlation (Beta = .01) with the posttest of low HRC. An additional finding of interest was that path model 5.2.1 enjoyed a significant fit (χ^2 (1) = .710, *p* = .399, χ^2/df = .710, GFI = .992, IFI = 1, TLI = 1, CFI = 1, RMSEA = .000, and PCLOSE = .435).

4.2.2. Path model of mid heart coherence ratio (HCR)

Path model 4.2.2 displays the relationships between the pretest and the posttest of the mid HCR and the posttest of reading anxiety. It was hypothesized that the pretest of the mid HCR was correlated with the posttest of the mid HCR, both of which, in turn, affected reading anxiety. The results indicated that:

A. If the posttest of the mid HCR increased by 1 full *SD*, the posttest of reading anxiety decreased by .32 *SD* (p = .007). That is to say, the higher of the mid HCR on the posttest lead to lower reading anxiety.

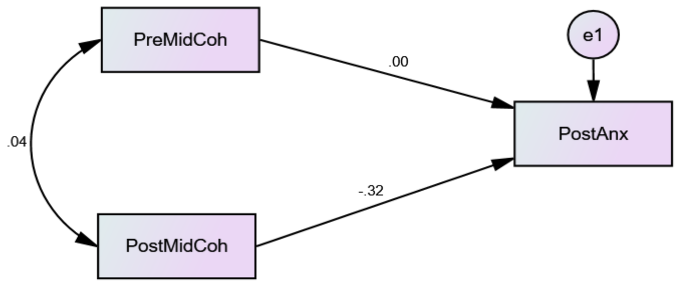

Figure 7. Path Model 4.2.2 Effect of the Mid HCR on Reading Anxiety

B. Also, the results indicated that the pretest of the mid HCR had a negligible effect on the posttest of reading anxiety (Beta = -.003, p = .986), that is, if the pretest of the mid HCR increased by 1 full *SD*, the posttest of reading anxiety decreased by .003 *SD*.

Table 5. *(Un)standardized Regression Weights; Mid HCR on Posttest of Reading Anxiety*

			Unstandardized Estimate	S.E.	C.R.	*p*	Standardized Estimate
PostAnx	<---	PreMidCoh	-.008	.466	-.017	.986	-.003
PostAnx	<---	PostMidCoh	-.978	.364	-2.687	.007	-.323

C. The pretest of the mid HCR had a negligible correlation (Beta = .04) with the posttest of mid HRC. Path model 5.2.2 enjoyed a significant fit (χ^2 (1) = .394, P = .530, χ^2/df = .394, GFI = .996, IFI = 1, TLI = 1, CFI = 1, RMSEA = .000, and PCLOSE = .561).

4.2.3. Path model of high heart coherence ratio (HCR)

Path model 4.2.3 displays the relationships between the pretest and the posttest of the high HCR and the posttest of reading anxiety. It was hypothesized that the high HCR on the pretest correlated with the high HCR on the posttest, both of which, in turn, affected reading anxiety. The results indicated that:

A. If the posttest of the high HCR increased by 1 full *SD*, the posttest of reading anxiety decreased by .53 *SD* (p = .000). It means that if the posttest of the high HCR is higher, the reading anxiety will be lower.

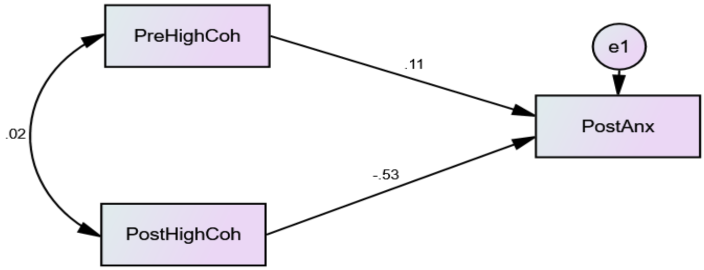

Figure 8. Path Model 4.2.3 Effect of the High HCR on Reading Anxiety

B. Also, the results indicated that the pretest of the high HCR had a negligible effect on the posttest of reading anxiety (Beta = .106, p = .323), that is, if the pretest of the high HCR increased by 1 full *SD*, the posttest of reading anxiety increased by .323 *SD*:

Table 6. (*Un)standardized Regression Weights; High HCR on Posttest of Reading Anxiety*

			Unstandardized Estimate	S.E.	C.R.	*p*	Standardized Estimate
PostAnx	<---	PreHighCoh	.424	.429	.989	.323	.106
PostAnx	<---	PostHighCoh	-.917	.187	-4.900	.000	-.526

C. The pretest of the high HCR had a negligible correlation (Beta = .004) with the posttest of the high HRC. Path model 5.2.3 enjoyed a significant fit (χ^2 (1) = .123, P = .830, χ^2/df = .123, GFI = .999, IFI = 1, TLI = 1, CFI = 1, RMSEA = .000, and PCLOSE = .745).

5. Discussion

Based on the abovementioned results of this study, it was revealed that the implementation of the self-regulated techniques could increase the participants' heart-brain coherence ratio. Moreover, it was found that the low HCR had the highest contribution to the posttest reading anxiety; the mid HCR had a negative effect on the posttest reading anxiety; and finally, the high HCR caused the lowest posttest reading anxiety. The results indicated that as the HCR increased, the reading anxiety decreased significantly.

Various methodologies have sought to eliminate affective barriers to L2 learning and make it a more pleasant and less stressful experience. Research on language anxiety shows it plays a detrimental role in L2 students' performance and achievements in language learning (Katalin, 2006; MacIntyre, 2002). The findings are greatly in line with the results of studies done in this field. Different studies have indicated that the application of heart rhythm coherence biofeedback has excellent results in various educational settings. For example, according to McCraty et al. (1999), the middle school students treated with emotional self-regulation techniques showed a significant improvement in areas like stress reduction, work management, risky behavior, attention, and the relationships with their teachers, classmates, and family members.

Segerstrom and Nes (2007) define HRV as a kind of parasympathetic control over the heart and state "more parasympathetic input results in more variable intervals between heart beats, that is, higher HRV" (p. 275). They suggest that as the parts of the brain involved in self-regulation skills overlap considerably with some parts involved in autonomic nervous system, specifically with regard to the prefrontal cortex, HRV measures may be considered as the indicator of self-regulatory capacity. The findings of their study confirmed that the HRV measures in the participants with a higher level of self-regulatory skills were higher than those with lower self-regulatory skills. In a study conducted on 60 students by Arguelles et al. (2003), stress resiliency was found more in the training group practiced the IHM self-regulation techniques than the control group who was not taught the techniques. Based on reserach findings, there is a high correlation directly between the HRV measures and improvement in emotional competence, cognitive performance, attention, stress reduction, and classroom behaviors (McCraty et al., 2009; Tiller et al., 1996). Moreover, Fabes and Eisenberg (1997, as cited in Appelhans & Leucken, 2006) found higher levels of resting respiratory sinus arrhythmia with the use of greater self-regulation and constructive coping strategies among university students. They found that those who had lower resting respiratory sinus arrhythmia felt more negative emotional state in response to stress, which caused interference with the implementation of adaptive self-regulation strategies.

In a similar vein, other investigations revealed that the IHM programs were effective in improving HRV that influenced emotional stability in turn (Arguelles et al., 2003; Bradley et al., 2007; Bradley et al., 2009; Bradley et al., 2010; Lloyd, Brett, & Wesnes, 2010; McCraty, 2003b, 2005, 2011; McCraty et al., 1999). Reading is also subject to variability within the affective factors such as anxiety, motivation, tolerance of ambiguity, and self-efficacy. More precisely, strategies for dealing with anxiety in an affective domain may have a kind of relationship to the test anxiety and learning (Kondo, 1996; Young, 1999). According to Bradley et al. (2007), the results of studies conducted by Test Edge National Demonstration Study (2005) showed a significant reduction in test anxiety with 75% reduced levels, a large increase in state-mandated test scores (from 60% to 70% in mathematics and 26% to 48% in English-language), and positive changes in their students' behavior.

In brief, it can be interpreted that programs teaching emotional self-regulation skills such as HeartMath techniques and tools increase HRV scores, boost learning and academic performance, and improve emotional well-being and classroom behaviors from the elementary school to the college level. However, it should be mentioned that there is not a large body of literature on heart-brain science, and specifically HRV measures, with education and learning. Without doubt, more research is needed in this direction; therefore, it is necessary to make more inquiries in this field to elucidate and verify the results.

Doubtlessly, this study is not without limitations which should be thoroughly taken into account before making suggestions for further research. For example, some variables like the length and genre of reading passages or the allotted time might change the results. The findings suggest further future research, as well. For example, by better understanding of the role of emotion, more instructional strategies can be designed to increase heart-brain coherence. The need for a wider range of contexts to be addressed can be considered in future investigations, too. As anxiety is an important factor in learning, a comparison between language learning difficulties in L2 and L1 can also be made. Moreover, investigating different aspects of L2 learning is also important in determining the role of heart-brain coherence in ELT. Furthermore, as a great deal of religious practices and beliefs are likely to draw on similar psychological processes as implicit self-regulation which may activate cognitive and emotional states, it could be of interest to investigate if there is a difference in HRV measures between students with religious affiliation and other students.

6. Conclusion

The key role of the physiology of the heart and positive emotions in making the learning context less stressful has been studied recently to enhance readiness and performance among learners. Practical tools have been developed to enable learners to self-regulate the physiological processes that are crucial in effective learning and performance. This study provides evidence which supports and extends most of earlier findings and indicates that HRV and emotions appear to be intricately interconnected. The most suggestive conclusion drawn from this study, compatible with many similar studies, is that effective self-regulating emotional techniques cause heart-brain interaction resulting in more regulated emotional responses. This study particularly showed a significant difference in reading anxiety with different levels of coherence—more coherence ratio causes less reading anxiety.

As HRV measures are responsive to and reflective of emotion, it seems better understanding of emotions can help educators facilitate learning. Consequently, the results of this study may have significant benefits to a large group of both teachers and students. Teachers can use this knowledge, as they plan lessons and actively encourage students to engage in activities that pay attention to self-regulation techniques which lead to heart-brain coherence. With respect to the efficacy of HRV biofeedback training, students could be prepared for the possibility of reading difficulties and possible anxiety. Therefore, we can conclud that L2 teachers should create a low-anxiety classroom environment in order to increase the psychophysiological coherence level in their learners.

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