MUSIC – A GATEWAY TO REACHING DEVELOPMENTAL PROCESSES OF CHILDREN WITH SPECIAL NEEDS

BY

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Abstract

The scientific and technological advances made in the discoveries of how the body physiologically responds to music have opened new possibilities for the development of therapeutic archetypes to actively channel specific aspects of music to assist in the learning processes of children with special needs. The resulting protocols actively engage the brain through the use of rhythmic entrainment and can have positive outcomes when actively treating issues related to motor, speech/language, and cognition.

This paper will show the connection that the structural properties of music can create in a therapeutic environment. The historical perspective of the joining of music and cognition will be briefly discussed, followed by a description of the physiological effect of music on the body. An explanation of techniques and protocols showing how the structural properties of music actively engage the brain is discussed, in addition to specific behavioral techniques utilized for behavior modification.

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Introduction

For millennia, music has retained a powerful influence over human emotions and imaginations; the power of music to influence cognition processes and the human body is not a new concept. Music has been contemplated and speculated about throughout centuries in realms of entertainment and communication as well as theorizing and analysis on the actual musical tones and resulting intervals and harmony. Two diverse philosophies have historically encompassed the opinions on the role music plays in humanity: one leads to the intuited meta-physical realm a second theory leads in the direction of the evidence-based empirical domain.

Discoveries, reached through scientific and technological advances, about how the body physiologically responds to music opened new possibilities for developing therapeutic archetypes to actively channel specific aspects of music to assist in the learning processes of children with special needs. The resulting protocols actively engage the brain by using rhythmic entrainment and can have positive outcomes when actively treating issues related to motor, speech/language, and cognition.

A brief historical retrospective showing the real and hypothesized connections of music with cognition will demonstrate the historic magnitude of this topic for the last three thousand years. This will be followed by an overview about how music affects the body, a description of neurologically based music protocols (evidence-based) and behavior methodologies, and conclude with two hypothetical case studies.

Historical Retrospective of Music and Cognition processes

Civilizations dating from antiquity such as the Greeks, Babylonians, Egyptians, and Hebrews avidly utilized music in religious, magical, or medical practice[1]. The Greeks contributed the preponderance of ancient knowledge to the basis of what would eventually lead to the musical intervals used in western music, as well as knowledge of musical elements influencing cognition. Pythagoras (c. 570-490 BCE) hypothetically discovered the ratio of perfection when passing by a blacksmith's forge and hearing the sounds created by different shaped hammers and anvils. The Greeks utilized the tectractys (the numbers 4, 3, 2, and 1) for calculating the consonant ratios of these intervals (i.e 2:1 = octave; 3:2 = perfect fifth; 4:3 = perfect fourth). Strongly influenced by Pythagoras, Plato (c. 423-348 BCE) wrote in *Timaeus* that the nature and direction of God manifested in the physical body of the planet; represented by the elements of earth, air, fire, and water, the four sacred entities of the natural world. In addition, the soul of the world was defined in the ratios of musical intervals such as 2:1 (the octave), 3:2 (the perfect fifth), and 4:3 (the perfect fourth). Therefore God was in represented in both the physical body of the planet, symbolized by the elements, and also the soul of the planet represented by the intervals.

Aristotle (c. 384-322 BCE), a student of Plato, had tremendous influence on what would become the major philosophy of the beginnings of Western music. He advocated

[1] Maranto, C. (1991) p. 10

a strong contrast between the actual theory of music (knowledge of the Pythagorean ratios) and the practical elements considered in the performance of music. In terms of Aristotle, music theory is considered to be the discipline of the final cause and gives the explanation of why something is made, while music practice is the discipline of formal cause and explains that into which a thing is made.[2]

In the 4th century BCE, the Greek philosopher Aristoxenus (born c. 375-360 BCE) composed two treatises, *Harmonic Elements* and *Rhythmic Elements*, that expanded the Pythagorean principles espousing the number/ratio theory of musical intervals. In addition, the relationships between music and the cosmos initially described by Plato are further developed. Aristoxenus established a system whereby there was a definition given to notes, intervals, genera, scales, tone and harmony ("tonoi" and "harmoniai"), modulation, and "melic" composition.[3] He considered the tetrachord as the basic unit of music and took the Pythagorean concept a step further by introducing the hypothesis that musical intervals are not only based on the perfection of the numbers but also represented by how they are perceived functionally by the ear and brain.

An important chain is established in the theoretical practice of music, which would manifest approximately four hundred years after Aristoxenus in Claudius Ptolemy's (c. 83 CE – 161 CE) treatise *Harmonics,* written approximately 148 CE. Ptolemy conceived of Aristoxenus' tonoi as based on seven specific octave species, and he referred to them as the Greek modes, i.e. Mixolydian, Lydian, Phrygian, Dorian,

[2] Christensen, T. (2007) p. 3
[3] Mathiesen, T. (2007) p. 120

Hypolydian, Hypophrygian, and Hypodorian. Since this is a late source for an original Greek treatise, Ptolemy's treatise was more accessible to be passed on to future generations. The dissemination of the practical knowledge of music was transmitted into the times of the Middle Ages by the Roman encyclopedist Marcus Varro (116-27 BCE), who defined harmony as one of the fundamental disciplines to be studied considered for study in Roman education. The Roman philosophers studied expansions of the later Greek treatises and moved them forward so their influence would be felt well into the Middle Ages.

The 6th century Christian philosopher Boethius (c. 480-524 CE) wrote works on many subjects and was influential up to the Renaissance. None were more influential on music than his treatise called *Fundamentals of Music*, written approximately 524 CE. Boethius was highly influenced by the ancient Greek dissertations and theories and he developed his own treatises in order to pass this information to future generations. Influenced by Ptolemy's treatise, Boethius incorrectly interpreted the number of tones defined by Ptolemy as eight rather than seven. This misinterpretation thusly established the model, which would later manifest as the eight modes used in church music.

Boethius classified music into the realms of the mundana (music of the spheres), humana (harmony of the human and spiritual realms of the human body), and instrumentalis (instruments and human voice).[4] Thus the hypothetical joining of body and soul with God was linked from the theories of the ancient Greeks and was passed into the Middle Ages. So great did Boethius consider the influence of music on mind, body,

[4] Boethius, A. (1989) p. 9

and spirit that music was included as one of the seven liberal arts described by Roman author Martianus Capella . Inspired by the works of Martianus, Boethius included music as one of a quartet of learned subjects called the quadrivium that included arithmetic, geometry, music, and astronomy. The three remaining liberal arts were grouped into the trivium of grammar, rhetoric, and logic. The works of Boethius were one of the greatest influences on all medieval works, advocated and passed on in generations until the Renaissance.

Scientific accomplishment during the Renaissance began expanding the physical and spiritual ideals that had been in place for the preceding thousand years. Such achievements were realized in the work of Harvey (1578-1657), Kepler (1571-1630), Newton (1642-1727), and Galileo (1564-1642) with the new paradigms of medical knowledge of the body, astronomical knowledge of the solar system, and an understanding of gravity on the earth. The Aristotelian mode of learning through simple observation was perceived as unacceptable in comparison to gathering empirical evidence through tested experiments. Breakthroughs in the field of music arrived in forms of new paradigms regarding instrument tempering. Tuning to this point was primarily based on the notions of the Pythagorean ratios favoring the consonance of the octave and the fifth, but the theories developed for Just Intonation and Meantone temperament allowed greater consonance for intervals of the third and sixth. Experimentation also resulted in the discovery of specific data regarding the harmonic partials in the overtone series.

Playing musical instruments, by philosopher and physicians alike, was compared to human body functions. A foremost music theorist of the Renaissance, Gioseffo

Zarlino (1517-1590), mandated that physicians study the art of music so as to adequately prescribe the correct balance of musical elements needed to help heal the four cardinal humors of blood, phlegm, bile, and black bile.[5] The philosopher Descartes (1596-1650) described in the *Treatise of Man* how the functions of the body are governed by the same concepts as the actions produced by musical instruments, i.e. the central nervous system of the body compared to the playing of a carillon or the vascular system compared to playing of the organ.[6]

Renaissance philosophers also advocated that music of the spheres, harmonies unseen and unheard but still hypothesized to exist in the universe, had an impact on the human mind and body. The astronomer Johannes Kepler theorized that harmonies are present in the motion of the planet's trajectories around the sun; he suggests that these harmonies can only be perceived from the sun rather than the earth, but greatly influenced humanity. His book written in 1619, *Harmonices mundi libri quinque*, describes in detail how planetary motions actually emulate notes of the scale and also imitate the major and minor modes.[7] Proportions of the natural world were explained through these invisible harmonic structures.

The issue of tuning and temperament for musical instruments was approached from a variety of angles during the Renaissance. There were those who were anxious to keep the strict Pythagorean tuning of the exact ratios intact so as to maintain the balance they were said to represent between mind and body reflected in the perfect consonances

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[5] Maranto, C. (1991) p. 14
[6] Gouk, P. (2007) p. 239
[7] Gouk, P. (2007) p. 234

of the octave and the fifth. However, the compositional trends towards use of the major third created a need for this interval to be more consonant than was possible in the Pythagorean tuning system. Differing ideas advocated the tempering of instruments away from Pythagorean tuning with the creation of Just Intonation and Meantone tempering as well as the initial hypothesized development of equal temperament.

The French mathematician and theorist Marin Mersenne (1588-1648) advocated the use of equal tempering between all notes on a monochord in his book *Harmonie universelle* written in 1636-7. Mersenne was extremely interested in the acoustic properties of the physical vibration of sound, and was the first person to explore in depth how overtones are derived from the production of a musical note. First utilizing bells and then moving to more adaptable string instruments, Mersenne determined that the movement of a string producing a musical note causes the air surrounding the string to vibrate in "diverse, consonantly related modes."[8] This resulted in the first theory of consonance, an explanation of why a sound is perceived as pleasant and consonant vs. harsh and dissonant.

The advances made in acoustics through the work of Mersenne, Kepler, and Descartes through the 18th century laid the foundation in the 19th century for the work of the scientist Hermann Helmholtz (1821-1894), who explored the scientific elements of audiology in music and the sensation in the human body created upon hearing musical tones. He shares the results following major acoustical studies on the overtone series as well as the details of the partials associated with the overtone series in his book, *On the*

[8] Green, Butler. (2007) p. 250

Sensation of Tone written in 1863. He also presents a hypothesis on a theory of consonance between notes based on his findings. In the laboratory setting, he was able to isolate the actual physical attributes of the musical tone and describes how the physiology of the ear and auditory system interpret these data. In addition, the book delves into a more aesthetic approach of listening to music. Thus, he not only advanced scientific knowledge on the physiology of the hearing process and the sensations created on the body, but also provided an explanation of the consonance requirement for the tonal system of Western music.[9]

Helmholtz theorized that the once the sound waves had passed through the auditory system that the actual interpretation of the music is left up to the individual; the individual's life experience would influence the resulting emotional interpretation of the music in the cerebral cortex. His theory of consonance specifies that the sensory response of consonance achieved between musical pitches is based on the similarity of the upper partials of two or more tones, as well as the absence of acoustic beating among the partials. Acoustic beating is evident in the auditory system as fluctuations in dynamic resulting from the "acoustic interference" of two tones that are almost in unison; more discrepancy in the tones produces a faster beat pattern. Helmholtz concluded that dissonance is therefore caused by a lack of affinity in the upper partials, as well as the additional presence of acoustic beating.[10]

[9] Green, Butler. (2007) p. 259
[10] Helmholtz, H. (1954) p. 194

In contrast to Helmholtz, the physician Carl Stumpf (1848-1936) was more interested in the experience and mental aspects of the individual perception of music rather than the physiology. He invented the word *Tonpsychology*, which is also the name of his two volume set written from 1883 to 1890. His theory of tonal fusion was based on each individual's perception of hearing intervals, and he hypothesized that two tones can actually be perceived to blend to the extent that the individual will hear them as a unitary event.[11] This theory had little influence at the time, but did open a new door to the psychology of music and the importance of individual perception.

A group of psychologists known as functionalists initiated their work in late nineteenth century America in order to attempt a more scientific explanation of the individual perception of music within the cerebral cortex. Functionalism is defined as "an orientation in psychology that emphasized mental processes rather than mental content and that valued the usefulness of psychology."[12] Carl Seashore (1866-1949), an American functionalist, set in motion the future connection of music and psychology with laboratory experiments to determine specific "capacities or abilities for the hearing of music tones."[13] Seashore's evidence-based work emphasized scientific procedures to help evaluate how musical aptitude is a positive influence in the area of education. The seven goals quoted from *The Psychology of Music* which he wrote in 1938 are as follows:

1. give us a "psychology of music"
2. furnish us with a "technique for the development of musical aesthetics"

[11] Green, Butler (2007) p. 266
[12] Gjerdingen, R. (2007) p. 962
[13] Gjerdingen, R. (2007) p. 965

3. form “a basis for the analysis and evaluation of musical talent”

4. develop a basis for “an intimate relationship between music and speech”

5. lay “the foundation of musical criticism, musical biography and autobiography, and music theory in general”

6. furnish “the foundation for the essential facts for the construction of the curriculum”

7. give “music its true place and influence”[14]

Twenty years following, Leonard Meyer’s (1918-2007) first book, *Emotion and Meaning in Music* written in 1956, provides a powerful proposition directly linking music and cognition. Meyer builds on Seashore’s connection that an understanding of psychology, specifically Gestalt psychology, can be utilized to comprehend individual meaning and perception in music. There is a delineation made between emotion (temporary and evanescent) and mood (relatively permanent and stable) as Meyer explains that emotion is the important focus.[15] Meyer proposes that both structural beliefs and previous experiences influence how an individual will react to music. “What we know and expect influences what we perceive.”[16]

This proposed theory of expectations asserts that there may be little personal meaning in hearing music when no previous exposure to the individual style of that music has occurred. However, when there is familiarity with a musical style and realization of expectations are present there can be a great deal of internal significance and meaning.

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[14] Seashore, C. (1938) p. 12
[15] Meyer, L. (1956) p. 7
[16] Meyer, L. (1956) p. 77

Memory plays a role in the meaning, since memory recalls most of the elements that are being played in a familiar piece. Meyer's insights were unique in dealing with the perception of musical meaning to each individual and how this meaning is communicated through music; he makes a powerful connection between music and cognition processes.

The evolutionary paths of the physiological reaction to acoustics begun by Helmholtz and Stumpf, and the process of the psychological reaction to music begun by Seashore and Meyer further opened the doorway to acoustic work accomplished with sound perception. Such scientists as Diana Deutsch and Albert Bregman have made significant contributions with evidence-based research in the realm of auditory scene analysis. These studies are generally investigated on the level of pitch relation or pitch perception by an individual. The analysis derives data in precise laboratory research at micro levels of measurement, and has produced significant findings on the scientific measurement of acoustics in both pitched (musical) and non-pitched (speech or environmental sound). The research utilizing the Gestalt principles of grouping to ensure that distinct visible elements grouped together form a coherent perceptual organization (as long as they fulfill specific conditions of similarity and contrast), is applicable to auditory perception. Sounds of similar timbres will group together such that differing timbres will be differentiated even when playing in the same register.

The connection of music with language

The connection between rhythmic flow and the spoken word also dates back to antiquity. The Pythagorean ratios of harmonic intervals can be traced to the ancient Greeks, as can rhythmic wording devices such as iambic and troachic meters. In 389 CE as the ancient Greek culture was evolving away from its zenith of civilization, the Christian leader St. Augustine (354-430 CE) wrote his treatise *De Musica* where he applies the Pythagorean ratios to poetic meter. St. Augustine illustrated that the purity of the numbers and ratios in Pythagorean theory was applicable to both music and poetry as a means for philosophical knowledge, which would theoretically make a path to God. The well known use of the trivium segment of the seven liberal arts (mentioned on page 5 of this document) also encouraged the use of grammar throughout the middle ages. A natural connection was formed between the two arts of grammar and music.

One of the original Middle Age treatises which referred to both the harmonic tradition of the Pythagorean ratios as well as the practical application of this information to the cantus (the practical application to Gregorian chants), was Aurelian of Reôme's (c. 9th century) *Musica Disciplina* written c. 850. Aurelian's writing is poetic, reflective, and full of metaphors: the verbal accents of "acute, and circumflex" are used in conjunction with how a voice should lift naturally on a given tone in a chant.[17] The symbols for acute and grave became part of the western grammatical tradition, which is also indicative that early chant and syllabic patterns were influenced from a natural flow of speech.

Following in Aurelian's footsteps, and very possibly the influence of St. Augustine's writings, the music theorists in the 11th and 12th centuries gradually

[17] Aurelian. (1968) p. 53

developed a system in which the original Greek poetic patterns were incorporated into a series of six Rhythmic Modes. The modes were in use well into the 13th century and formed a significant part of the basis of much of the polyphony during this time. More connection is made three hundred years later between music and grammar when in the 16th century, a musician named Juan Bermudo (c. 1510-1559) wrote *Comiença el libro llamado declaratión de instrumentos musicales*. He cites important medieval and contemporary composers and gives examples of their writing style as well as his own techniques of composition. He notes that making an error in counterpoint is synonymous with a grammatical error, and that anything that doesn't make sense in a composition is "contra rhetorica."[18] Two centuries following in 1782, the theorist Heinrich Koch (1749-1816) began work on a treatise written on the subject of using melodic line in composition. He likened musical phrases to a spoken sentence in the use of punctuation and the resting points made in natural speech.

In more modern study of linguistics, a new paradigm was created in mid 20th century by the work of Noam Chomsky (b. 1928). His theory of generative grammar hypothesizes that all grammatical properties rise from an "innate" kernel common to all grammar. The great American composer and conductor Leonard Bernstein (1918-1990) made a cohesive argument in his six talks at Harvard documented in his book *The Unanswered Question*, that the innate kernel of Chomsky's theory could be compared to the universal placement of the overtone series in any musical phrase. Bernstein also argues that while a phrase really can't be compared to a sentence (since a sentence stops

[18] Schubert , P. (2007) p. 528

with a period whereas in music you don't stop until the very end of the piece), that melodic material could actually be compared to nouns, while rhythm (meter) could be compared to verbs, and harmonic function could be compared to adjectives.[19] This theory has admittedly received mixed reviews, but presents a valuable hypothesis stage to research.

The combination of linguistic, acoustical, and theoretical data garnered from prior research further demonstrated the connection of music and cognition through the efforts of Fred Lerdahl (b. 1943) and Ray Jackendoff (b. 1945), who introduced their *Generative Theory of Tonal Music* (GTTM) in 1983. The theory analyzes an experienced music listener's intuition process by using a model that includes a reduced time span (rhythmic reduction), a Schenkerian linear process, and the epistemological "rule" framework borrowed from linguistics.[20] The simple act of taking a breath in the correct place in a melody highlights the important insight that linguistics adds to the process. The Gestalt emphasis on rhythmic reduction follows a similar line to the previously mentioned research being simultaneously produced in acoustics with auditory scene analysis. Although the initial GTTM model introduced in 1983 was based on hypothetical rather than empirical data, the model became greatly improved five years later following significant research which led to some basic changes in stability conditions. An error in baseline data could be supposed however, since a cross section of all individuals regardless of their musical experience was not used; Lerdahl just focused on experienced

[19] Bernstein, L. (1976) p. 89
[20] Lerdahl, Jackendoff (1983) p. 8-9

listeners of music. Nevertheless, this was a major development providing evidence for the connection of music and cognition processing.

One of the world's best known neurologists, Oliver Sacks (b. 1933), has recently completed a book called *Musicophilia*, which is dedicated to the issues of music and the brain. He argues that human beings possess an innate and instinctive tendency to understand music, and hypothesizes that music understanding and language development run parallel paths in the evolutionary cycle. "We humans are a musical species no less than a linguistic one,"[21] quotes Sacks. Medical advances have also been realized from current technology in brain scans, and the connection between language and music can now also be confirmed on the neurological level.

Treatises dating back to the ancient Greeks, Augustine, Aurelian, Zarlino, and many others show the intrinsic connection theorists and philosophers throughout centuries of recorded history have made between music and varieties of cognition. Following the treatises through chronological history, a connection chain is formed dating from the time of the Greeks and going through to today's modern technology. Theorists, performing musicians, and even physicians should take this into consideration and realize that our predecessors intuited this connection without the benefit of the current technological tools. The tools and current research have opened further doorways in evidence-based research that could only have been dreamed of without the help of technology.

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[21] Sacks, O. (2007) p. xi

Use of music in typical growth development

It is clear that music has been considered a valuable tool in assisting with the development of cognition processes. An explanation will now be made of how education and neuroscience professional disciplines have determined how music and rhythm are physically utilized in the building of motor, language, and cognition skills in childhood development. Typical childhood development skills are built utilizing music to help these development patterns in somewhat predictable and defined stages in most maturing growth.

The Theory of Cognitive Development was developed by Swiss philosopher Jean Piaget (1896-1980) and defined four stages of how children acquire emotional and intellectual information as they grow. The initial stage of growth, beginning with the newborn and continuing to approximately two years of age, is referred to as **sensorimotor** development.[22] During this phase, the child responds to musical sounds and differentiates from whence their source directions occur, and can discern differences in timbres of musical instruments such as bells and percussive sounds and changes in dynamic levels. Approaching six months of age when the child's muscular development is more mature, they respond with physical movements to the music that can assist in their motor development and coordination. Such movement can be encouraged with such rhythmic games as "Patty Cake" or by striking percussive musical instruments like bells.

[22] Davis, Gfeller, Thaut (1999) p. 37

Around 19 months of age, sing-song like patterns emerge from the child as the music assists with developing language vocalization. Music can serve multiple purposes in this initial sensorimotor developmental stage, which includes the expansion and experimentation of sensory, cognitive, communication, social, and motor skills.[23]

Stage two of childhood developments is referred to as the **preoperational** stage, which typically occurs in children between the ages of two years to seven years. This stage manifests in language development emerging in most typical children as they learn much greater vocabulary and can express themselves verbally. This is also the period when the child develops the ability to grasp concepts and is extremely absorbed in his/her own evolvement.[24] He/she may start to improvise short, melodic patterns in the earlier years of this development, and in later stages differentiate contrasting pitches much more accurately. Music is also used for motor development at this time, as can be observed when a toddler starts to briefly beat or dance in rhythmic motion to music. By the age of four, children are generally walking and jumping in time to music very naturally. In the later stage of this preoperational development, most typical children have acquired the skills needed to skip or clap in time to music.

The third developmental stage is referred to as **concrete operations**, and this stage of development typically occurs in children between the ages of seven and eleven.[25] Around age seven, most children develop the capacity to focus outside the world of their own development and concentrate on more external interests. It is at this stage that they

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[23] Davis, Gfeller, Thaut (1999) p. 38
[24] Davis, Gfeller, Thaut (1999) p. 39
[25] Davis, Gfeller, Thaut (1999) p. 40

begin to develop capacity to solve mental and systematic problems. As they learn to become skilled readers of language, they also develop a greater capacity to read musical notation and symbols. Since they can direct simultaneous attention to more than one task, their musical attention can be focused on singing a particular line of harmony while another line is sung in duet form, such as soprano/alto part singing. The gross motor skills of the body become fully developed, so they have the additional coordination necessary for playing a variety of musical instruments.

The fourth and final stage of development is called **formal operations**, which is entered around age eleven and continues through adulthood. During this stage in typical development, the child learns to think both systematically and in abstract terms.[26] Systematic thinking allows the child the capacity to solve problems, but abstract thinking lets them ponder the existence of the problem itself. This stage allows the child to respond to and feel the experience of the music from a deeper point of view. They become more interested in creating line and real movement and emotion in the music instead of just playing the notes.

These stages occur in typically developing growth patterns, but are also applicable to facilitate development of children in atypical growth patterns. An important element of using music for growth development is the presence of rhythm, creating a temporally based environment. A phrase of music structurally develops both sequentially (melodically) and simultaneously (harmonically); both developments occur in the same

[26] Davis, Gfeller, Thaut (1999) p. 41

time and space.[27] The temporal beat in the music generally organizes itself into groupings based on meter. By organization of rhythmic events through meter, the sequences of beats create a hierarchy in the space of the music.[28] Music theorists have also considered grouping sets of meters into a high-level background structure called hypermeter; at approximately the phrase level each background segment contains essentially equivalent spans of time.

In addition to this hierarchy, rhythm also orders the events such that the listener can anticipate the next sequence in the chain. Michael Thaut refers to this in his book *Rhythm, Music, and the Brain* as follows: "Rhythm determines, assigns, and builds time relationships between events in the perceptual process. Because all efforts in perception must fundamentally include a multi-dimensional temporal process, regardless of sense modality, rhythm assumes a critical role in the shaping and modulating of meaning in perception."[29]

Rhythm is perhaps the most elemental aspect of music, and while auditory and motor systems exist in the brain there is no actual "rhythmic" cortex. Rhythm is an innate and intuitive element, which is accessible throughout much of the human central nervous system, and as such can be tapped into even when there are neurological damages caused by insult or accident of birth. The next section of this paper will discuss the scientific basis for using rhythm to lay the foundation for specific neural music protocols.

[27] Thaut, M. (2006) p. 3
[28] Thaut, M. (2006) p. 5
[29] Thaut, M. (2006) p. 5

Perception of Music in the Brain

A temporally (rhythmically) based auditory event provides an environment that can be utilized for positive therapeutic outcome. Rhythm is structured and predictable as well as time-ordered, so the brain responds with predictable entrainment patterns. Rhythmic entrainment creates an activation of the auditory cortex, the prefrontal cortex, and the cerebellum.[30] A simple beat pattern without pitch (metronome) can suffice to activate these levels, or the beat can be surrounded by the other structural elements of music such as pitch, harmony, etc. in an actual musical experience.

The process of music perception begins as music enters both ears as a collection of sound waves vibrating at a certain level. The sound waves travel through the outer and middle ear mechanisms and arrive at the cochlea of the inner ear. They then pass through the tiny hair cells of the inner ear and are dispatched into the brain via the circuit of nerve fibers connected to the auditory center of that hemisphere's cerebral cortex. At this point in the auditory process, the distinct perception of the music differs in each individual as different affective responses are raised based on past associations and experience.

Music is first perceived as structure in the brain, with the perception of pitch, harmony, rhythm, melodic contour, intervals, dynamic, etc. The act of listening to a piece of music awakes auditory and emotional response areas, and in addition creates a motor response. Oliver Sacks quotes Nietzsche in saying "We listen to music with our

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[30] CSU (1999)

muscles…we keep time to music, involuntarily, even if we are not consciously attending…"[31]

How does a motor response physically occur? The brain is a cellular structure, with an estimated total neural cells of somewhere between 100 billion and 1 trillion. The neurons are receivers, integrators, and transmitters of information. When they come into functional contact with each other for any purpose, a chemical reaction releases specific chemicals (called neurotransmitters), that cross the synaptic gap to create the reaction. Synaptic interaction appears to explain much of how brain functionality works. Nerve cells become excited by sensory stimulus, such as sound, and they produce reactions; the stronger the input the larger the reaction generated. When a stimulus action creates a synapse between neurons, the chemical release produces a chain synaptic reaction in adjoining neurons. A chain of these communicating neurons is created as several are linked via the connection of the synaptic gap between each cell; this is referred to as a pathway. This pathway chain eventually leads through the central nervous system sending a message to muscle cells, which in turn produces a motor response.[32]

With motor response resulting from the synaptic reaction, the body is able to rhythmically synthesize its movements. Each individual has an independent "internal cadence" established by a probable combination of heart rate and steps-per-minute; and physical motor patterns tend to be more consistent within an individual when the external

[31] Sacks, O. (2007) p. xi
[32] Dowling, J. (1998) p. 34

beat cadence is structured to equalize the individual's internal cadence.[33] Small changes (plus or minus four percent) in the cadence pattern will not be perceived by the individual and therefore the beat stimulus can be slowly changed to accommodate a therapeutic goal. For example, if an individual cadence is studied to be sixty-four beats per minute and the goal is to speed the cadence, a beat pattern can be set up to sixty-seven beats per minute and there will be an ability to follow the change in physical movement without perception that the beat pattern is faster than the internal cadence.

Of particular interest in recent research are the findings that the response to the temporal environment is directed not as much to the actual beat itself as it is to the span of time in between each beat's occurrence. This indicates that the motor movement and synchronization of the body is not just occurring at the time of the actual beat, but during the entire duration of the timing pattern. The end result is that the rhythmic entrainment potentially improves dynamic elements of all movement, not just the movement that coincides with the actual beat.[34]

Music and the temporal structure can evoke consistent response in the body and can therefore be used to intentionally direct therapeutic changes. Due to major advances in technology, neuroscientists have become aware of a condition in the brain referred to as "plasticity", which indicates that changes can occur in the structure of the brain based on the experience and training of each individual. Any process of learning or thinking can assist with brain plasticity. Musicians are intuitively aware of this process, since it is

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[33] Thaut, M. (2006) p. 144
[34] Davis, Gfeller, Thaut (1999) p. 46

the essence of practicing an instrument. When an action is repeated in a temporally based environment, such as practicing a phrase of music on an instrument, the muscles and motor patterns react with learning to make automatic movement.

An evidence-based example of typical development of plasticity can be found in the brain patterns of professional musicians, where the "hard-wiring" of the brain structure correlates the auditory and the motor centers. Brain scans of these musicians have shown that motor areas will light up in the brain when the musician is asked to just think of (not move to) a piece of music. In a similar fashion, the silent practice on a tabletop when no instrument is present will evoke the memory of a particular piece of music, and the auditory center will light up.[35] Due to intensive use of both the auditory and motor systems in musicians, the brain hard-wires these two areas together. In non-musicians, the areas work much more independently of each other.

In the realm of affect and emotion, musical experience and the emotions invoked from such experiences are stored in the memory of each individual. Among the case studies of Dr. Oliver Sacks, he writes of occurrences where electric stimulation was utilized with epileptic individuals to assist in controlling their seizures, often resulting in patients hearing music within their heads. Different patients heard different music even in the same area of the cerebral cortex; it could be a piano, a voice, and orchestra, a choir, or even a radio commercial. The evidence shows that the selection of music tapped into is random, and based on the "evidence of cortical conditioning" for each individual.[36]

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[35] Altmuller, E. (2006) p. 176
[36] Sacks, O. (1990) p. 141

There is an unconscious selection of musical events stored in memory accumulated during the course of a lifetime, and that repertoire residing in any individual reflects the experiences of their own lives.

The next section of this paper will concentrate on the goals and outcomes of specific techniques developed using evidence-based research; these protocols help influence motor, speech/language, or cognition goals with the directed use of music in therapy.

Music and the Neurological process

The following techniques and protocols described as rhythmic entrainment for therapeutic purposes were developed and researched at the Center for Biomedical Research (CBRM) at Colorado State University. These protocols are defined as techniques which utilize the therapeutic application of music to cognitive, sensory, and motor dysfunction due to neurological disorder or disease.[37] All protocols are based on a neuroscience model of music perception and the influence of music on functional changes in nonmusical brain and behavior functions. The protocols will be described under the headings of motor, speech/language, and cognitive techniques.

It should be noted that only certain protocols developed at the CBRM are listed in this paper, as they are applicable to working with special needs children. The model utilized for creating individual therapeutic outcome with the protocols is referred to as the Transformation Design Model (TDM). This model follows the progression of five functional steps:

1. Diagnostic and functional assessment of the patient
2. Development of therapeutic goals/objectives
3. Design of functional, nonmusical therapeutic exercises and stimuli
4. Translation of previous step into functional, therapeutic music experiences
5. Transfer of therapeutic learning to real-world applications[38]

[37] CSU (1999)
[38] Thaut, M. (2002) p. 35

The model's fourth step manifests in utilizing the techniques described below. It should be noted that these techniques are not specific to a single diagnosis, but are applicable over a wide range of neurological problems. For example, gait training is generally used for stroke rehabilitation but is also very appropriate to utilize for a child afflicted with autism who has deficient gait skills.

Motor protocols

Motor therapeutic protocols fall into three main categories:

1. The use of musical instruments to simulate practical motor patterns
2. Gait training
3. Sensory cues to regulate movement patterns

Protocols result from knowledge gained from research literature and from repeated applications to clinical situations until predicable outcomes occur. Clinical protocols are developed by professional practitioners and used within interdisciplinary teams to facilitate functional outcomes of those in treatment.

The protocol for motor change begins with an assessment of an individual's internal cadence. This is done through the observation of spontaneous movements of the body including arm movements and/or step cadence. The individual's internal cadence is identified from the outset of each therapeutic session. Depending on individual goals based on diagnosis, the external cadence beat may be set to deliberately match the internal cadence, or the goal may be to either slow down or speed up the internal cadence.

The initial category of motor protocols is **therapeutic instrument music performance** and involves the use of musical instruments to assist with simulating motor patterns. Playing instruments utilizes either gross or fine motor skills and generally requires some form of repetitive muscular action. Percussion instruments are particularly suited for this kind of protocol, although other instruments such as strings or keyboard can be used to target specific muscular areas as well. This exercise design creation is based on the following three elements:

1. The musical structure facilitating the organization of movement in time, space, and force dynamics
2. The choice of instruments and the mechanics for playing the instruments to enhance therapeutically meaningful movements
3. The spatial arrangement and location of the instruments to facilitate desired motion paths of the limbs and positions of the body[39]

To illustrate, a hypothetical individual with a diagnosis of cerebral palsy whose symptoms have resulted in tremors and spasticity of the hands has received a therapeutic goal of strengthening fine motor movement of the fingers. A program is established to work with a keyboard and thus strengthen the individual fingers of each hand. This will also assist in arm control for larger motor movements. The same individual may work towards improving gross motor skills for the whole arm in an exercise utilizing percussion instruments to assist with muscle building and coordination. The end result will be the further development of muscle strength and speed of motor response as well

[39] Thaut, M. (2005) p. 154

as range of motion and more dexterity in physically reaching for different patterns of vertical or horizontal alignment.

Using musical instruments in a therapeutic environment has an additional desirable element; it is usually considered fun to play an instrument and it is not perceived as a chore. By utilizing this motor technique, an individual can learn or re-learn functional movement skill processes, increase strength and endurance, and potentially overcome motor compensation that may have become unhealthy and unbalanced.[40]

The second neurological music motor technique is **gait training**. Gait is a biologically rhythmic function that can be affected by many forms of neurological trauma including Parkinson's disease, Autism, late stage dementia, stroke, Traumatic Brain Injury (TBI), and many other medical issues. Rhythm functions as an external means to assist the individual in keeping time to a beat; motor functions in gait are entrained or retrained through the cuing of movement patterns. Depending on the diagnosis of the individual, the resulting goal may either be to retrain neural networks using the techniques to promote plasticity, or the goal may simply be to enhance the quality of life for a person affected with a disease for which there is no immediate neural rebuilding capability, such as Parkinson's disease.

An example of gait training is working with an individual in stroke rehabilitation who has lost partial movement on one side of their body. After determining the internal cadence (it will most likely occur at a slow walking pace at this point), a beat is set with either live music or metronome that matches their cadence. The individual will then

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[40] Thaut, M. (2005) p. 155

attempt to walk in time to that beat. Eventually the cadence can be gradually increased (by up to four percent at a time) so that the client will keep in tempo with the increased tempo. This results in retraining body movements to keep pace at a cadence that is faster than previously accessible.

A different illustration is exemplified in working with patients affected by Parkinson's disease. Typical Parkinson's patients are affected by a shuffle of the feet sometimes referred to as a kinetic stutter, as well as a loss of ability to navigate room corners or initiate spontaneous movement on their own. The automation of the gait becomes worse in clients with Parkinson's due in part to a deterioration of the basal ganglia in the brain, which is associated with motor control.[41] By creating an external cadence, which will speed or slow their gait to a normal pattern, the shuffle retrains to become more of a normalized gait pattern; the automation of the beat pattern replaces what had been the automation gained from the neural networks.

The inability to initiate movement or navigate particular structures can also be assisted with an external temporal environment. The basal ganglia deterioration tends to disable spontaneous movement such that the patient will not be able to navigate out of a corner, but music or even the simple beat of a metronome can be utilized as an external stimulus that will replace the automation lost in the brain and allow the patient to move freely out of that corner. This is an example where rhythm is not being utilized to assist with brain plasticity, but to externally replace brain function, which cannot be repaired; thus a better quality of life is achieved.

[41] Sacks, O. (2007) p. 255

The third form of motor movement technique, **patterned sensory enhancement**, utilizes music to generate an environment where kinetic movement can be mirrored from the actual structure of the music being created. This technique is not merely rhythmic but utilizes other structured elements, such as pitch and melodic contour. As a particular therapeutic muscular motion is manifested, such as a shoulder roll or toe tap, music is created that reflects the spatial, temporal, and dynamic elements of the motion by using the appropriate tempo, rhythm, pitch and dynamic for the desired motion.[42] This protocol is more complex than the two previous techniques (the playing of musical instruments and gait training) and therefore is more specialized to specific individual therapeutic goals.

The cuing elements utilized to create an action requiring concentration of a muscular motion include pitch (high or low represent the vertical axis), loudness (large or small movements), duration (extended muscular motion for longer phrasing), and harmony (open or closed chords can reflect desired range of body movement).[43] Cuing elements related to temporal action include tempo, meter, the rhythmic pattern of the phrase, and the final musical form (such as ABA, chorus/refrain, etc.) created.[44]

Patterned sensory protocols are useful for specific kinetic goals. For example, if a movement is required where a client needs to reach as high as possible to extend the shoulder muscles to stretch them following surgery, a running melody reaching up in pitch would mirror the action needed to be manifest with the muscles. This technique is

[42] Thaut, M. (2005) p. 150
[43] Thaut, M. (2005) p. 151
[44] Thaut, M. (2005) p. 152

particularly applicable to movements in the arms and hands, trunk, or full body consideration. Another example is illustrated with a special needs child who learned to swim but could only dog-paddle because he/she would not extend arms out from the shoulders. A kinetic musical pattern is matched to the motion of arms rolling over a shoulder bilaterally and then sequentially, so that the motion of "swimming" would be manifest by a musical pattern. Once the muscular entrainment is complete, the music cue is removed and the muscular pathways are entrained when the client is actually swimming.

Speech/language protocols

Speech and language can be assisted through using neurological music protocols. Language processing is typically accomplished in certain areas of the cerebral cortex but because the brain is flexible, language processing can generally be maintained even when one cerebral hemisphere is damaged through neural trauma or accident. Hemispheric processing tends to be fairly distinct, particularly with language. The left brain hemisphere is typically oriented towards verbal processing, sequential processing, rational analysis, and language evaluation and detail. The right brain hemisphere is generally oriented towards nonverbal processing and communication, global processing, forming impressions, evaluation of emotions and "big picture" processing. Should neural trauma result in speech production problems, the location of the damage in the brain will determine what symptoms are manifested from the neural problem.

Since music is processed in both brain hemispheres it can be utilized as a therapeutic structure to redirect damage reflected in an alternate hemisphere via brain plasticity. The key structural elements needed to make the connection of music with speech and languages are rhythm, syllabic stress, and melodic line. The simplest protocol to use is called **therapeutic singing**; this uses such warm-ups and breathing techniques as might be found in a church choir. This protocol can establish full breathing capacity and also tends to help work out specific phrasing issues for clients affected by stuttering.

More complex protocols are required for clients affected with fluency disorders where initiation or speech pace is affected. Disorders such as verbal apraxia (difficulty in coordination of mouth and speech movement), and dysarthria (difficulty in articulation of words) are common afflictions following neural damage from a stroke and can be helped therapeutically with a protocol called **rhythmic speech cuing**.

Speech cuing is accomplished using an external auditory stimulus, such as a metronome, in addition to rhythmic tapping of the client to help them internalize the given tempo. There are two distinct categories of speech cuing: metric cuing and patterned cuing. Metric cuing utilizes a beat pattern in which one syllable of a phrase or word is laid over each beat for equal duration (i.e. syllable-to-beat). This technique does not manifest in normal speech patterns due to the particular syllabic patterns that are forced, but it does tend to negate any interruption of speech and initiate correct sequence for word structure (which tends to be jumbled) due to apraxia.[45] Contrary to the syllable-to-beat pattern in metric cuing, patterned cuing utilizes a temporal duration and syllabic

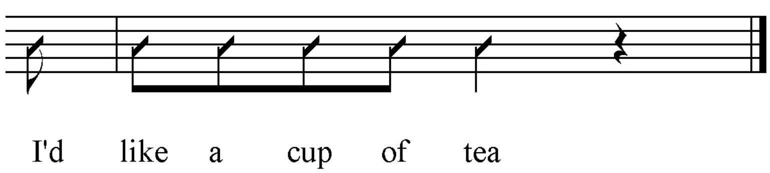
[45] Thaut, M. (2005) p. 170

pattern between beats, which mirrors normal speech patterns. This would be a preferable technique for a client with a less severe form of a speech disorder, or possibly someone who stutters. The patient's functional speech pace must be considered when setting the cadence for this technique, as a speech disorder will typically result in a slower speech cadence.

An unfortunate speech disorder manifested in stroke is aphasia. When hemispheric damage is the result of a stroke, the division of communication tasks between brain hemispheres can result in confusion. For example, stroke patients may be able to physically say the word "ball", but when a ball is placed in their hand or they are given a picture of a ball, they cannot identify what the actual object is they're holding or observing. Most patients with aphasia also have difficulties with the motor function of speech, and they tend to have a flat intonation with little variance of pitch when speaking. Typically though, patients with aphasia will retain the ability to sing even when they are unable to produce normal speech. Music is utilized to activate the brain to support recovery in speech; since the entire brain can be activated with music, speech function can therefore be rerouted to an area beyond the damage.

Two protocols are helpful for this circumstance, one is easier to utilize and one is much more complex. The easier technique is musical **speech stimulation** using a format that will help trigger an automatic response from a patient. Music in songs, chants, and rhymes are initiated for a client, with the resultant goal being that the client will reflexively join in when prompted. For example, a geriatric client who would remember the children's songs from six decades previously would have a deep childhood memory of these songs, and make a verbal association when presented with the singing of "Twinkle, Twinkle, little…" by filling in the word "Star". Musical speech stimulation therefore attempts to create automatic speech output due to a strong memory of lifetime experience and the probable over-learning of such things as childhood songs.[46]

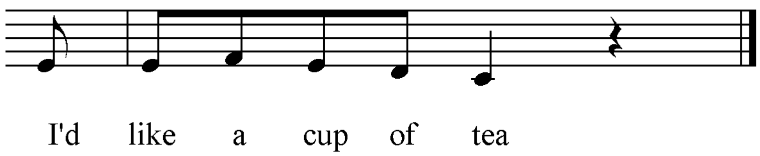
A more complex technique in assisting with a diagnosis of aphasia is **melodic intonation**. This is a protocol that will help a client increase both the length of spoken phrases and will also assist the client in initiating spoken phrases. Melodic intonation therapy starts by first creating a goal of a spoken phrase for the client will verbalize. Typically it will be something utilized in everyday life at home or work, such as "I'd like a cup of tea'. A rhythmic manifestation of this expression should be as phased as closely as possible to how the phrase is normally demonstrated in speech. A possibility is as follows:



When the initial rhythmic pattern has been established, then an easy melodic phrase is juxtaposed onto the rhythm. This melody should be as simple as possible, preferably using melodic steps with intervals no larger than a third. It should be easy to

[46] Thaut, M. (2005) p. 169

remember with strong intervals matching the strong syllables, and not exceeding the total interval of a fourth in the entire phrase. A possible match for the above rhythm is as follows:



After setting the external cadence on the metronome to the client's functional speech pace (which will probably be quite low), there is a series of taps on the hand of the client imitating the rhythmic phrase; this will enable the client to ascertain the rhythm of the phrase. The tapping will include syllabic stress in the correct notes of the phrase. This is all in conjunction with humming of the selected melodic line; this established melody, basic rhythm, and syllabic stress of the phrase and familiarizes the patient with the phrase without their yet having to play a part.

Eventually the patient is asked to hum along with the facilitator. In an expurgated description of the technique, the phrase is sung rather than hummed by both facilitator and client after a period of time. The client gradually gains ability to sing the phrase as the facilitator fades their own participation. The final step requires the music be phased out so that the client speaks the phrase without the aid of the music. Typically the facilitator will ask verbal questions of the client to confirm the accuracy of the results; in the present case it would be similar to "would you like a cup of tea?" The client will then respond using the phrase learned through melodic intonation.[47]

In order for this technique to succeed the client must possess enough executive functioning and cognition to be able to learn the new phrase, they must maintain the ability to focus on the process, and have proficient auditory comprehension to hear and repeat the phrase. Results can take weeks to months but they are generally permanent. Melodic intonation therapy is utilized not only for stroke patients suffering from aphasia, but potentially also for clients with other speech disorders where the client understands the language but lacks the verbal abilities to manifest it in speech. An example is a client with autism who has been non-verbal since birth. Many moderate to severe clients can comprehend the words spoken to them to some degree, and this is an excellent technique for them to begin intoning certain verbal phrases.

A certain order and sequence of protocol use must be considered in a case like this, though. A nonverbal child will most likely have poor motor skills in the mouth and throat since they don't utilize the muscles associated with language functions. Therefore they would not be able to initially form words adequately when utilizing the melodic intonation protocol. Prior to starting melodic intonation training, it is appropriate to consider therapeutic singing for specific syllabic practice. An example of such is working with a rhythmic pattern of single repeated consonants or vowels in order to micro-practice those individual sounds. Beginning with either vowels or bilabial

[47] Thaut, M. (2005) p. 167

(articulated with two lips such as “m” and “b”) consonants are generally the easiest, since these sounds involve less complex mouth gestures.

Cognition protocols

The final variety of neurological music protocols for therapeutic use is in the field of cognitive rehabilitation. It should be noted that musical perception is experienced on many levels; the individual does not need to be highly trained and experienced in music in order to benefit from the protocols.[48] Cognition techniques engage many areas of the brain; an especially complex neural network provides the potential to reorganize neural activities due to brain plasticity. Factors addressed with these techniques include such brain functions as: executive implementation of decision-making, auditory training, memory, and attention training. As with the motor and speech/language protocols, the cognition protocols are utilized across the board for therapeutic assistance in various cognitive challenges diagnosed from such disabilities as late stage dementia, stroke, autism, and many other neurological problems.

Executive functioning training is a primary protocol to consider when using the cognition techniques, since most of the techniques require a client to already have the abilities associated with this skill. Executive function is defined as “a person’s ability to formulate goals; to initiate behavior; to anticipate the consequences of actions; to plan

[48] Unkefer, Thaut (2002) p. 26

and organize behavior according to spatial, temporal, topical, or logical sequences; and to monitor and adapt behavior to fit a particular tasks or context."[49] In essence, a person must be able to make decisions, solve problems, and take action upon direction.

Training in executive functioning involves the creation of musical exercises that help practice skills involved with decision-making, comprehension, organization, problem solving, etc. An illustration can be found in working with a child with autism who has some musical background in the way of singing songs and playing instruments but has trouble making decisions. The child can be instructed to "compose" a song which will require him/her to make decisions on how long the song will be, what form it will take, what instruments will accompany, will there be words, should it be fast or slow, and so forth. These decisions help affect both the creative processes as well as assisting with the creation of neural processes for executive functioning.

Auditory Perception protocols integrate sensory stimuli within the auditory system; training takes the form of discrimination of musical components that include the structural elements of pitch, tempo, timbre, and rhythmic patterns. It can also include the tactile or visual systems with such activities as feeling the reverberation of sound while playing a drum or observing and moving to a form of dance with the music.[50]

Attention control is an important protocol for cognition, and is appropriate for adults with dementia, children with autism, clients in stroke rehabilitation, and so forth. Any

[49] Thaut, M. (2005) p. 187
[50] Darrow, A. (2004) p. 149

genre of individuals with problems in attention focus can benefit from this protocol.

Attention control is divided into the following categories:

1. Focused attention: the ability to respond specifically and completely to a single stimulus
2. Sustained attention: the ability to maintain a focus on a stimulus during continuous activity
3. Selective attention: the ability to maintain an attentive response to a specific stimulus when there is another stimulus competing for the attention
4. Alternating attention: the ability to shift attention between alternating tasks
5. Divided attention: the ability to simultaneously respond with multiple tasks present [51]

While music helps facilitate all of these categories of attention control, the simplest to facilitate is focused attention. Generally, the playing of a musical instrument will focus the attention of an individual. Young clients with severe autism who pay no attention to verbal cues will tend to visually focus on a facilitator playing an instrument in front of them. An added advantage of this protocol is that it can readily be used in a group situation, which provides added social benefits for various individuals trying different instruments.

Sustained attention is exemplified by creating a musical task in which a client focuses on the immediate task for an extensive period of time. An example is demonstrated in a game in which inattentive children diagnosed with autism are given two different rhythmic instruments and allowed to choose two simple songs they wish to hear. The songs are each associated with one of the instruments and the children are told to play one of the rhythmic instruments when they hear one song (either sung or played on an

[51] Thaut, M. (2005) p. 184

instrument), and then the other rhythmic instrument when the song changes. In this way, they are focusing sustained attention on the musical task and building the neural networks to focus sustained attention on other generic tasks.

Selective attention is developed when the musical task created has competing attention from an additional stimulus. Using the above example with sustained attention, an additional step to move from sustained to selective attention levels could involve the addition of a "heckler" to try to disrupt the attention of the child listening to the two songs and associating them with the correct instruments.[52] The heckler is typically given some kind of loud percussive instrument, which is hard to ignore, and attempts to disrupt the attention of the child focused on the original task of listening to the two songs.

Alternating attention develops as an individual deliberately shifts his/her attention focus from one task to another. This is easily accomplished as a musical task with two facilitators who each sequentially play a different rhythmic pattern on some kind of percussion instrument. Assuming the client to be the same as described above, he/she will now be given a rhythmic instrument and asked to follow and imitate the rhythmic pattern given by the first facilitator. Once that is pattern is established, the first facilitator will stop and the second facilitator will immediately start playing with a different rhythmic pattern, which the child will be asked to imitate immediately. The two facilitators pass back and forth and as the child follows first one and then the other; this works with alternating attention skills.[53]

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[52] Thaut, M. (2005) p. 209
[53] Thaut, M. (2005) p. 209

Divided attention is perhaps the most complex of the attention control protocols based on the abilities of a particular client. The difference between divided and alternate attention lies in the client's ability to focus on two different stimuli simultaneously as opposed to two different stimuli sequentially. An example is as follows: Given the clinical situation previously described with two facilitators carrying out two different tasks, in this circumstance the first facilitator will continuously play a percussive instrument and the client will be asked to imitate. The facilitator will, however, keep changing rhythmic patterns and the client will follow and imitate as the patterns change. The second facilitator will set up signals for the client to start playing or stop playing. Anytime the clients are playing their instruments, they are following the rhythmic pattern of the first facilitator, but the second facilitator could ask them to start or stop at any given time.[54] In this way, the children must maintain focus on both facilitators simultaneously and develop the ability for divided attention.

The final protocols to be discussed under the subset of cognition protocols deal with music to assist with memory functions. The association between memory and music is powerful; Leonard Meyer even stated in 1956 that "without thought and memory there could be no musical experience."[55] The human memory is activated by a physiological process referred to as "chunking", where small units of information, (seven to nine in total) are eventually grouped into larger units and moved from short-term into more

[54] Thaut, M. (2005) p. 215
[55] Meyer, L. (1956) p. 87

permanent memory banks.[56] An example of this can be found with observation of a child learning the "ABC" song. The first phrase of the song contains seven pieces of information: A, B, C, D, E, F, and G. The child first struggles with these seven individual pieces, but eventually the rhythmic and musical association functions to "chunk" this information into the single unit of "ABCDEFG", where it is now a part of a more long term memory. In essence, the grouping is now one whole unit rather than seven individual units.

A most useful protocol lies in the creation of **musical mnemonics**, when working with memory. The structure provides a perfect vehicle to help "chunk" words or phrases together; that structure can then be used to recall the information and assist in the process of learning. When dealing with neural memory issues, the combination of both melody and rhythm is more powerful than the use of rhythm by itself. The example described above of the ABC song shows the value that mnemonics can play with learning. Rote memorization is greatly assisted by the hierarchical organization found in melody and rhythmic material due to the structure provided by the music.

An interesting side note to the method of chunking is that professional musicians are constantly using this technique to learn music. Given the insightful experience that most musicians have had with musical analysis, the tendency is to remember an entire chord (C Major) as one unit rather three individual notes (C, E, G). Knowing the rule of how a chord is constructed and what kind of position it will be in (root, inversion, and so forth)

[56] Thaut, M. (2005) p. 75

allows that chord to be contained in only one unit of information in memory due to the experience of the musician.[57]

Protocol summarization

When recalling the five-step Transformational Design Model described earlier, it must be stressed that the last step of the model consistently involves the fading of the music associated with the therapy so that the neural pathways opened with the use of music are then associated with "real life" activities as opposed to musical tasks. For instance, in the example given of attention control with the client who is practicing with sustained attention protocol, the final step of the process is actually to substitute a real life stimulus for the musical instrument…perhaps a homework paper that would require focus during the duration of the music. With the removal of the music, the fading is completed and the direction of the neural networks that had been developed using the structure of music can now focus on tasks involved in everyday living. Each of the protocols will always have a final step that will remove music and establish the nonmusical environment.

Reviewing the described neurological music protocols, it is apparent that the generic protocol grouping functionality (i.e. motor, speech/language, cognition) can be applied to many differing neurological problems. A stroke patient will most probably have a combination of difficulties requiring all three groups. Similarly, a child with

[57] Levitin, D. (2006) p. 214

autism could have similar difficulties in gait, speech processing, and cognition processing that necessitate the use of all three groupings of protocols. The protocol is not specific to any diagnosis; music can redirect neurological patterns, and these protocols can be used across-the-board for many different types of neurological difficulties.

The next section of this paper will specifically deal with the neurological problems associated with children with special needs, and how to specifically apply these protocols to individuals that fall into this category.

The special needs child

Special needs children, both within and outside of the current educational environment, are growing. "Special needs" can arise from a plethora of reasons, such as medical problems, learning disabilities, behavioral issues, developmental disabilities, and many other such issues. Most children enjoy participating in music-related environments and are therefore excellent candidates for using neurological music protocols for therapeutic intervention.

Being defined within the realm of "special needs" generally puts a family with such a child into a very difficult position emotionally, physically, and also financially. Based on information from the National Institute of Child Health and Human Development (NICHD), the society cost of autism alone in this country is approximately an annual forty-three billion dollars ($43,000,000) per year. The Autism Society of America (ASA) reports that within ten years of this writing, the annual cost of treating autism will have risen to an estimated two hundred to four hundred billion dollars. Ninety percent of these costs are in adult services, and the cost of lifetime care can be reduced by two thirds with early diagnosis and intervention.[58]

The US Department of Education (DOE) and the ASA report that while the US experienced a population growth of thirteen percent in the 1990's, there was a simultaneous growth of those persons with disabilities by sixteen percent; the growth of

[58] Autism Society of America (2008).

children with autism at the same time was one hundred and seventy-two percent (172%). According to recent ASA reports, approximately one in one hundred fifty births that will be affected by the disease (one in ninety-four boys), with an annual growth factor of ten to seventeen percent (10-17%). Emotional as well as financial tolls are taken on these families. Unfortunately, eighty percent of marriages who have children with disabilities end in divorce, so the great majority of children are in single parent households.[59]

The Society for Neuroscience reports that although there is no cure for autism, research indicates that many with autism can respond well, especially early in life, to highly structured, specialized education programs designed to correct behaviors, teach social skills, and aid language.[60] The young brain is thought to be particularly adept at modifying its connections and function. Researchers believe that starting interventions early may take full advantage of this brain malleability and help improve an individual's mental, emotional, and physical functioning.

Children with autism can particularly benefit from using music in therapeutic environments, since so many individuals with autism have a high capacity for learning musical skills. The Autism Spectrum has exceptionally differing ranges of symptoms for the individuals affected, but most typically display symptoms of unusual social, emotional, and sensory reactions to their environment. Neural patterns of those affected with autism tend to lead to an access of stored neural information using non-linear and non-verbal methods. Dr. Temple Grandin, a highly respected professor at Colorado State

[59] Personal info – D. Miller
[60] Society for Neuroscience. (2008).

University who is affected with autism, describes her thought process as visual and picture-oriented rather than relating to the verbal processing that much of the "typical" world relates to.[61] The learning process of a child with autism is therefore much different than that of a typically developing child, largely due to the affected child's inability to understand the concept of using words for communication. The neurological music protocols help to bridge this gap and are a very effective method for reaching children with autism.

The statistics on the population with autism garnered from the NICH and DOE reflect only a small percentage of the entire population of children with special needs. Other developmental disability diagnoses include Down's syndrome, Tourette's syndrome, dyslexia, ADHD, Fetal Alcohol Syndrome, and many more afflictions. In addition to learning problems manifesting from their neural conditions, most children in these populations typically have some form of behavioral issues accompanying either the diagnosis or the resultant life experience. The children are frequently frustrated with their own conditions and limitations; much of the time they are very aware that they are "different" from their typically developing peers. Parents and educators are often thrown off-balance in working with the child by such issues as the uncontrolled physical impulses associated with Tourette's syndrome, as well as the "acting out" problems associated with many children with special needs. These children are particularly at risk for having serious problems in school, and the home environment can be degraded to a level of chaos that wreaks havoc on the associated families.

[61] Grandin, T. (1996) p. 20

Unless behavioral problems, functionality, and potential modification resolutions are taken into consideration when utilizing neurological music protocols with this population of children, the therapeutic intervention may not achieve the highest level of success. It is therefore extremely important to consider recognizing various tools utilized to modify behavior.

Function and Behavior

Most individuals have observed or encountered situations in various environments (home, school, or community) as a parent or societal agent gives an instruction to a child…with the end result that the child throws a temper tantrum rather than acquiesce to the instruction. The same response can potentially occur when attempting to facilitate neurological music protocols to assist a child, and they refuse to participate in the process. The response of "I can't" or "I won't" generally has underlying motivation. In order to effectively circumvent that motivation from occurring, the actual behavior problem must be addressed before the effect of the music can help the child.

Cliff Madsen of Florida State University is a leading behaviorist; his career research in music education has further extended the techniques initially established for educational circumstances by B.F. Skinner. Behavioral techniques researched and described by Madsen are documented in his book on education and behavioral issues;[62] the techniques described in this paper are particularly helpful in working with special

[62] Madsen, C. (1998)

needs populations. These techniques can be utilized to help surmount client behavior problems for children with special needs, both in parenting and educational environments.

First in the behavior process, is a distinct four-step process in the targeting, understanding, and overcoming of a behavioral issue; Madsen's terminology is "pinpoint, record, consequate, evaluate."[63] The initial step is to identify the specific behavior to overcome, and count the frequency the behavior manifests. The identification should be measurable and based on objective observation without emotional involvement. An example might be "Jimmy interrupts verbal instructions"; this observation is simple, identifiable, and easy to measure with an actual count of occurrences.

The second step is to document the behavioral events as well as the magnitude of the events. This is critical to be able to appraise the effectiveness of the entire progression in the evaluation of "before vs. after" observations and establishes the measurable criteria.

The critical third step is where contingencies are introduced to help motivate the child into modifying his/her behavior towards a more positive direction. These contingencies must typically be in place for a period of time in order to establish a new behavioral prototype in the child.

The fourth and final step is to evaluate the results garnered in the continued observation of the child. When the levels of modification criteria have been met and measured (including the observation and measurement that the behavior is now self-

[63] Madsen, C. (1998) p. 303

sustaining) then the contingencies are withdrawn and the modified behavior becomes permanent.[64]

The contingencies applied in the third step of behavior modification are relative to a range of individuals under various circumstances. Each technique involves implementation and feedback and is applied for different behavioral problems. These techniques are divided into three categories:

1. Techniques for teaching new behavior[65]
2. Techniques for increasing a desired behavior[66]
3. Techniques for weakening an undesirable behavior[67]

The first category of techniques is applicable to the goal of *teaching a new behavior:*

Task analysis: The process of breaking down and delineating a complex task into a list of simple elements. Children can become frustrated when presented with a task requiring steps from start to finish that they cannot perceive. For example, when working with a child who has never seen a drum before who has been given the instruction to "play the drum." Frustration could take over unless explicit instructions are given similar to the following:

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[64] Madsen, C. (1998) p. 303
[65] Madsen, C. (1998) p. 278
[66] Madsen, C. (1998) p. 285
[67] Madsen, C. (1998) p. 292

1. Facilitator identifies the instrument as the drum to play
2. Facilitator identifies the beater or drumstick
3. Facilitator demonstrates the (assumed) rounded/padded head of the beater coming in contact with the drum
4. Facilitator asks the child to walk to the drum
5. Facilitator asks the child to grasp the beater in their dominant hand; the portion in the hand is the opposite end of the rounded end of the beater.
6. While modeling, facilitator asks the child to raise the arm in the air holding the beater
7. While modeling, facilitator asks the child to lower the arm such that the beater comes in contact with the drum

This may seem like an elementary process, but when the child has not had experience with this type of musical encounter, it is necessary to break down the overall task direction into individual components to enhance success.

Prompt: A visual, verbal, or physically guided cue utilized to help the child respond to an instruction. A visual cue from a facilitator/parent results in placing a finger on lips to cue the child to be quiet. Verbal cues are useful when children are asked to identify an object they'll be singing a song about, such as a dog, but they do not respond. The prompt is verbally stated as "dah" (the initial syllable of the desired word) to help the child initiate the full word, "dog". Physical guidance is utilized as a tactile prompt if the child is involved with a physical task; an illustration of such is playing an instrument but with bent posture. A brief tap on the shoulder can prompt the child back to correct posture. Once the desired behavioral change is achieved by the prompt, the process is faded and eventually eliminated.

Errorless learning: a procedure utilizing prompts which ensures accurate learning with no mistakes in as rapid a fashion as possible. For example, when a child learns to read music and has difficulties associating the musical symbol on the page with the physical note played on the instrument, errorless programming techniques could be utilized in creating worksheets with only one or two defined and identified notes which are repeated over and over again. To begin with, the sheet would also have a picture of how to physically play the note along with the note name each time it occurs so that the child cannot make an error. Gradually the note name and the repetition will be faded, and the child will learn to play the note while accurately associating it with the correct musical symbol.

Chaining: Initiates sequential behavior in the form of two or more smaller tasks joined in order to carry out a more complex task. The sequence of chaining tasks can either run forward or backward through the designated task steps for completion. In teaching the first phrase of Twinkle, Twinkle Little Star in the key of C Major, a parent/facilitator starts forward chaining in the following steps of introducing notes:

1. C – C
2. C – C – G
3. C – C – G – G
4. C – C – G – G – A
5. C – C – G – G – A – A
6. C – C – G – G – A – A – G

Madsen refers to the following final two techniques in shaping new behaviors as successive approximations.

Shaping: Starting at each child's individual level of capability, the parent/facilitator will set small increments of goals for behavior modification. As each small goal is mastered the next step of the process is taught. Applied music teachers are natural facilitators of shaping, as weeks and months of applied lessons go by and small behaviors are learned, the teacher moves to the next step in the process towards a more complex goal of having the child play a musical instrument.

Modeling: This is a powerful technique for teaching new behaviors and involves the parent/facilitator demonstrating an action and having the child then mimic that action. The principle of modeling works both with imitation of a physical action (i.e. play the note on the instrument THIS way) and also behavioral emulation (teacher does not interrupt student and student learns this way not to interrupt teacher.)

The second category of methods defined by Madsen involves the techniques for *increasing desirable behaviors*:

Positive reinforcement: the presentation of a stimulus following a desired behavioral response, which will serve to increase the potential that the same response will be repeated. Stimuli serving as reinforcers include the following:

1. Primary reinforcer – stimulus relates to a biological connection, generally in the area of food or drink. For example, a bag of nuts is given to a child when he/she correctly plays their lesson assignments.
2. Secondary reinforcer – stimulus that has been learned as desirable in a socially-learned context. For example, when the assignment is played correctly the teacher praises the student.
3. Social reinforcer – a variety of a secondary reinforcer. Most children enjoy being the focus of attention; acquiring the direct attention of the teacher/facilitator will serve as a reward for a child.
4. Tangible reinforcer – an object used as a reward for a job well done. If the student plays the lesson well, the teacher provides some kind of music trinket such as a pencil marked with musical symbols.
5. Activity reinforcer – referred to as the Premack Principle, this uses an anticipated activity as a reward for making it through a less desirable task. A teacher/facilitator can set a "reward" for the end of the session by allowing the student to play his/her favorite musical instrument as long as the technique regimen of scales and arpeggios have been performed well.

6. Generalized reinforcer – provides access to other varieties of reinforcement. Usually in the form of tokens or money used to "purchase" rewards.

Negative reinforcement: Whereas positive reinforcement presents desirable stimuli to encourage a behavior, negative reinforcement involves the contingent removal of an aversive stimulus. An unpleasant condition already exists in this environment, and the negative reinforcement indicates the removal of that condition.

Natural reinforcement: The desired balance in any relationship between teacher/facilitator and child. This is the preferred goal to achieve for any educational environment.

The last of Madsen's behavior techniques are methods designed to *weaken an undesirable behavior:*

Differentiated reinforcement: The use of positive reinforcement to encourage a specified behavior in conjunction with a specified undesirable behavior being eliminated. For example, children with autism will typically be adverse to eye contact for long periods of time. By presenting them with a favored musical instrument (positive reinforcement) while simultaneously engaging in eye contact, the social element of using the eye contact is reinforced by the reward of playing the musical instrument.

Extinction: The complete withdrawal of all positive reinforcement that contributes to poor behavior. If the teacher/facilitator's attention is helping to unintentionally sustain undesirable behavior then an abrupt halt of all attention to the child (completely ignoring the child) is initiated. For example, if a child refuses to engage in a task and the facilitator starts asking or even begging them to please begin, then that facilitator is unintentionally providing the child with much attention for their negative activity. Abrupt withdrawal of that attention can create a turn-around so that the child will engage in the required activity so as to receive positive attention once more.

Time out: The complete removal of all desirable stimuli. Positive reinforcement of all forms is completely removed during the time the child is excluded from a positive environment.

Overcorrection: Teaching corrective behaviors in an educational manner by introducing an exaggerated method of correcting an issue. A child must keep repeating a correction many more times than necessary to actually resolve the behavioral issue. Madsen's famous quote on this matter is that it is easier to act one's way into a new way of thinking rather than to think one's way into a new way of acting.

All of these described behavioral techniques should be carefully considered when working with special needs children. There are many potential rewards seeing the neurological music protocols facilitating positive change for these children, but there is little value to using the protocols if behavioral problems exist that cannot be addressed.

Application of music prototypes

The individual elements for utilizing neurological music protocols with special needs children have presently all been defined; illustrations will now be made for setting up an effective overall program for use with a child. It is first necessary to recall the five-step Transformational Design Model listed on page 26 of this paper. Following functional and medical diagnosis, a determination is made of what physical goals need to be accomplished. Non-musical exercises are created to help reach the goal, and then music is associated with these tasks. Finally, the music is withdrawn. In addition, an analysis of any known behavioral problems should also be considered with the first step of the process, although such problems could also manifest without warning and will be handled in a more spontaneous manner. To demonstrate how to determine goals and choose techniques, two hypothetical children with the developmental disability of autism will be described in a form that will include their symptoms, diagnosis, age, and current abilities, along with solutions of how these children can benefit from music as described previously.

Child 1: This child is nine years old and has moderate to severe autism. In addition to autism he has fetal alcohol syndrome and cerebral palsy. He has a tremor in his hands and an unsteady gait, with no bilateral coordination. His speech is clear and he enjoys singing but he is limited in his physical activities due to his unsteady gait and shaky hands. He has cognition problems with comprehension and decision making and also seems unwilling to focus on a task for any length of time. He follows instructions with tasks he enjoys but tends to withdraw if he doesn't wish to engage in a situation.

Interventions for this child include motor and cognition activities. Since his speech is clear and understandable, specific speech goals are not initially necessary. Motor goals include gross motor skills in gait and coordination, and fine motor skills with hands. Initial cognitive goals incorporate attention focus and decision making with plans to increase criteria levels throughout the duration of treatment.

Suggested program:

1. Auditory perception – this child enjoys singing so this protocol has double significance for him. Used as a warm-up, it opens the auditory system as the pathway to entrainment of the neural network. Secondly, since the child enjoys music there is potential for him to learn discrimination of pitches such as high vs. low, loud and soft, and major and minor. Following a warm-up of walking and playing drums in time with the music, the child will be asked to differentiate between instrument timbres and various pitches in order to train his discernment for musical tones.
2. Therapeutic instrument performance – Utilized to help develop gross muscle development in legs and hips. Gait issues are due to a lack of coordination and also to a lack of strength in the legs and hips. In order to help strengthen the leg muscles, the facilitator first positions 2 drums for playing where 1) one is placed high requiring a reach and 2) the other is placed low requiring a deep body squat. The child moves back and forth between high and low with squats and stretches; he is now strengthening leg and arm muscles as he pats each drum with both hands. Following this, the facilitator places the drums on each side of the child far enough apart to require the child to move from side-to-side to strike the drums,

one with each hand. This involves training a different set of muscles in the hips that are required for coordinated gait.

3. Gait training – Begins with just walking in rhythm and then rhythm is used to add various modifications to the walk, such as stepping high, sliding, and walking backwards. Once walking on the beat is established and the rest of the variations are completed, drums are added. Two drums are placed in front of the child so that the child can walk in place and strike the drum with the hand that is opposite to the leg that is stepping. This facilitates bilateral coordination, much like in a normal gait a normal arm swing pattern is employed during walking.
4. Therapeutic instrument performance (2) – Utilized to assist with fine motor skills in the fingers and hands. The facilitator has the child repetitively play two sequential notes on a keyboard, i.e. C, D, C, D, C, D. Additional fingers are added one at a time until eventually all five fingers are playing five sequential notes. The child can then play a song using those five notes with either the facilitator pointing to each note individually or by the creation of a color-coded system with tabs on the keys; the child does not need to know how to read music in order to play a song in this fashion.
5. Executive functioning – In order to train the child to effectively make decisions, the facilitator will create a musical game where the child will be asked to "organize" the game rules. For example, the game may simply be to play instruments associated with a particular song. The facilitator will have the child choose the song, choose the instrument that both of them will play, determine

how long (how many verses) the song will be, associate any desired body movement or dance to the song, and so forth. This encourages the child to make the decisions and be comfortable not only in the decision process itself but also in the outcome of his/her decision making.

6. Attention control – The child has very little ability to focus on a given task, so the facilitator will initiate the attention control process with a game that encourages sustained attention. Three to four instruments, generally rhythmic in nature, are placed directly in front of the child and each instrument is assigned for playing during a particular song of the child's choosing. When one of the songs is played, the child plays along on the instrument assigned to the song, and when the song changes the child shifts his/her playing to the new instrument to which it is associated. Once the child is able to focus attention for a sustained period, then more complex attention controls can be initiated for selective, alternating, and divided attention.

Child 2: This child is eleven years old and has moderate to severe autism. His gait and muscular build are relatively normal, but he is non-verbal. He has speech capability but does not use speech. When coaxed, he will say "hi" and "bye" but only when coaxed; he does not initiate speech on his own. To facilitate his communication, he uses a technology device that can externally "talk" for him. This is a computer outfitted with signs and symbols that verbalizes what he is wanting or thinking. He has good comprehension of symbols and appears to take instructions well as long as the instruction is not too complex.

Goals for this child are completely devoted to speech/language development. The bulk of the protocols utilized for each session are directed to speech development, and each session begins with auditory perception for warm-up.

Suggested program:

1. Auditory perception – used as a warm-up to open the auditory system, the child is asked to walk in time to rhythm while he plays two drums, which the facilitator holds in front of him as he walks.
2. Therapeutic singing – At one time the boy's parents noticed that he particularly enjoyed the song "Happy Birthday", and it appeared that he was attempting to sing along when he was with several peers at a birthday party. The facilitator plays the song and sings along to see if the child will eventually join in with. After several attempts, the child joins in and sings the word "you" each time it appears in the song.
3. Rhythmic Speech Cuing – The facilitator chooses syllables that the boy is capable of saying (since it is known he says "hi, bye, you") and sets a metric pattern such that the child can repeat the syllable over and over again to practice verbalizing just that syllable.
4. Melodic intonation – The facilitator identifies easy-to-use phrases that the child asks for on his computer device. The device verbiage prefaces most sentences

with “I want…” at which point the child will fill in the blank. In this case, the two things that this child makes requests for on a normal basis include, “I want mama” and “I want dinner”. Using melodic intonation protocol, the facilitator begins using these expressions in rhythmic and melodic phrases and melodic intonation therapy initiates from this point.

The goals for these two children are clearly different, so different sets of protocols are utilized for each session. Typically, children enjoy music-related tasks and thus willingly participate in the program. If behavioral issues arise on “bad days”, the techniques, listed earlier, can be incorporated, with the realization that the facilitator may need to be rapidly creative in finding the right technique for the right situation. Behavioral contingencies, however, are a powerful incentive to perform and receive the right attention stimulus.

Another consideration when utilizing music for therapeutic purposes is that each individual has his or her own personal taste in music. Some children may want to improvise and create their own non-verbal sing-song music; others may want to only work with children’s tunes they know, such as Mary Had A Little Lamb. Still others may prefer various styles of classical, jazz, or even rock or hip-hop. The music that the child prefers will have the greatest effect on the success of utilizing the neurological music therapy protocols.

Assistive Technology

Although technology assistance for special needs children is technically not included within the realm of neurological music therapy techniques, it is an important topic with which to be briefly acquainted. Technology is taken for granted by many individuals in the current day and age, but it can make a real difference in life quality for some persons with special needs. A 1991 training manual released from IBM quotes, “For people without disabilities, technology makes things easier. For people with disabilities, technology makes things possible.”

Assistive technology (AT) is any device, piece of equipment, or system that helps increase, maintain, or improve functional capabilities of individuals with disabilities. AT potentially enhances instruction and is inclusively utilized with both educational and therapeutic circumstance; it encourages success at working independently. Low tech AT is generally easy to use and low cost: dry erase boards, clipboards, and photo albums are examples. Mid tech AT is generally in the line of a simple electronic device requiring limited technology such as tape recorders, calculators, overhead projectors, and simple output devices. High tech AT is defined as more complex tech devices that are typically higher in cost and require more personal expertise such as video cameras, adaptive hardware, and certain MIDI devices.

Combining AT with the music protocols potentially enhances the learning process. Utilizing computers and MIDI devices for their musical effects can make the musical task more pleasant for many children, and most devices can also be programmed to “catch” the results in a database format so that empirical data concerning the session results can be formed as the database grows. Children with autism process visual information more readily than auditory information, and the message on a computer screen is predictable and consistent with no confusing mixed messages so there is higher motivation and interest. Even keeping a “task list” on a laptop computer that can be checked off as the child accomplishes each task in a session can be motivational.

The power of modeling as a behavioral motivation was discussed on page 54 of this paper; by utilizing a video camera in a session with a child there is: 1.) a visual record of all activities, and 2.) images captured, which can be later edited, to create a video the child can utilize to self-model. When the child observes themselves doing something correctly, there are much greater odds that the process will be repeated in the future. Assistive technology should be considered partnership with neurological music protocols for specific circumstances; under various conditions it is an effective association for inclusion in many of the protocols.

Conclusion

The qualities of music have attracted theorists, artists, physicians, and scientists as well as the "man on the street" for millennia. Pythagoras and the ancient Greeks opened the door for a flood of ideas and ideals in the discovery of the numeric ratios creating the basis for intervals and harmony. The phenomenon of music has since served roles from entertainment to the opposite side of the spectrum with engaging curiosity and fascination for the scientific principles that so affect the emotions and the brain. The potential of music in medicine and the improvement of cognition processes has been both demonstrated and also intuited for centuries on differing levels; it is now, in the current age of technology, that the benefits of music have been proven to benefit populations of mankind through evidence-based research.

Through using music protocols that can energize the neural networks of the brain, an entire generation of children with special needs can potentially benefit from music in tested therapeutic environments. The field of cognitive neuroscience has proven that the structure of music is truly a gateway to the brain. That miraculous instrument has the capacity to rebuild itself with rhythmic entrainment; reaching these children with the use of neurological music protocols can help to organize their neural networks in a way that will encourage them to mainstream into environments with their typical peers. It should not be assumed that these techniques will "cure" neural afflictions such as autism, but they will provide a basis for those affected to live within bounds of inclusion rather than exclusion.

Neuroscientists, physicians, and professional therapists are becoming more aware of the benefits of these techniques. It is now time for parents and educators to realize the benefits, and deduce that the home and the classroom are potentially as effective an environment to work towards the deliberate rebuilding of neural networks as a clinical setting. A successful parent or pedagogue can utilize these techniques in many different ways to reach special needs children. While this population of children can certainly be challenging to work with, the end result of enhancing the life of a special needs child is truly a remarkable undertaking. The parent or educator is challenged to achieve continuously higher levels of creativity and artistry in the process of pursuing the intellectual quest of the contemplation of how music can serve to improve the life of a child.

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