Biofeedback in Grandmothers Raising Grandchildren:
Correlations Between Subjective and Objective Measures

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Research shows that 20% of grandmothers raising grandchildren experience stress and depression. Heart rate variability (HRV) biofeedback may help grandmothers track and regulate their physiological response to stress. This study therefore examined correlations between coherence scores reflecting HRV and self-report measures of stress, negative emotions, and depressive cognitions in 20 grandmothers raising grandchildren. Higher coherence scores were inversely and significantly correlated with self-report measures, suggesting the need to examine the effects of HRV biofeedback on biomarkers reflecting stress and depression.

The number of children living with grandparents in the United States has increased by 64% over the past 20 years; the majority of these grandparents are grandmothers (Kreider & Ellis, 2011; United States Census, 2009). Reasons for their taking on the role of primary caretaker range from death of the grandchild’s parents, or parental physical or mental health problems, including substance abuse, financial or legal problems, incarceration, and military deployment (Sprang, Choi, Eslinger, & Whitt-Woosley, 2014). However, assuming the mothering role for a second time can take a toll on the health of grandmothers (Dowdell, 2004), and keeping these grandmothers healthy is critical if they are to continue caregiving to their grandchildren.

Grandmothers who raise grandchildren are at risk for experiencing more stress and depressive symptoms than their peers (Musil et al., 2011; Musil, Warner, Zauszniewski, Wykle, & Standing, 2009). These grandmothers often report complex family relationships with the grandchild’s parents, who often have unstable living situations and may be in and out of the grandchild’s life (Musil et al., 2009). Grandchildren raised by grandparents are more likely than other U.S. children to have health and behavioral problems, including psychiatric diagnoses that may stem from prenatal exposure to drugs, early childhood neglect, or violence in the home (Smith & Palmeiri, 2007). Most grandmothers raising grandchildren are in their mid-to-late 50s (Ellis & Simmons, 2014), and many are experiencing the emergence of their own midlife health issues. These ongoing stresses and strains place grandmothers raising grandchildren at increased risk for physical and mental health problems.

Thus, it is important to identify strategies to minimize grandmothers’ stress and depressive symptoms so they can continue to provide care for grandchildren. However, intervention research with these grandmothers has been restricted to the examination of psycho-educational programs, social service networks, parenting skills training, and support groups (e.g., Brown et al., 2000; Collins, 2011; Cox, 2002; Kelley, Whitley, & Campos, 2010; Kelley, Whitley, & Sipe, 2007), and unfortunately, these strategies have had limited effectiveness in reducing stress and depressive symptoms.

Heart Rate Variability Biofeedback in Grandmothers
Heart rate variability (HRV) biofeedback enables individuals to learn to alter their physiology in order to reduce their stress and improve their overall health. Devices are used to capture breathing and heart rate, and to provide feedback to users that prompts them to make desirable changes that will persist after use of the device is discontinued. HRV, defined as the beat-to-beat variation in heart rate that reflects parasympathetic/sympathetic interaction, is considered the most accurate, noninvasive measure of autonomic activity (Lehrer et al., 2003; Vaschillo, Lehrer, Rishe, & Konstantinov, 2002). An imbalance in autonomic activity can be remedied by slow,
paced breathing that is facilitated with the use of a biofeedback device. One such device is the personal biofeedback device called the StressEraser (Muench, 2008).

The StressEraser is a portable, noninvasive, handheld biofeedback device manufactured by Helicor, Inc., and registered as a 510(k) exempt, Class II medical device (FDA) for use in relaxation training and stress reduction. Evidence of the feasibility, accuracy, and effectiveness of the StressEraser has been widely published (Ebben, Kurbatov, & Pollak, 2009; Heilman, Mandelman, Lewis, & Porges, 2008; Prinsloo et al., 2011). The portability and convenience of this biofeedback device (Kennedy & Pretorius, 2008) make it possible for grandmothers to use in their homes. The first study of HRV biofeedback for grandmothers raising grandchildren showed that following a 4-week HRV biofeedback intervention, grandmothers reported lower stress and fewer negative emotions and depressive cognitions (Zauszniewski, Au, & Musil, 2013). A follow-up study of grandmothers compared the effects of HRV biofeedback with Resourcefulness Training (RT) and journaling. Though the sample in that study was small, there were trends indicating that HRV biofeedback was slightly better than RT and journaling in decreasing stress, and it was superior to journaling in reducing depressive symptoms and improving quality of life (Zauszniewski & Musil, 2014).

In those studies, however, the outcomes were self-report measures, and self-report measures are subjective; therefore, it is not clear whether they reflect physiological changes that could be detected through an objective indicator. The StressEraser senses the fingertip pulse rate and displays the user’s breath wave on a screen as an uneven wave when stressed, or a smooth wave when relaxed. HRV amplitude is maximized by slow, paced breathing (e.g., six breaths/minute) to achieve heart rhythm coherence (McCraty & Tomasino, 2004). At the end of each biofeedback session, the StressEraser produces a coherence score, indicating whether breathing is sufficiently slow and in synchrony with heart rate (Ebben et al., 2009). Points are scored each time the user’s breathing rate is synchronized with the HRV waveform displayed on the StressEraser screen. Thus, the consistency between the user’s breathing rhythm and the HRV waveform is displayed in real time and the points earned, which may range from 1 to 3, with 3 representing the best synchronization, are computed to create a total score for the session. The StressEraser protocol recommends a score of 30 points per session and a sufficient number of sessions per day to attain a total minimum daily score of 100 points (Helicor, 2007).

This pilot study of 20 grandmothers raising grandchildren examined the effects of a 4-week biofeedback intervention focusing on HRV. HRV was selected as the modality for testing because impaired HRV, defined as the amount of fluctuation from the average heart rate reflecting sympathetic–parasympathetic interaction, has been linked to stress and depression (Prinsloo et al., 2011; Siepmann, Aykac, Unterdörfer, Petrowski, & Mueck-Weymann, 2008), and research shows that grandmothers raising grandchildren consistently report greater stress and depressive symptoms than other grandmothers who are not raising grandchildren (Baker & Silverstein, 2008; Musil, Jeanblanc, Burant, Zauszniewski, & Warner, 2013; Musil et al., 2009). The daily coherence score produced at the end of each HRV biofeedback session completed by the grandmothers was used as an objective measure that was correlated with self-report measures of perceived stress, negative emotions, and depressive cognitions, at 2 and 8 weeks postintervention.

Methods

Design and Sample

A longitudinal, correlational design was used with a convenience sample of 20 grandmothers raising grandchildren to examine associations between average coherence scores and subjective measures of stress, negative emotions, and depressive cognitions over time. The study was approved by the University Institutional Review Board as part of a larger study testing other interventions in grandmothers raising grandchildren. Data on subjective measures were collected at three time points spaced 6 weeks apart: (a) before the HRV biofeedback (baseline/Time 1); (b) within 2 weeks after the biofeedback (Time 2); and (c) 8 weeks after the biofeedback (Time 3). The HRV biofeedback was performed for 4 weeks between Time 1 and Time 2 data collections (Figure).

Grandmothers were recruited through flyers posted in health centers, churches, and places of business (e.g., grocery stores, department stores, restaurants, coffee houses, bookstores, libraries, etc.) and distributed to support groups for grandmothers raising grandchildren.
Grandmothers had to have grandchildren younger than 18 years of age who had lived with them for at least 6 months. Grandmothers’ ages ranged from 42 to 68 years with an average of 58 years. Ten were married and 10 were single, divorced, separated, or widowed. Ten were African American and 10 were Caucasian. Twelve reported having less than a college education and eight had college degrees. Eleven reported annual incomes less than $50,000.

**Variables and Measures**

Self-report measures were collected during structured face-to-face interviews before the 4-week biofeedback intervention and at 2 and 8 weeks afterwards. During these interviews, the data collectors read the items comprising the measures of the study variables to study participants; no other content was discussed. Objective data were recorded daily by the StressEraser biofeedback device for the 4-week intervention period, and scores were averaged to provide a mean coherence score.

Perceived stress was measured by the 14-item Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983) on which items are rated on a 5-point Likert scale from never to very often. Seven items, phrased in the opposite direction (indicating low stress), were reversed before calculating the perceived stress score. The scale’s internal consistency has been supported with Cronbach’s alphas ranging from .84 to .87 (Cohen et al., 1983; Cohen & Williamson, 1988). Construct validity has been supported by associations with self-assessed health, health service use, health behaviors, help-seeking behavior, and salivary cortisol (Schwartz & Dunphy, 2003; Wright et al., 2004).

Negative emotions were measured by the 10-item Emotional Symptom Checklist (ESC; Zauszniewski, Morris, Preechawong, & Chang, 2004). This scale asks respondents which negative emotions they experienced over the past 2 weeks. The 10 emotions on the scale are anxiousness, nervousness, tension, worry, anger, restlessness, irritability, sadness, loneliness, and unhappiness. Respondents score one point for each symptom reported and no points for those unreported; higher scores indicate more negative emotions. Internal consistency has been shown in studies of elders, with Cronbach’s alphas of .73 and .76 (Zauszniewski, Morris, et al., 2004; Zauszniewski, Bekhet, Lai, McDonald, & Musil, 2007; Zauszniewski, Eggenschwiler, et al., 2004). Significant correlations with established measures of anxiety and depression provide evidence of construct validity (Zauszniewski, Eggenschwiler, et al., 2004).

Depressive cognitions were measured by the eight-item Depressive Cognition Scale (DCS; Zauszniewski, 1995); responses are rated on a 6-point Likert scale, from strongly agree to strongly disagree, to indicate the degree to which items describe depressive cognitions (e.g., hopelessness, worthlessness, etc.). All eight items are worded in a positive way, such as “I am hopeful about the future.” Therefore, to capture depressive cognitions, scoring on all items is reversed. Internal consistency of the scale has been reported in various populations with Cronbach’s alphas ranging between .75 and .88 (Zauszniewski & Bekhet, 2012). Significant correlations in the expected direction with measures of psychosocial development, adaptive functioning, depressive symptoms, life satisfaction, resourcefulness, and health practices provide evidence of construct validity (Zauszniewski & Bekhet, 2012).

Coherence scores were obtained from the history function of the StressEraser and averaged across the number of sessions completed by each of the grandmothers. The number and timing of the daily sessions were also recorded from the device.

**HRV Biofeedback Intervention**

After the grandmothers completed the baseline data collection, during which they completed the self-report measures, a research assistant (RA) taught them the breathing protocol, developed by Helicor, Inc., to use with the StressEraser, (Helicor, 2007). Grandmothers were to (a) insert their left index finger into the pulse rate sensor clip on the top of the device; (b) inhale slowly while viewing the waves on the screen; (c) exhale slowly while counting slowly from one to five and watching for a triangle to appear above the wave; and (d) start to inhale again as the next wave began to rise. Grandmothers practiced with the RA present until they felt confident in using the device. Each grandmother was given a StressEraser to use for 4 weeks.

The RA instructed the grandmothers to use the StressEraser for 10–15 min every day for 28 days with a goal of achieving 30 points per session. Though these instructions deviated from the protocol developed by Helicor (2007), they were consistent with recommendation of daily performance of other interventions tested in the larger study. We used minutes per day, number of days, and points attained as indicators of implementation fidelity (Carpenter et al., 2013).

**Treatment Fidelity**

To assess the implementation fidelity of the HRV biofeedback training, we found that most of the grandmothers used the StressEraser at bedtime and, on average, the grandmothers used the StressEraser more frequently.
than recommended (i.e., 43 sessions over 28 days, compared to the recommended one session per day). The average duration of StressEraser use was 11–12 min, while the protocol recommendation is 10–15 minutes. The average points per session were 18, while the protocol suggests 30 points per session. We found a moderately strong correlation \((r = .50, p = .02)\) between the average minutes per session and average coherence points, indicating that the longer the grandmothers spent using the StressEraser, the better they coordinated their breathing with their heart rate. Correlations between average minutes per session and self-reported stress, negative emotions, and depressive cognitions at 2 weeks after the 4 weeks of biofeedback training were not statistically significant. However, the magnitude of these correlations \((r_s = -.36, -.51, \text{ and } -.32)\) suggests that associations might have emerged with a larger sample. More detailed information regarding treatment fidelity of the biofeedback training appears in Table 1.

**Results**

Given the pilot nature of this study and the small sample of grandmothers, our analysis was restricted to the examination of large effect sizes (i.e., \(r = .50\)) for correlations between average coherence points and measures of perceived stress, negative emotions, and depressive cognitions; the findings should be interpreted with caution.

**Perceived Stress and Coherence Points**

When perceived stress was examined in relation to the objective measure of coherence, we found significant correlations at all three time points, baseline (i.e. pre-intervention) and at 2 and 8 weeks postintervention, with the strongest correlation at baseline. Self-reported stress was strongly and inversely correlated with average coherence points: Greater perceived stress was associated with lower coherence, suggesting poorer HRV. The magnitude of the inverse correlations became weaker over time, which was consistent with the decreasing perceived stress scores over time. Table 2 shows the means and standard deviations for the subjective measures of perceived stress, negative emotions, and depressive cognitions over time. Table 3 displays the correlations between perceived stress and average coherence points over time.

**Negative Emotions and Coherence**

We also found significant correlations between the subjective measure of negative emotions and the objective measure of coherence at all three time points. Self-reported negative emotions were strongly and inversely correlated with average coherence—that is, greater negative emotions were associated with lower coherence reflecting poorer HRV. However, as with perceived stress, the magnitude of the correlations decreased over time. There was also a similar trend in decreasing mean scores on negative emotions over time (Table 2).

**Depressive Cognitions and Coherence**

Similar to our findings on measures of perceived stress and negative emotions, we found significant inverse correlations between depressive cognitions and average coherence

| Table 1. Implementation fidelity of heart rate variability biofeedback training |
|----------------|---|---|---|
| Parameter      | \(M\) | \(SD\) | Range |
| Total number of sessions | 42.95 | 39.52 | 10–154 |
| Total minutes recorded | 506.90 | 564.06 | 56–2,055 |
| Total points recorded | 743.50 | 700.25 | 56–2,877 |
| Average minutes per session | 11.30 | 7.82 | 4–30 |
| Average points per session | 18.05 | 13.18 | 3–60 |

| Table 2. Descriptive statistics on subjective measures over time |
|----------------|---|---|---|---|---|---|---|---|
| Variable       | Before Biofeedback (T1) | 2 Weeks After Biofeedback (T2) | 8 Weeks After Biofeedback (T3) |
|                | \(M\) | \(SD\) | \(M\) | \(SD\) | \(M\) | \(SD\) | \(M\) | \(SD\) |
| Perceived stress | 23.05 | 6.82 | 18.15 | 8.20 | 17.85 | 9.17 |
| Negative emotions | 6.30 | 3.37 | 5.20 | 3.47 | 4.50 | 3.38 |
| Depressive cognitions | 6.20 | 3.90 | 5.05 | 3.84 | 4.55 | 3.84 |
at the three time points; greater depressive cognitions were associated with lower coherence, which suggests poorer HRV. As with the other measures, the correlations between depressive cognitions and coherence grew weaker over time, which may be explained by the decreases in mean scores on depressive cognition that were found over time (Table 2).

**Discussion**

In summary, this pilot study of correlations between subjective measures of perceived stress, negative emotions, and depressive cognitions, and an objective measure of coherence obtained during 4 weeks of biofeedback training using the StressEraser found that higher mean coherence scores were correlated significantly over time with all three subjective measures, although the magnitude of the correlations diminished over time. Thus, the findings are consistent with our prior work (Zauszniewski et al., 2013) where we found that the self-reported distress variables of stress, depressive cognitions, and negative emotions all decreased from the baseline measurement before biofeedback to 8 weeks posttraining.

Unfortunately, we were unable to measure the self-reported psychological variables while the grandmothers were actively practicing biofeedback using the StressEraser, during which time the HRV coherence data were being collected. The measurement of perceived stress, negative emotions, and depressive cognitions during biofeedback may reveal more clearly the association between coherence and these psychological variables. However, the correlations decreased over time even though only the averaged coherence scores were used, suggesting that the psychological variables must have varied over time.

It is interesting to note that, in the current study, the highest correlations were between self-report variables measured prior to HRV biofeedback and coherence scores averaged after that time during the 4-week HRV biofeedback period. The correlations were in the expected direction, indicating that greater perceived stress, negative emotions, and depressive cognitions are associated with lower success in achieving coherence. However, correlations with self-reported psychological variables measured 2 weeks after HRV biofeedback training were substantial and significant and they remained significant, though lower, over time. Since an individual’s coherence score, as a measure of average coherence, remained constant across analyses, and psychological variable scores decreased over time, this suggests that HRV biofeedback training may have both immediate (2 weeks) and sustained effects (8 weeks) even if practice of the technique is not optimal. This may well have been the case with this sample, since the average coherence score was only 18 points per session, compared to the recommended achievement of 30 points (Helicor, 2007). However, we do not know whether grandmothers continued to use the breathing techniques after they completed the biofeedback training and no longer had the device.

The results are encouraging about the effects of HRV biofeedback. While the small sample size likely contributed to instability of the results, we can cautiously suggest that these results offer support for the effectiveness of HRV biofeedback in reducing stress, negative emotions, and depressive cognitions in grandmothers raising grandchildren. Further, substantial relationships were found between self-report measures of stress, negative emotions, and depressive cognitions and the objective measure of coherence. The relationships were particularly strong when grandmothers were in an untrained state. However, the variability at later time points may reflect treatment effects that were mediated by intervention uptake by the participants (Zauszniewski & Musil, 2014). These findings thus provide support for the validity of subjective measures

<table>
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<tr>
<th>Subjective Measure</th>
<th>Objective Measure: Average Coherence Points</th>
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<tr>
<td></td>
<td>Before Biofeedback (T1)</td>
</tr>
<tr>
<td>Perceived stress</td>
<td>( r = -.94^{***} )</td>
</tr>
<tr>
<td>Negative emotions</td>
<td>( r = -.89^{***} )</td>
</tr>
<tr>
<td>Depressive cognitions</td>
<td>( r = -.76^{***} )</td>
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*\( p < .05 \), **\( p < .01 \), ***\( p < .001 \).
of stress, emotions, and cognitions using the coherence score as an objective indicator.

There may be cause for concern about the overall health and well-being of the grandmothers in this study and women like them. Low HRV is associated with a host of health issues, including heart problems and mental health disorders (Wheat & Larkin, 2010). Further research to examine the effects of HRV biofeedback on stress biomarkers is needed. Future research should also include larger sample sizes and a nontreatment comparison group in which coherence is measured at baseline but without the benefit of continued training. Finally, capturing multiple concurrent measures of psychological stress variables and the coherence measures during HRV biofeedback training could elucidate the processes by which stress, negative emotions, and depressive symptoms are minimized.

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