Original Research

P300 Wave Outcomes in Subluxation Based Chiropractic in Residential Addiction Treatment: A Randomized Controlled Clinical Trial

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Abstract

Objective: Research is needed to determine if P300 wave analysis has significance as an outcome assessment of subluxation-based chiropractic care in the addiction treatment setting.

Methods: Two groups of male subjects in residential addiction treatment are studied for 90 days. The chiropractic group received chiropractic adjustments using Torque Release Technique® and the Integrator® adjusting instrument three times per week. The Placebo group received a sham adjustment three times per week. Both groups were assessed with the Beck's Depression Inventory and the Speilberger State-Trait Anxiety Questionnaire at intake and every 30 days. P300 analysis was taken at intake and every week for both groups.

Results: In the chiropractic group; depression scores improved by 97%, anxiety scores improved by 36.5% with 100% retention rate in the chiropractic group and 0% retention rate in the Placebo group. P300 wave results improved in the chiropractic group.

Conclusions: We conclude that chiropractic care utilizing the Torque Release Technique® improves retention rates, psychosocial inventory assessments and prevents relapse. More research is warranted to determine the significance in the use of the P300 wave as an outcome strategy in chiropractic intervention. Subluxation-based chiropractic care should be considered as standard care in the management of addicted individuals.

Key Words: *P300, Depression, Anxiety, Addiction, ADHD, Electroencephalography, Torque Release Technique®, Subluxation, Adjustment, Chiropractic, Integrator®*

Introduction

The nature of this study was to determine 1) if use of the P-300 wave has significance as an outcome assessment in the addiction treatment setting, 2) if use of the P-300 wave has significance as an outcome assessment of subluxation based chiropractic care, and 3) if the use of the P300 wave has significance as a biofeedback tool.

We hypothesized that P300 amplitude and latency will normalize with chiropractic intervention and positively correlate with favorable health and addiction outcomes including depression scores and anxiety scores. We hypothesized that P300 amplitude and latency will be more reluctant to normalize in the Placebo group and unfavorable health and addiction outcomes will be reflected.

We hypothesized the P300 wave will play an active and positive role as a biofeedback intervention and provide objective pre and post outcome assessments in both the addiction and chiropractic patient population.

Materials and Methods

This study was reviewed and approved by the Life University Institutional Review Board, Marietta GA. The study consisted of a placebo group (n=3) and a chiropractic group (n=2). Both groups received traditional residential addiction treatment, which consisted of counseling, group therapy, 12 step groups and addiction education. Both groups were assessed for outcomes over the course of 90 days.

Outcome assessments utilized included the following: P300 Event Related Potential (ERP) analysis using the Enigma™ P300, Beck's Depression Inventory II (BDI-II), and the Spielberger State-Trait Anxiety Inventory (STAXI). P300 ERP analysis was performed at intake and weekly; BDI-II and the STAXI were performed each at intake, 30 days, 60 days, and 90 days. Some participants elected to discontinue participation in the study prior to the full 90-day course of care, and data is reported with respect to each participant's length of time of participation (retention rate).

Chiropractic analysis with subsequent adjustments utilizing Torque Release Technique® (TRT) were performed three times per week for each participant in the chiropractic group for the total course of care. Those in the Placebo group were given a sham analysis and sham adjustment three times per week for the total course of care.

A chiropractic adjusting instrument known as the Integrator® was utilized to deliver both the chiropractic adjustments and the sham adjustments. Randomization was performed for group assignment and patients were blinded as to which group, they were in with the exception of one participant (Participant "C") who was assigned to the chiropractic group. Examiners were not blinded to group assignment.

Inclusion and Exclusion Criteria

Participants were obtained voluntarily and were administered their initial P300 assessment within eight days of initial intake at the outpatient addiction facility where this study was conducted. Clients of this facility were in residential addiction treatment and consisted of only males over the age of 18. The study excluded those diagnosed with severe co-occurring psychiatric disorders (e.g. schizophrenia, depression, anxiety diagnoses). The Drug Abuse Screening Test (DAST) was utilized at intake to document the existence of drug abuse for each participant. A thorough history and physical examination was performed at initial intake for each participant to determine eligibility.

Randomization

Pre-formed, sealed envelopes with group assignment were opened sequentially upon patient intake. Random Assignment was performed by www.randomizer.org Research Randomizer. Randomized permutations of five sets of numbers, with six numbers per set, with a number range from 1-2 (specifying Placebo or Treatment group), with each number in a set NOT remaining unique (meaning that each number can be used more than once), were performed. Five sets of six numbers were produced simply for the purpose of having enough random sets to accommodate for 30 participants, although we only obtained six participants. We used, therefore, only the first set of numbers.

An electronic randomized coin toss was then used to determine which number (1 or 2) would pertain to which group (Placebo or Treatment). Before the coin toss was performed, heads was designated to represent the Treatment Group and tails would represent the Placebo Group. The first (and only) coin toss determined which group the number "1" pertained to. The coin toss resulted in "tails", meaning that the number "1" pertained to the Placebo group.

Chiropractic Intervention

The chiropractic group received chiropractic assessments and adjustments utilizing Torque Release Technique® (see below) and the Integrator® adjusting instrument (see below). All adjustments were administered either of two clinicians. As the participants arrived for their scheduled adjustment, they were escorted to a sequestered room containing an Integrator Adjusting Table™.

They were then instructed to lie face down on the table and then re-positioned to ensure that they were centered on the table. This is done by holding the ankles and positioning the legs in such a way to center the pelvis on the table. The examiner then began using the Torque Release Technique® protocol for diagnosing the primary subluxation. This included the TRT Pressure Test in conjunction with TRT's 15 Diagnostic Indicators and TRT's Functional Leg Length Reflex (FLLR) invoking the Achilles deep tendon reflex, an objective neurological exam.

If the participant presented with a primary subluxation it was adjusted using the Integrator®. They were adjusted up to, but not exceeding, three adjustments per intervention session. If they did not present with a primary subluxation, then they were not adjusted that day. Regardless of whether they were adjusted or not, each visit counted as an intervention. The participants then presented for another intervention at their next scheduled appointment.

Placebo

The placebo group received a sham-adjustment in lieu of an actual adjustment three times per week throughout the course of their participation in the study. As the participants arrived for their scheduled adjustment, they were escorted to a sequestered room containing an Integrator Adjusting Table™. The examiner then instructed the participant to lie face down on the table and then re-positioned the patient to be centered on the table. The examiner then began using the Torque Release Technique® protocol for diagnosing the primary subluxation. This included the TRT Pressure Test in conjunction with TRT's 15 Diagnostic Indicators and TRT's Functional Leg Length Reflex (FLLR™) invoking the Achilles deep tendon reflex.

A location on the spine, which was determined not to be the area of primary subluxation, was utilized to deliver the sham adjustment. The examiner then turned the Integrator® force setting all the way down to off, placed his or her thumb over the area of the spine to be utilized, and discharged the integrator into his or her thumb. This was performed two or three times for each visit in order to imitate an actual chiropractic adjustment. The participant was debriefed at the end of the study regarding the use of deception and placebo.

Torque Release Technique®

Torque Release Technique® (TRT) is a chiropractic model and technique, which was created by Dr. Jay M. Holder beginning in 1994 for the purposes of conducting a randomized clinical controlled trial.[1] The principles of the Torque Release Technique model are based upon all of the original chiropractic principles as laid forth in Stephenson's Chiropractic Textbook[2] and the Art of Chiropractic[3] as well as D.D. Palmer's The Chiropractor[4] to provide a non-linear, vitalistic, tonal model.

TRT embraces a quantum physics paradigm, which accepts a holographic relationship between a living body and the mind, recognizing the nervous system as the predominant transmission medium of the field of intelligence and conscious intention. TRT also recognizes the subluxation as a neurological lesion, in that the subluxation is not the bone, but it is the bone that subluxates, leaving the subluxation as a neurological projection in three-dimensional space in the X, Y and Z axis. TRT embraces the neurophysiological mechanisms responsible for state of well-being and human potential, namely, the Brain Reward Cascade.[5,6,7]

Integrating the evidence based physical examination protocols and TRT's 15 Diagnostic Indicators of Subluxation from seven established first century chiropractic techniques, Torque Release Technique® was first created to design and perform a randomized clinical trial to determine the purpose of adjusting the subluxation (salutogenesis) and then was developed in an effort to create a differential diagnosis of the primary subluxation representative of a non-linear, vitalistic, and tonal model for Chiropractic's second century.

These seven techniques include: Thompson Terminal Point, Network Spinal Analysis, Sacro-Occipital Technique, Palmer Upper Cervical, Directional Non-Force Technique, Logan Basic and Toftness Technique. There is a total of 15 TRT Diagnostic Indicators for subluxation that are used to differentially diagnose subluxation findings on each visit.

These indicators with their respective indications are as follows:

1. Postural Faults (standing, sitting, prone): postural compensation and decompensation.
2. Abnormal Breathing Patterns: compartmentalized vs full spine sub-optimal respiratory mechanics and possible sympathetic neurological dominance.
3. Congestive Tissue Tone: chemical etiology of primary subluxation.
4. Inappropriate Sustained Patterns of Paraspinal Muscle Contractions: sympathetic neurological dominance and/or emotional etiology of primary subluxation, and/or defense physiology.
5. Functional Leg Length Reflex (FLLR™): to objectively differentially diagnose the primary subluxation

Note: FLLR is obtained by applying forceful dorsiflexion of the feet in the prone position over the cuboid to initiate an Achilles deep tendon reflex bilaterally. The FLLR is paired with the TRT Pressure Test and is NOT a challenge. It is an extremely light skin contact of the finger over a subluxation in a particular vector, in order to test for the proper lines of correction for the primary subluxation, within the X, Y and Z axis.

6. Abductor Tendency/Adductor Resistance: subluxation at the vertebral level of C2.
7. Foot Flare (inversion/eversion): anterior rotation of spinal segments which have direct dural attachment (Sphenoid, Occiput, C2, C5, S2, S3, S4, Coccyx).
8. Foot Pronation/Supination: anterior-superior coxofemoral subluxation with respect to the Greater Trochanter.
9. The 4 Palpations of the Cranio-Spinal Meningeal Functional Unit™ (CSMF):
    a. Scanning: Tactile contact throughout the spinal region)
    b. Tissue: Very light, superficial to muscle layer, for texture and fluid congestion
    c. Inter-segmental Static Palpation
    d. Inter-segmental Motion Palpation
10. Heel tension (Achilles tendon): C2, C5, Sacrum, or Coccyx subluxation, but may be any other segment as well.
11. Cervical Syndrome Test: C1 or C5 posterior rotation with or without laterality.
12. Bilateral Cervical Syndrome Test: PI subluxation listings of Occiput, Coccyx C5, C1, or T6
13. Derifield Test: pelvic tilt/rotation subluxations.
14. Wrong-un Test: C1 laterality
15. Scanning: by hand or device (thermography) for abnormal heat, cold, autonomic asymmetry.

All procedures are performed with the patient in the prone position with the exception of the pressure test for a superior pubic rami listing (which is performed with the patient in the supine position).

The primary subluxation and its line of drives in the X, Y and Z axis is determined by pressure testing the segment in the line of correction in each axis (posterior rotation, laterally and torque for superior/inferior line of drive), initiating the FLLR™, and observing the result at the 3rd second of this evoked potential. Only the primary subluxation when pressure tested in the line of drive (vector) for correction in all 3 axes with the proper torque, the resulting FLLR™ will become bilaterally equivalent (perfectly even) at three seconds and then release, secondary and tertiary subluxations will not.

An adjustment is then delivered by the Integrator® adjusting instrument to the primary subluxation with the specified

vectors including torque in all 3 axes simultaneously with recoil. The examiner proceeds by re-checking the segment with another pressure test and the FLLR™. If the adjustment was well-received and holds, FLLR™ will no longer become bilaterally equivalent.

Torque Release Technique® utilizes an additional differential diagnostic protocol known as the Non-linear Testing Priorities as a means for guiding the practitioner in implementing the pressure testing. These testing priorities were derived by sequentially organizing the odds ratio analysis of probable primary subluxation listings (vectors) of vertebral subluxation as they are most commonly found statistically in the human population. This allows the examiner to assess the patient for primary subluxation in a time-efficient fashion.

A maximum of three primary subluxations may be adjusted in one visit. No other subluxations are adjusted (i.e. ruling out secondary and tertiary subluxations). These systems of differentially diagnosing the primary subluxation from secondary and tertiary subluxations and the use of the Non-linear Testing Priorities are unique to TRT and is separate from the actual methods of delivering an adjustment. In this study we elected to utilize an adjusting instrument known as the Integrator® to deliver the (toggle recoil) adjustment. TRT is taught in the curriculum of at least three chiropractic colleges.

The Integrator® Adjusting Instrument

The Integrator® is a hand-held instrument that delivers straight axial force with concomitant adjustable "left" or right" torque capability along with "recoil" and true adjustment of force at 1/10,000 of a second. It was designed to reproduce the thrust and movement components of a "Toggle Recoil" adjustment by hand, but in addition it is able to do so with exacting reproducibility in both kinetic and HZ frequency, as it fires independently from the practitioner. The Integrator® the first legally marketed chiropractic device and is indicated for the "adjustment of the vertebral subluxation".

Inventories

Drug Abuse Screening Test

The Drug Abuse Screening Test (DAST), developed by Dr. Harvey A. Skinner, is a brief, practical and valid method for identifying psychoactive drug abuse. The DAST was designed to be used in a variety of settings to provide a quick index of drug related problems. It takes approximately five minutes to administer and may be given in questionnaire, interview or computerized formats. In this study we used the questionnaire.

The test is comprised of twenty questions. One point is scored for every "yes" answer with the exception of questions 4 and 5 which receive one point for a "no" response. The cutoff score for abuse/dependence is generally 6 or above.[8]

Score	Severity	Intervention Recommended
1-5	Low	Brief Intervention
6-10	Intermediate (likely meets DSM criteria)	Outpatient (intensive)
11-15	Substantial	Intensive
16-20	Severe	Intensive

Table1. DAST – 20 Interpretation Guide

In the past two decades, a great deal of research has been conducted to assess psychometric properties of the DAST. It was found that the DAST is a highly face-valid instrument since it appears to measure problematic drug use as it was designed. An internal consistency coefficient of 0.92 was obtained for a sample of 256 drug/alcohol abuse subjects.

Adequate concurrent or convergent validity was reported to have been demonstrated by the fact that the DAST attained 85% overall accuracy in classifying subjects according to DSM-III diagnosis and also to have been demonstrated by significant correlations of DAST scores with frequency of various types of drugs used during the preceding 12 months. The statistical significance of the DAST scores to distinguish between DSM-III diagnosed abuse "cases" from "non-cases" is reported evidence of discriminant validity.[9]

Beck's Depression Inventory

The Beck's Depression Inventory (BDI) is an assessment instrument used to measure the severity of depression. Developed by Dr. Aaron T. Beck, the BDI is a multiple choice question inventory designed to not only evaluate the severity of depression, but also to monitor changes over time. It can serve as an objective measure for evaluation of improvement and effectiveness of treatment methods.[10]

In its current version, the questionnaire is designed for individuals 13 years or older and is comprised of items relating to symptoms of depression. Each answer is scored on a score value of 0 to 3. The version BDI-II was used in this study

BDI Score	Severity of Depression
0 - 13	Minimal
14 - 19	Mild
20 - 28	Moderate
29 - 63	Severe

Table 2. BDI-II Interpretation Guide

One measure of the instrument's usefulness is to see how closely it agrees with another similar instrument that has been validated against clinical interview by a trained clinician. The

BDI-II has been positively correlated with the Hamilton Depression Rating Scale. The test was also shown to have a high one-week test-retest reliability suggesting that it was not overly sensitive to daily variations in mood.[11]

State-Trait Anxiety Inventory

The State-Trait Anxiety Inventory (STAI) measures anxiety in adult populations. Developed by Charles D. Spielberger, this assessment tool is unique in that it differentiates between the temporary condition of state anxiety and the more general long-standing characteristics of trait anxiety. State anxiety refers to an emotional response at a given moment in time and at a particular level of intensity. Anxiety states are characterized by subjective feelings of tension, apprehension, nervousness and worry and by activation of the autonomic nervous system. Trait anxiety describes an individual's proneness to anxiety and their tendency to perceive stressful situations as dangerous or threatening. The stronger the anxiety trait, the more probable the individual will experience a more intense state anxiety in a stressful situation.

The STAI form Y is the most popular version and was the formed used in this study. It consists of forty questions with a range of four possible responses to each question. Twenty questions assess state anxiety by posing questions that assess the subject's feeling at the moment. State anxiety questions include: "I am tense; I am worried" and "I feel at ease; I feel comfortable." Response to questions range from "not at all" to "very much so". Twenty additional questions assess trait anxiety by asking how the subject generally feels. Trait anxiety questions include: "I have disturbing thoughts; I wish I could be as happy as others seem to be" and "I feel rested; I feel pleasant." Responses to questions range from "almost never" to "almost always". Scores range from 20 to 80 with higher scores correlating with greater anxiety.

Current research reports that internal consistency/reliability estimates obtained from STAI state and trait scores are generally satisfactory for a broad range of studies involving various populations.[12]

Review of Literature

Chiropractors and other health care practitioners need a reliable, reproducible, and valid means of assessing for improvements or lack of same in states of wellbeing, human potential and neurocognitive function, in order to direct or redirect treatment plans and measure treatment outcomes.

This term "well-being" is not as vague as one might think. Research by Holder and Blum has demonstrated that a "Brain Reward Cascade" of neurotransmitters exists, and when operating properly, results in a state of well-being.

Interference in this cascade termed "Reward Deficiency Syndrome" (emotional pain) by them results in their state or feelings of well-being, being reduced or replaced by depression, anxiety, anger, and or by craving mood altering substances which often leads to a number of addictions. The meso and spinal limbic systems are where emotions are mediated and then expressed through the neurochemical reward cascade.[7,13,14,15]

Emotions and Neurotransmitters

Autoradiography has demonstrated that opiate receptors are densest in the amygdala and hypothalamus. In 1988 Pert and Dienstrey recognized that the limbic system includes not only the amygdala and hypothalamus, but discovered that the dorsal horn contains these same tissues thereby establishing an additional location of limbic system.[16]

Indeed, more of the limbic system exists in the dorsal horn of the spinal cord than the brain, thus the modern terms "meso-limbic system" (brain) and "spinal limbic system" (dorsal horn of the spinal cord). Further, there is a direct nociceptive reflex at every level of the spine to the mesolimbic system. In 1993 Burstein and Potrebic of Harvard Medical School provided evidence of direct projection of spinal cord neurons to the amygdala and orbital cortex suggesting that they play a role in modulating neural circuits involved in enabling somatosensory information, including pain, to effect autonomic, endocrine, and behavioral functions.[17] It was once thought that nociceptive information reached the hypothalamus through indirect, multisynaptic pathways but in 1994 Giesler, et al. of the University of Minnesota found the spinal pathways to limbic system for nociceptive information which included the hypothalamus bilaterally.[18]

In 1993 Kyles et al. of the University of Bristol found that the spinal cord mediates nociceptive information processing by the dopaminergic and opioid systems[19] and evidence has been reported which links the immune and opioid systems.[20] We maintain that the primary subluxation via its Tonal Model interferes with the limbic system's ability to express a state of well-being and that a subluxation free spine is necessary to achieve one's highest state of well-being and human potential.[7,14,15,21]

Because the foundation of chiropractic is based upon tone,[22] which is primarily expressed through the neuroendocrine system, our focus "should be" shifted from musculoskeletal anatomy and biomechanics to neurophysiology and neuroimmunology.[4] Advancements in the field of neurology have led to the implementation of an Event Related Potential known as the P300 wave for diagnostic and intervention outcome assessments.

An event related brain potential is a measurement of voltage deflections taken from electrodes placed on the scalp which represent neural processing, memory functions, attentional allocation, and other cognitive processes.[23] They can occur in response to a sensory stimulus, a mental event, or the omission of a stimulus. For the past 45 years the P300 wave has been the most depended on objective measurement of cognitive ability and state of well-being in psychiatry.[24]

The P300 Wave

In the 1960s Sutton *et al.* first described the P300 wave, which appears on an electroencephalograph approximately 300ms after a stimulus.[25] The P300 is thought to be "composed of several parts that reflect an information-processing cascade when attentional and memory mechanisms are engaged".[26] The P300 is a correlate of neurocognitive function, meaning that conclusions can be drawn regarding a subject's cognitive

processes by assessing his or her P300 wave characteristics. There are two components of the P300 wave which are routinely assessed, namely, amplitude and latency.

P300 amplitude indexes 'brain activity required in the maintenance of working memory when the mental model of the stimulus environment is updated'.[27] It reflects the individual's 'allocation of attention resources for a given task and is associated with superior memory performance'. These attentional resources include phasic attention and working memory. Phasic attention is the ability of an organism to shift mental processing activity in response to changing stimuli. Working memory is the ability to hold information in mind while performing a mental operation.[28] In other words, P300 amplitude reflects the amount of neurological resources utilized to process an event.

It is interesting to note that conclusions about long-term memory can be drawn from P300 amplitude analysis. Memory representations of a stimulus are updated with the result that previously encountered stimuli which are remembered elicit larger P300 amplitudes.[29] Sights and sounds which are personally meaningful trigger P300 waves with larger amplitude. This is the mechanism by which researchers have utilized P300 analysis for anti-terrorism and lie detection applications.[30]

P300 latency is a measure reflecting the speed at which stimuli are classified but is not related to processing time to generate a response. Higher levels of cognitive function are correlated with shorter latency.[27] It is useful for determining early progression of dementia[31] and familial Alzheimer's disease,[32] and was found to be more sensitive at finding early memory deficits than was the Mini-Mental State Examination (MMSE) or Wechsler Memory Scale-III (WMS-III).[33] Latency is a measure of stimulus detection and evaluation time, but not response selection or behavioral action.[34]

A P300 wave is elicited when an infrequent, task-relevant stimulus is voluntarily detected, and this stimulus can be auditory, visual, somatosensory or olfactory.[35] The most commonly used method of eliciting a P300 ERP is to utilize a two-stimulus discrimination paradigm which is commonly known as the 'oddball' paradigm. This method has been shown to have good test-re-test correlation coefficients for both amplitude and latency measures.[27] For these reasons we chose to use the oddball paradigm for eliciting P300 ERPs utilizing the Auditory Evoked Potential (AEP) method.

External and internal factors may contribute to P300 variance. These factors include circadian rhythms (body temperature, heart rate, food intake, etc.), exercise, fatigue, drugs (caffeine, nicotine and alcohol), age, handedness, gender, personality, and genes. [27] In this study all P300 assessments were administered in a stable environment free from interruption or external influence, in the same room and on a consistent schedule to account for environmental factors. It should be noted, however, that no measures were taken to control for smoking or coffee intake.

Biomarkers and Related Disorders

P300 analysis in the addicted population has demonstrated significant changes in P300 characteristics compared to non-addicted populations. It has been shown that cocaine-dependent patients have lower P300 amplitude which was then correlated to a higher incidence of errors of commission (false positive errors) in which the patient would inappropriately respond to a non-target stimulus. This could indicate heightened impulsivity and/or lessened discriminatory ability.[28]

Alcoholics have been shown to have reduced amplitude which does not revert to normal even after continued abstinence,[36] yet a much more recent study demonstrated that P300 amplitude significantly increases to normalized levels with continued abstinence. This study also demonstrated that those with a family history of alcoholism did not have a predilection for diminished P300 amplitude but that those with multiple conduct disorder diagnosis were highly correlated with diminished P300 amplitude. It was also shown that improvements in P300 amplitude had no correlation with depression or anxiety scores regarding the Beck's Depression Inventory and the Spielberger State-Trait Anxiety Inventory.[37]

Many published papers report and establish that reduced P300 amplitude is strongly associated with substance use disorders (SUD) and is potentially a marker of substance use vulnerability.[14,15,38] One can plausibly conceive that if P300 amplitudes are improved then the SUD vulnerability and relapse may be diminished, and that P300 amplitude may be utilized as an outcome measure in the treatment of addictions.[14,15,24]

One recent case study has demonstrated that subluxation-centered chiropractic care dramatically improves brain function and P300 amplitude in one recovering cocaine addict after failing to complete nine previous traditional addiction programs. The first eight months of care consisted of only traditional addiction treatment, and P300 amplitudes continued to diminish as time passed. Amplitudes are listed as follows: month 1, 4.39μV; month 2, 3.25μV, month 8, 3.03μV. With the addition of chiropractic care in the last eight months amplitudes began to increase dramatically: month 10, 6.09μV; month13, 7.2μV, month 16, 9.1μV. This study also demonstrated positive outcomes in Addiction Severity Index scores and Paraspinal Thermal Scans.[39]

There is a great need for sensitive biomarkers of early progression and treatment response for cognitive disorders such as Alzheimer's, ADHD, and schizophrenia.[40] In 2007 Pfizer requested proposals for the development of virtual translational medicine units such as pharmacology tools, biomarkers, clinical methods, clinical technologies and study designs which would advance our understanding of therapeutic index in humans, enhance effective decision making in exploratory development of new drugs, and, in particular, to improve confidence in the activity of exploratory CNS drugs.

"Pfizer research has invested substantially in the use of spontaneous EEG, evoked potential and sleep endpoints as a means to assess central pharmacology".[41] At one time EEG and ERP analysis was exceptionally time consuming and inconvenient due to a lack of computing ability for processing of complex raw data sets, lack of portability of EEG

amplifiers, and the need for dermal abrasion to apply electrodes with low impedance.[40] Recent technological advancements such as computer power, processing algorithms, and high-density array nets have eliminated these problems and have made it possible to elicit, collect, and process EEG data to provide P300 wave results in less than five minutes by equipment first innovated, designed, and developed by Dr. Jay Holder: the Enigma P300™.

Chiropractors and other health care providers have an opportunity to become involved in the search for drug-free alternatives in the treatment and management of individuals with cognitive disorders. Indeed, the first randomized placebo controlled clinical trial of chiropractic with addicted individuals in residential treatment demonstrated outstanding outcomes in retention rate (100%), and significantly improved (lowered) depression and anxiety scores and nursing station visits.[1] Chiropractic case studies and other published clinical reporting have demonstrated improved quality of life with those suffering from addiction,[39] ADD,[42] depression,[43] autism,[44] and ADHD.[45]

Research in the Journal of Psychoactive Drugs on RDS [7] has outlined a direct link between addictions, compulsive and impulsive disorders (which include ADD, ADHD, Autism, many Dyslexias, Tourette's Syndrome, Asperger Syndrome, binging, eating disorders, smoking behavior, PTSD, pathological gambling, and polysubstance dependence) and the Brain Reward Cascade via RDS. This highlights the salutogenic role of chiropractic care in establishing a proper Brain Reward Cascade (BRC) through the adjustment of vertebral subluxation.[7,13,14,15,21,42]

A Model of Subluxation

The Brain Reward Cascade and RDS provide us a better understanding of neurophysiological mechanisms underlying emotions and wellbeing. It is also the first scientific model of subluxation published outside of chiropractic journals and implicates the vertebral subluxation complex as the hallmark of insult to a vertebrate's ability to establish a state of wellbeing.[7]

Only vertebrates can manifest a state of well-being via the dorsal horn/limbic Brain Reward Cascade. Although invertebrates have opioid-like material, only vertebrates have confirmed opiate receptors which are in "intimate and direct contact with the limbic system" so that "it is fair to say that only vertebrates have the ability to conjure a state of well-being"; the common denominator being the spine.[6,7,14,15]

Neurophysiological insult to the dorsal horn of the spinal cord via primary subluxation results in Reward Deficiency Syndrome and consequently the inability to establish a state of wellbeing. Dysafferentation of proprioceptive and nociceptive information leads to impaired central integration which causes an imbalance of neurotransmitters reaching higher brain centers with a critical focus on the nucleus accumbens and ventral tegmental area as focal constituents of a midbrain-forebrain-extrapyramidal circuit.

There are three main systems involved in the Brain Reward Cascade, namely, the dopaminergic, opioidergic, and gabaergic / benzodiazepine system. The opioidergic system consists of Beta-endorphin, enkephalin, and dynorphin which are peptides involved in modulation of nociceptive response to painful stimuli and stressors, reward, and homeostatic adaptive function such as food, water, and temperature regulation.[7,14,15]

Nociceptive information processed by the dopaminergic and opioid systems is mediated spinally and indeed science is showing that the spinal cord is involved in mediating "immune system function, growth factor, chemotaxis of human tumor cells, body temperature, water saving and water seeking behavior."[7,14,15]

Nerve tissue is piezoelectric (tonal) in nature, meaning that the application of mechanical stress will cause cell polarization and alter normal hertz frequency of nerve tissue, substantiating what is referred to as a tonal model. This allows for the conversion of mechanical signals into altered frequency modulated electrical signals and vice versa. Dural torsion and tension, dysfunctional cerebrospinal fluid pumping mechanics, spinal cord pressure and tension, and other tonal distortions within the cranio-spinal meningeal functional unit™ will manifest in neural disintegration (nerve interference) and localized inflammatory response. This phenomenon results in the Vertebral Subluxation Complex.[2,4,21,46]

Inflammation at the nerve root creates hyperfacilitation of the associated structures. Dorsal horn facilitation produces excessive nociception to the cortex, contributes to Reward Deficiency Syndrome, and carries over into the anterior horn cells which control motor function.

Hyperfacilitation of the anterior horn cells may create abnormal muscle stinting and spasm, further exacerbating and prolonging the mechanical stresses to the spinal cord and manifesting in tight muscles, tender nodules, and edematous tissue tone. This vertebral subluxation complex also may distort other sensitive neural structures including but not limited to dorsal root ganglia, spinal nerves, sympathetic ganglia, sinuvertebral nerves, Golgi tendon organs, Pacinian corpuscles, Type I, II, and III mechanoreceptors, and unencapsulated nerve endings.[47,48]

All communication in the third dimension (our universe) is tonal.[21] Structure, function and communication within the human body takes place through tonal dynamics, which are expressed as hertz frequencies. All normal nerve frequencies are multiples of five hertz. For example, the Vagus nerve is commonly stimulated with electrical micro-currents at specific hertz frequencies to treat certain conditions such as portal hypertension or epilepsy by manipulating abnormal vagal tone (hertz frequency) back to normal.[49,50,51]

One particular study involved stimulating the Vagal nerve at 5 Hz to trigger the release of Acetylcholine, and 10 Hz to trigger the release of vasoactive intestinal peptide.[49] Indeed, the structure of every hormone, neurotransmitter, and cell membrane is dependent upon the energy states of vibrating molecules. We maintain that the chiropractic adjustment allows for the normalization of the piezoelectric discharges (hertz frequencies) from the affected nerve tissue by removing this nerve interference and thus restoring the proper tonal dynamics throughout the nervous system.

Results

Results are reported in Tables 3-10 for both group statistics and individual data. No statistical significance of this data may be attributed to the results due to the small study population.

Discussion

In spite of the small population of participants, this study's statistics are confirmed and validated by the outcomes of a larger study.[1] Each participant presented with varying complaints and drug use history. The proceeding attempts to explain the mechanisms for the results that we obtained by taking a closer look at each patient in a case series format.

Placebo Group

Participant A

This participant presented to a residential addiction rehabilitation facility due to a history of recreational drug use which included using marijuana three times per day for the past 25 years and "crack" cocaine three times per week for the past year. He reported alcohol use consisting of five drinks per week for the past three years. His initial DAST-20 score was 16 indicating "severe" drug abuse. He reports no other complaints.

He reported no exercise habits and had an unhealthy diet consisting of only two glasses of water per day, three caffeinated drinks per day, and no fruits or vegetables. He reported having no eating disorders and a daily stress level of 3/10. He smoked six cigarettes per day and had done so for the last 19 years but does not use smokeless tobacco. He reported four to five hours of "poor" sleep for the past six months and says this may be from drinking a lot of coffee and from being off drugs. He currently uses no medications.

He presented with a P300 amplitude of 10.97μV and a latency of 327.34ms. Three weeks following the conclusion of the study he was discharged from care due to an alcohol and marijuana relapse. At the conclusion of the study he had an improved P300 amplitude of 13.23μV and a worsened latency of 342.97ms. His initial BDI-II score was 14 and was reduced to 3 at outtake (12 weeks). Initial STAXI score was a State sub score of (S) 36 and Trait (T) sub score 23 for a total of 59. At outtake it was reduced to S21 and T26 for a total of 47. This demonstrates improvement in depression and anxiety scores and improvement in P300 amplitude with regression in P300 latency.

The patient demonstrated a positive attitude during treatment, however, three weeks after completing the study he relapsed and was dismissed from care at the addiction facility.

Participant B

This participant presented to a residential addiction rehabilitation facility due to a 40-year history of alcohol abuse. His initial DAST-20 score was 14, indicating "substantial" drug abuse. He concurrently suffered from numerous musculoskeletal complaints of moderate to severe nature.

He presented with a P300 amplitude of 2.86μV and latency of 354.69ms. After five weeks of care his P300 amplitude had improved to 4.82μV and P300 latency regressed to 467.97ms. Initial BDI-II score was 0 and increased to 3 at outtake. Initial STAXI scores were S25 and T25 for a total of 50; they improved to S21 and T23 for a total of 44. This demonstrates improvement in P300 amplitude and anxiety scores with regression in P300 latency and depression scores.

This participant elected to drop out of the research study at five weeks due to concurrent musculoskeletal complaints which were not being directly addressed (placebo group) due to the nature of this research study. He was referred to a chiropractic clinic but did not follow up with chiropractic care. Four weeks following this time he relapsed due to alcohol consumption and was dismissed from care at the addiction treatment facility.

Participant C

This participant presented to the addiction facility due to a history of alcohol abuse. He had a history of having about 12 beers per night for the past twelve years but currently does not drink any alcoholic beverages. He smoked one pack of cigarettes per day. He reported smoking "pot" when he was a teenager but has had none since that time. In the past six months he had taken "pain killers" a few times per week for about four months but not daily. His initial DAST inventory score was 2, indicating no clinical drug abuse.

He reported getting only four hours of sleep per night since moving to the addiction facility. He drank four to five cups of water daily and two to three cups of coffee with very little fruits or vegetables. He denied food allergies or eating disorders. He reported a daily stress level of 6/10 and reported having "a lot on his mind due to homelessness".

Concurrent complaints included urticaria and slight right leg and foot neuritis (foot and ankle examination revealed a negative study). He was recently diagnosed with hypertension for which he takes 80 mg of Propranolol three times per day. Blood pressure upon examination was found to be 110/68 mm Hg.

He presented with a P300 amplitude of 0.86μV and a P300 latency of 370.31ms. After six weeks of care his P300 amplitude improved to 4.88μV and P300 latency regressed to 397.66ms. Initial BDI-II score was 26 and improved to 13 at outtake. Initial STAXI scores were S49, T63, for a total score of 112. Final STAXI scores were S47, T52, for a total of 99.

Chiropractic Group

Participant A

This participant presented to the addiction facility due to a 20-year history of cocaine, methamphetamine, and marijuana use. His initial DAST-20 score was 14, indicating "substantial" drug abuse. He concurrently complained of sciatica, neck pain, headaches, and shoulder problems. He reports being diagnosed with ADHD and began taking 1 mg of Guanfacine per day during week seven of the study. His dosage was increased to 2 mg per day at week 11 of the study.

His diet consisted of only three servings of fruits and vegetables per day, six glasses of water, one soda and one coffee. He reported no eating disorders. His daily stress level is a 7/10 and he stated driving is stressful and occasionally has some anger issues. He smoked about 15 cigarettes per day but consumes no smokeless tobacco or alcohol. His sleep habits consisted of seven hours of "fair" sleep per night, which is interrupted about two times per week.

He took about two doses of 800 milligrams of Ibuprofen per day for his sciatica until it was minimized at approximately nine weeks of care.

He presented with a P300 amplitude of 7.38μV and a P300 latency of 331.25ms. After twelve weeks of care his P300 amplitude regressed to -3.06μV. His P300 latency regressed to 370.31ms. We suggest that his intake of Guanfacine acted as a chemical substitute for his drug addiction and arrested most, if not all, potential brain recovery from the neurochemical effects of his addiction.

Guanfacine is an investigational treatment for nicotine, opioid, and alcohol withdrawal.[53] It is a non-stimulant medication used widely for the treatment of ADHD. Guanfacine mimics the effects of norepinephrine by acting as an agonist to postsynaptic alpha-2A adrenergic receptors to improve regulation of behavior, attention, and emotion.[54] Normally, norepinephrine is released in response to stress and acts upon these receptors to inhibit cyclic adenosine monophosphate (cAMP) in prefrontal cortex dendritic spines, which improves neural connectivity and thereby improves focus and self-control in those suffering from ADHD.[53]

The locus ceruleus (LC) is the principle site in the brain for norepinephrine synthesis and serves as a neural highway for transport of norepinephrine throughout the entirety of the brain including the tectum, thalamus, hypothalamus, hippocampus, amygdala, cerebral cortex, cerebellum, lower brain stem, and spinal cord. The LC is known to serve as a modulator of behavioral arousal and the level of forebrain and sensory perception as well as muscle tone. This includes modulation of sensory inputs from the solitary nucleus and the dorsal horn of the spinal cord,[55] which is a principal spinal region responsible for central afferentation of nociception and directly contributes to the Brain Reward Cascade.

Norepinephrine is directly involved in the Brain Reward Cascade; release of norepinephrine at the CAx site of the hippocampus causes reward.[7,14,15] Amphetamines cause a release of both dopamine and norepinephrine in the brain. We posit that Guanfacine served as a substitute source of norepinephrine activity in the absence of methamphetamines and cocaine, thereby preventing neuro-chemical restitution.

Although direct evidence of neuro-chemical recovery is lacking, evidence of improvement in depression and anxiety scores is demonstrated. The psycho-social effects of addiction have been largely reduced due to the positive, stable environment, provided in residential addiction treatment as well as the chiropractic care provided and the reduction in symptomatology of his concurrent complaints.

Participant B

This participant presented to the addiction facility due to a 35-year history of alcohol abuse. His initial DAST-20 score was 16, indicating “severe” drug abuse. He had no other complaints. The patient exercised three days per week for one hour each day including weights, push-ups, and sit-ups. He had a healthy diet consisting of two or more servings of fruits or vegetables per day and eight or more glasses of water per day. He drank two cups of coffee per day and smoked 15 cigarettes per day for the last 25 years. He slept about seven hours per night that is "good quality sleep".

He presented with a P300 amplitude of 5.0μV and a P300 latency of 307.81ms. After 12 weeks of care his P300 amplitude improved to 12.82μV and his P300 latency improved to 303.91ms. His BDI-II improved from nine to zero, and his STAXI improved from S31 T41 for a total of 72, to S20 T20 for a total of 40. Throughout care he demonstrated normalization of P300 amplitude and latency, as well as significant improvements in depression and anxiety scores. The patient exhibited a positive attitude throughout care, obtained a steady job, and is expected to complete his time in treatment successfully.

This patient was on no medications during care. The results of this case demonstrated significant improvement over traditional addiction treatment alone and represent what we believe to be the normative outcome for those undergoing subluxation centered chiropractic care in addition to traditional addiction treatment.

Participant C

This participant presented to the addiction facility due to a 4.5-year history of oxycodone abuse. His initial DAST-20 score was 17, indicating “severe” drug abuse. He also presented with a musculoskeletal complaint of moderate severity.

He presented with a P300 amplitude of 15.9μV and a P300 latency of 260.94ms. After one week his P300 amplitude dropped to 7.5μV and steadily increased to 11.34μV after four weeks of care. His P300 latency improved to 268.75ms.

The researchers are confounded as to why his P300 amplitude dropped so dramatically in the first week and propose that the first measurement may possibly be due to protracted opiate withdrawal or conceived as an outlier. It is interesting, however, to note that his P300 latency changed dramatically at the same time (week 1). It would have been beneficial to see his progress over a longer period of time; however, we were only allotted four weeks with this participant due to time constraints. Following the initial drop in P300 amplitude he demonstrated consistent improvement in amplitude and improvement in normalization of P300 latency over the course of his care.

Conclusion

It appears that chiropractic care may support and improve patient outcomes in residential addiction rehabilitation. Depression scores improved by an average of 97.1%, which was 44.6% better than traditional addiction treatment alone.

Anxiety scores improved by an average of 36.5%, which is 22.4% better than traditional addiction treatment alone.

A larger study which was a randomized controlled clinical trial also using Torque Release Technique® had similar outcomes.[1] Mixed results were obtained with P300 analysis, yet when complicating factors are accounted for it appears that those under chiropractic care exhibited strong improvements toward normalization in both amplitude and latency while those under placebo care demonstrated marginal improvement in amplitude and a worsening in latency.

Furthermore, it should be noted that no participants in the chiropractic group relapsed during or within two months following the conclusion of this study intervention period (12 weeks). This substantiates the findings of a previous and larger Torque Release Technique® study.[1] All participants in the chiropractic group presented with either "severe" or "substantial" drug abuse as documented by their initial DAST-20 scores.

Two out of the three participants in the placebo group presented with "severe" or "substantial" drug abuse according to the DAST-20. Both of these participants relapsed during or within three weeks following the conclusion of the study intervention period. The other participant in the placebo group did not relapse, however, he presented with an initial DAST-20 score of 2, which indicates clinical absence of a drug abuse problem.

Retention rate among those clinically documented with drug abuse in the chiropractic group was 100%. Retention rate among those clinically documented with drug abuse in the Placebo group was 0%. We conclude that chiropractic care utilizing the Torque Release Technique® (TRT) dramatically improves retention rates and prevents relapse and supports the findings of a larger previous randomized clinical trial incorporating Torque Release Technique®.[1]

The improvement in depression and anxiety scores, 100% retention rate, and total lack of relapse of those receiving chiropractic care (TRT) in this study are also substantiated in the findings of a previous and larger randomized clinical trial incorporating Torque Release Technique® in residential addiction treatment.[1]

The results of this study indicate that subluxation-based chiropractic utilizing the Torque Release Technique® promotes improvement in residential addiction outcomes and general measures of wellbeing and salutogenesis, corroborating previous findings of improvements in wellbeing and functional neurological health assessments related to conditions including autism, ADHD, infertility, depression, pseudoseizures, anxiety, and blood pressure.[43-45,56-68]

Similar research utilizing a larger population is needed to conclusively determine if use of P300 wave analysis has significance as an outcome assessment of subluxation based chiropractic care in the addiction treatment setting.

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Appendix

P300 Analysis

Table 3. Placebo Group Amplitudes (μV) for each week

	Initial	1	2	3	4	5	6	7	8	9	10	11	12
A	10.97	11.85	12.76	14.65	11.46	-----	10.51	12.68	10.8	10.36	11.38	9.85	13.23
B	2.86	0.8	0.73	-----	3.61	4.82							
C	0.86	-0.45	-----	2.48	11.44	5.73	4.88						

- Average total change: + 2.746μV
- Average change at 4 weeks: + 3.94μV
- Note that improvements toward P300 amplitude normalization were made, yet no patient improved more than 4.82μV throughout the course of care.

Table 4. Placebo Group Latencies (ms) for each week

	Initial	1	2	3	4	5	6	7	8	9	10	11	12
A	327.34	339.06	339.06	339.06	339.06	-----	342.97	339.06	358.59	323.44	355.16	327.34	342.97
B	354.69	471.88	366.41	-----	440.63	467.97							
C	370.31	362.50	-----	342.97	327.34	382.03	397.66						

- Average total change: + 52.086ms
- Average change at 4 weeks: + 18.23ms
- Note that each participant increased in latency and therefore did not demonstrate normalization of P300 latency.

Table 5. Chiropractic Group Amplitudes (μV) for each week:

	Initial	1	2	3	4	5	6	7	8	9	10	11	12
A	7.38	3.02	10.43	2.83	-0.51	1.98	-0.13	-1.04	-----	2.27	-1.08	-1.34	-3.06
B	5.0	11.68	-----	5.52	10.46	5.82	11.71	7.05	-----	7.53	12.27	8.43	12.82
C	15.9	7.5	9.21	11.35	11.34								

- Average total change: -7.18μV
- Ave total change excluding medicated patient: + 3.26μV
- Average change at 4 weeks: -6.99μV
- Ave total change at 4 weeks excluding medicated patient: 0.9μV
- Note that participant "A" was concurrently taking Guanfacine for ADHD beginning in week 7, which may act as a substitute for Opiates and prevent or complicate neural recovery and consequent P300 scores.
- Note that participant "B" demonstrated a 7.82μV increase in P300 amplitude.

Table 6. Chiropractic Group Latencies (ms) for each week:

	Initial	1	2	3	4	5	6	7	8	9	10	11	12
A	331.25	331.25	311.72	303.91	346.88	335.16	335.16	393.75	---- -	323.44	350.78	335.16	370.31
B	307.81	327.34	-----	389.84	319.53	303.91	300.00	300.00	---- -	374.22	307.81	303.91	303.91
C	260.94	303.91	272.66	260.94	268.75								

- Average total change: 42.97ms
- Average change at 4 weeks: 11.72ms
- Average change at 4 weeks excluding medicated patient: 9.765ms
- Note that participant "B" began above 300.00ms and demonstrated normalization of P300 latency.
- Note that participant "C" began below 300.00ms, and demonstrated improvement toward P300 normalization.
- Participant "A" was concurrently taking Guanfacine for ADHD, which may act as a substitute for opiates and prevent normalization of P300 scores.

Depression Scores

Table 7. Placebo BDI-II

	Initial	1	2	3
A	14	4	2	3
B	0	3	3	-
C	26	9	13	-
Total	40	16	18	19

- Average change at four weeks: ↓ 60%
- Average change at second assessment: ↓ 55%
- Average total change: ↓ 52.5%
- Note that depression scores worsened for participant "B" and although immediate improvement was noted for participant "C", the following assessment demonstrated regression.
- Note: second assessment was at eight weeks for "A", and outtake for "B" and "C" which were five weeks and six weeks respectively.

Table 8. Chiropractic BDI-II

	Initial	1	2	3
A	23	4	0	0
B	9	3	1	0
C	2	1	-	-
Total	34	8	2	1

- Average change at four weeks: ↓ 76.5%
- Average change at eight weeks: ↓ 94.2%
- Average total change : ↓ 97.1%
- Note that all depression scores dropped significantly within the first four weeks of care and were virtually minimized at the conclusion of care.
- Note that participant "B" was administered the BDI-II late (nine days following initiation of care).

Table 9. Placebo STAXI

	Initial	1	2	3
A	S:36 + T:23 59	S:22 + T:35 57	S:22 + T:28 50	S:21 + T:26 47
B	S:25 + T: 25 50	S:28 + T:31 59	S:21 + T:23 (5 weeks) 44	-
C	S:49 + T:63 112	S:51 + T:54 105	S:47 + T:52 (six weeks) 99	-
Total	**221**	**221**	**193**	**190**

- Average change at four weeks: 0%
- Average change at second assessment: ↓ 12.7%
- Average total change: ↓ 14.1%
- Note: second assessment was at eight weeks for "A", and outtake for "B" and "C" which were five weeks and six weeks respectively.

Table 10. Chiropractic STAXI

	Initial	1	2	3
A	S:57 + T:52 109	S:46 + T:42 88	S:31 + T:24 55	S:29 + T:31 60
B	S:31 + T: 41 72	S:22 + T: 26 48	S:27 + T:23 50	S:20 + T:20 40
C	S:27 + T:28 55	S:24 + T:26 50	-	-
Total	**236**	**186**	**105**	**150**

- Average change at four weeks: ↓ 21.2%
- Average change at 12 weeks for participants A and B: ↓ 44.8%
- Average total change: ↓ 36.5%
- Note that participant "C" only participated for a total of four weeks, therefore there is no STAXI data for this participant for weeks five through 12.
- Note that participant "B" was administered the STAXI late (nine days following initiation of care).
- Mean S-Anxiety scores for working male adults is 35.72.
- Mean T-Anxiety scores for working male adults is 34.89.[52]