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Research Article

Pilot Study Investigating the Efficacy of Tempo-Specific Rhythm Interventions in Music-Based Treatment Addressing Hyper-Arousal, Anxiety, System Pacing, and Redirection of Fight-or-Flight Fear Behaviors in Children with Autism Spectrum Disorder (ASD)

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Abstract Many behaviors in children diagnosed with autism spectrum disorder (ASD) resemble fight-or-flight avoidance responses resulting from habitual states of fear, possibly induced by sensory processing issues, causing on-going stress and deregulation of systemic pacing. This study hypothesized that patterned, tempo-based, rhythm interventions, at 60-beats per minute (pbm), can regulate and induce systemic pacing, reduce repetitive anxiety behaviors and enable focus and calm in persons with ASD. Eight-week pilot study investigated the influence of four sensorimotor rhythm interventions for habituation (entrainment) of systemic inner rhythms, pacing, stress, anxiety, and repetitive behavior reduction, ultimately yielding eye-contact, attention, motor planning, and memory. Six subjects ($n = 6$) ages 8–12, with ASD and minimal expressive language, were treated in 45-minute weekly one-on-one music therapy session, over eight weeks. A rating scale tracked responses and progress in vivo per session, and on video-tape. Lifeshirt heart-monitor vest with embedded wireless sensors, worn by each subject during the first, fifth and eight sessions, tracked heart-rate data. Results support the hypothesis that highly structured rhythmic interventions at a slow tempo can yield levels of systemic pacing, motor planning, visual contact, attention, reduction of anxiety and repetitive behaviors, and functional adaptation.

Keywords ASD; autism; fear; stress arousal; repetitive behavior; fight-or-flight response; system pacing; music-based treatment; rhythm; entrainment; functional adaptation

1 Impact of tempo on human function

In addressing the implication of tempo and rhythm on human behavior and physiologic regulation, McAuley and Marsden [31] conducted a research on human movement and balance, physiological and pathological tremors and rhythmic central motor control, but with "normal" participants. They discuss oscillatory neural activity in the Central Nervous System (CNS) and its role in motor control, binding function of synchronized oscillations and the possibility that motor signals could be coded by frequency of modulating oscillations. This alludes to a form of *entrainment* that external rhythm can influence, and could mean that a music therapy task of metronomic tempo-specific pulsations could play a role in organizing binding factors in a system with autism spectrum disorder (ASD). Bengtsson et al. [10] at the Institute of Neurology, University College, London, experimented with rhythmic and isochronic sequences in metric and non-metric forms to groups listening to rhythms to investigate impact on motor control, and determined that listening to metered rhythms activates motor and pre-motor cortices. However, this was not undertaken with diagnosed persons, which would inform music therapists a bit more on the relationship between rhythmic stimulus and motor responses in ASD where the brain may not understand what is going on.

Two recent music therapy studies investigated rhythmic entrainment in children with ASD. Azbell and Lakin [5], students of the University of Wisconsin-La Cross, exposed four children of a facility to 20-minutes of background music of the CD produced by Strong [45] called *"Calming Rhythms 3"*. This was presented daily for 8 sessions over two weeks, while other treatments were being administered simultaneously. This was continued and monitored for another 2 weeks by having the music played as background in creative arts activities. Results seemed to indicate a calming effect, but it is still unclear if that was the case, whether it was actually the CD, and if so, what contributed to this – was it only the CD music? Or the CD in conjunction with other activities? And what portion of the CD? Orr et al. [34] investigated the impact of rhythmic medicine (see [22,45]) using a CD of metered music at between 50 bpm and 65 bpm which had been created by Hoffman [22] in a

1-case study with an autistic girl of chaotic, self-injurious behaviors. Hoffman's CD, based on her book *"Rhythmic Medicine"* [22], was used as background over several phases of the intervention. The results seemed to indicate that behavioral changes deemed resultant from having the CD play during certain daily activities.

Neither of the above studies involved physical participation in conjunction with the music (instrumental playing, or interactive involvement). The only physicality was used in the Azbell and Lakin [5] study cited above, in which students could rock in tempo to the music during OT interventions. In areas of speech and language, Corriveau and Goswami [14] discovered the relationship between rhythmic motor entrainment in children with speech and language impairments, and also its possible implication in Dyslexia. It should be noted that no study has yet indicated how long it takes, or would take, for entrainment to occur, whether immediate, over what period of time stimulation, or whether it can become a permanent homeostatic manifestation.

Music therapy clinical rhythm work with Parkinson's Disease has demonstrated some positive results through the use of rhythmic auditory stimulation (RAS) and tasks for addressing limb tremors [48]. Several additional papers discuss the influence of rhythm and tempo on Parkinson's Disease movement and emotional rehabilitation (see [1, 36]). Music therapy and entrainment mechanisms are also discussed in Rider's paper [37] relative to pain reduction, muscle relaxation, and music-mediated imagery. A recent paper by Thaut et al. [50] pursues a lengthy discussion on cortico-cerebellar activations in rhythmic auditory motor synchronization. This detailed investigation suggests that rhythm synchronization resulting from external stimulation is basically expressed in motor control, the sensing structure of tempo modulations, and a conscious tracking of rhythmic patterns. These are associated with different brain sites within the anterior and posterior lobe of the cerebellum – the brain organ involved in motor control and believed to be deficient in ASD [9]. In a presentation at the New York Academy of Sciences [46], Thaut reported that the study of rhythmicity can provide insight into understanding the temporal coding of music and temporal information processing. Music Therapist Edward Roth, along with nurse Susan Wisser discuss RAS approaches in general, in their paper [39]. Bengtsson et al. [10] recently found that listening to rhythms activates motor and premotor cortices. Music Therapist Kwak [29] discusses the effect of RAS on gait performance in children with spastic cerebralpalsy.

Researchers in the Psychology of Music investigate physiologic elements in perception of music rhythm (see [51]). But in general, researchers discussing tempo and rhythmic timing on arousal and physiologic processes often do not specify whether the stimuli consist of pure rhythmic patterns, at what specific tempo input, or whether tempo and rhythm just happen to be part of a genre, tune, melody, performer, and so on [13, 19, 23]. This would present many auditory variables regarding what is actually perceived, to what the system is responding, whether the system would respond similarly to acoustic pitches instead of pure tones, and which if any, other element(s) of the music might be influencing responses.

Neuroscience information on rhythmic oscillations in the brain is increasing, particularly the interrelationship between alpha (relax state brain waves), delta and gamma oscillations key to arousal, anxiety and relaxation responses [12, 26, 27, 35]. The role of rhythmic *entrainment* is also discussed in music therapy as affecting brain changes, heart beat, pain reduction and muscle relaxation, and music-mediated imagery, among other interventions [37, 45, 48, 49]. However, specifics of music elements or metronomic tempo aiding entrainment (is it the melody, or flow, or speed, or harmony, or all of the above), in accurately defining entrainment, what part(s) of the system become entrained and how, are basically left to clinical imagination, assumption and anecdotal information, except for a few who attempt to consider this aspect of systemic behaviors (see [37, 45, 48, 49] and Rhythm Entrainment Institute www.reiinstitute.com; Interactive Metronome www.interactivemetronome.com).

Trevarthen and Daniel [52] suggest that disorganized rhythm and synchrony in infants can be early signs of ASD and Rett's syndrome. Chen et al. [13] inform us that listening to musical rhythms recruits motor regions of the brain, assessed through a basic pulse-tapping task. Thaut offers extensive scientific and clinical information in his book [47]. One other treatment using specific meter and pace, but which is not conducted within the music therapy profession, is the system of Interactive Metronome (IM). This intervention is conducted by non-music therapists, usually by neuro-chiropractics, OTs, and sometimes educators. It involves a computer program, and the listening to a "beat" click through worn earphones while looking at a computer screen in which the pulse is graphically observed. The participant, who is hooked up with sensory devices connected to the computer, is given several rhythm pulsing tasks, such as hand clapping, or foot tapping, the objective of which is to synchronize the action with the visible cues on the computer screen. Interactive Metronome researchers claim much positive success in aiding predominantly high-functioning ADHD patients (see [44]; and www.interactivemetronome.com).

2 Stress, anxiety and ASD

Fear and *stress arousal* in many diagnoses, including ASD, are most probably due to erroneous sensory interpretations of environmental and systemic conditions that thrust the Central Nervous System's sympathetic system into action from which the person cannot easily modulate. The sympathetic nervous system is that which prepares the body for fight-or-flight causing changes in heart beats, flow of adrenaline, rush of oxygen and sugars to muscles, and more, for quick reaction and response to threats (see [3, 6, 18, 20, 41, 42]). One of the concerns of Occupation Therapists is in sensory processing disorders (SPDs), which apparently are part of ASD. (Note that SPD is a diagnosis separate and apart from ASD. While ASD appears always to include sensory processing deficits, persons with SPD are not necessarily also diagnosed with ASD. For further readings in OT, SI and ASD see [4, 8, 11, 17, 18, 28, 32, 37, 40, 43].)

In his book [16], Nick Dubin states: *"If you could watch a videotape of me when I was in middle school, you would see one very anxious and self-conscious boy. I lived in a constant state of fear. What was I afraid of? Virtually everything"* (p. 13). Williams [56] refers to this state of fear as *"Exposure Anxiety – The Invisible Cage"*, the title of her book in which she discusses and explores self-protection responses in ASD. Several authors in the spectrum, who are verbal and can share their experiences of sensory malfunction and on-going states of fear, detail their "fear" issues quite clearly (see [16, 21, 56]). Others who lack verbal abilities can only "act out" behaviors which we NTs (neuro-typicals) consider to be "inappropriate" socially, failing to associate arousals with typical 'fight-or-flight' reactions resultant from fear and stress.

Dr. Neimark, on an on-line site called Body and Soul Connections, defines fight-or-flight behaviors as "... our body's primitive, automatic, inborn response that prepares the body to "fight" or "flee" from perceived attack, harm or threat to ... survival" (www.thebodysoulconnection.com/EducationCenter/fight.html). The operative word is "*perceived*". As long as the brain "*perceives*" danger, whether real or mistaken, it will thrust the system into fight-or-flight behaviors (peripheral vision, ambient hearing, erratic fleeing movements, etc.) (see [11, 42]).

Investigations by Dr. Davis and colleagues at East Carolina University, NC, [15] found that although anxiety disorders appear to be common in individuals with developmental disabilities, they are predominantly left undiagnosed. He further found that persons with mental retardation, ASD, and other pervasive developmental disorders may exhibit co-morbidity with anxiety disorders such as generalized anxiety, obsessive-compulsive disorders (OCDs), phobias, and other anxiety symptoms at a much higher rate than in the general population. However, identification of these co-morbid anxiety disorders may be more difficult due to language communication problems of the population. Furthermore, assessment of these characteristics appears to lack consistent and standardized approaches ([15]; for definition of the characteristics of ASD see also [3, 7, 11, 17, 28, 32, 42]).

ASD and physiology literature reveal a myriad of information dealing with the physiology of stress and coping in ASD, and the fight-flight "fear" response at the sub-cognitive, amygdala level of instinctive brain function (see [6, 30, 34, 36, 42]). Since much of autistic behaviors include the above-mentioned co-morbidities, it stands to reason that addressing systemic issues causing arousal behaviors would be primary goals for targeted music therapy interventions prior to undertaking other behaviors (social, cognitive, language, etc.). Baron et al. [7] suggest that poor arousal modulation may interfere with autistic population's ability to understand and engage in the environment (p. 52), while Romanczyk and Gillis [38] declare that *"it is anxiety modulation and coping that is of concern, not simply the elimination of anxiety"*.

The physiology of fear, the role of the amygdala, and the HPA Axis (Hypothalamus-Pituitary-Adrenal) operant in fear, stress and anxiety informs of the hormonal structures of survival mode. This area of investigation continues to be major in the sciences. Morgan [33] discusses the overlap between biological, behavioral and physiological correlates in ASD, when she asks *"Is autism a stress disorder?"* Morgan perused extensive literature indicating that excessive stress and anxiety alters brain activity in ways that promote hyper-vigilance and abnormal behaviors, exaggerated fearfulness, and other characteristics observed in ASD. She concludes by insisting that *"it behooves us ... to increase efforts to understand the overlap between autism and ... stress ... and to reduce this stress as much as possible."* (p. 159). The literature indicates that perhaps the time has come for codified and dose-response approach to music therapy interventions specific for addressing physiologic and behavioral issues of anxiety, fear and fight-flight arousals, modulation deficits, and sensory deficits contributing to the behaviors of ASD, treatment aimed at regulating the system.

3 Research design

Arousal and repetitive behaviors in children on the autism spectrum resemble fight-or-flight avoidance responses theorized to result from habitual states of fear, possibly induced by sensory integration issues causing on-going anxiety and deregulation of systemic pacing (see [3, 7, 9, 11, 17, 28, 32, 42]). Behaviors often noted include slow information processing, irregularities in breath control, abundant stereotypical and repetitive movements, arm and hand flicking, erratic gross-motor movement, slow responses to movement and language cues, and in some cases, responses that are too fast and uncoordinated.

A review of music therapy literature for the treatment of ASD appears to indicate that music therapy goals, interventions and research primarily focus on addressing socialization and connection skills, language deficits, cognitive functions, and less on *physiologic* functions (see [2,24,25,53,54]). Results from interventions seem limited to temporary *behavior modifications*. As for the kind of music being employed, little information is found relating to precisely *how, why and what features* of music have done something, and *which elements* were responsible for the doing.

Based on the theory that behaviors of ASD are probably due to deficient sensory information processing which morphs into "fear" fight-or-flight chaotic and uncoordinated hyper-arousals to external and internal factors (see [11,16,21,42,56]), this study investigated the role of *tempo* in altering such responses. The question asked was whether, and how, *slow* rhythm-based treatment interventions might influence habituation (*entrainment*) towards a more regulated, internalized (synchronized) rhythm, thus systematically coordinating and pacing behaviors, reducing fight-or-flight fear and hyper-arousal responses on a sustainable, adaptive basis. Prediction was that slow and repetitive tempo-based rhythmic interventions, at 60-beats per minute (bpm), addressing sensory regulation (proprioceptive, vestibular, and breath-control), would influence and yield systemic pacing, movement coordination, diminished repetitive behaviors, ultimately approaching a level of *functional adaptation*.

Study objectives were to apply, and to evaluate the following: (1) breath-control intervention sequences at metronomic 60 beats per minute (bpm) for adapting and regulating breath control to induce a level of calmness; (2) 60-bpm-paced upper body intervention of hand-clapping sequence to regulate upper body pacing, motor planning, purposeful arm movements, redirection of repetitive self-stimulating behaviors; (3) 60-bpm-paced upper/lower body movement coordination intervention in the form of marching while beating tambourine, to habituate paced gross-motor vestibular, proprioceptive and motor-planned responses; (4) 60-bpm-paced drum sequence playing specific rhythmic-pulsed pattern to help further rhythm internalization and motor-planning pace.

Six elementary school level research subjects of a school for special needs students in Rhode Island, male and female between ages 8 and 12 years, of lower to moderate spectrum range, were recruited to participate in eight once-weekly 45-minute sessions of individual music therapy treatment. Selection of research subjects was basically random, based upon (a) teacher and allied clinician recommendations, (b) accommodation of schedules for both participants and therapist, and (c) familiarity with, and/or tolerance for donning *Lifeshirt*, for the measurement of heart-rate during first, fifth and eighth sessions. Appropriate care-giver and student consents were obtained, along with school IRB approval to undertake project on the premises, and IRB consent from Roehampton University under whose aegis (Department of Psychology) the research was undertaken. In addition, music researcher completed the National Institutes of Health (NIH) web-based training course, *"Protecting Human Research Participants"*, obtaining appropriate Certificate of Completion, in order to undertake the study.

In addition to heart-rate data, all sessions were video-taped and rated on a specially designed form, tracking performance both in vivo and on tape. It was considered that the attainment of better (non-prompted) execution skills over the eight weeks would indicate changes in physiologic function. In three of the sessions – sessions one, five and eight – *Lifeshirt* technology was employed for tracking heart-rate activity during task execution; *Lifeshirt* is a specially designed vest containing sewn-in wireless sensors for tracking physiologic information (heart-rate, etc.) during function in a natural environment. Data from the vest transmits to a portable mini computer chip housed in a container on a belt worn by subject. Immediately following *Lifeshirt* session, information was transferred to a desk-top computer and processed for targeted physiologic data. (For description of the use of *Lifeshirt* in behavior management see [55].)

Interventions consisted of four discreet, tempo- specific tasks, each executed at 60-bpm in four repetitions: (i) 64-count recorder-blowing sequence (four 16-beat phrases of 8-short blows and 4-two count blows); (ii) 8-part, 64-beat hand-clapping sequence (eight different phrases of 8-counts each); (iii) marching to *Yankee Doodle* while simultaneously clapping on tambourine or cymbals (task time approx. 40-seconds per repetition); (iv) 4-part (32-beats) drumming sequence (4 different 8-count phrases). Each of the four tasks was rhythmically sustained by a 60-bpm pulsed simple rhythmic pattern programmed in the Casio electric keyboard. Each task had its own programmed rhythmic pattern. *Yankee Doodle* tune was programmed to play at 60-bpm, rendered automatically by the keyboard.

Each session presented precisely the same structure and musical conditions, in order to retain as much consistency as possible, and to aid in developing research subject's expectation and familiarity with session structure and stimuli to further nurture entrainment and relaxation. Researcher was the sole clinical music provider, since the school has no other music-based clinician nor music teacher. Subjects had no other out of school music activities (lessons, therapy, etc.). This was a "new" experience for all involved. Each intervention sequence was repeated *four times* through, with 1-minute rest break between each completed repetition, and 2-minute rest and transition break to the following task. Total session time was approximately 40–45 minutes per subject. A specially designed rating scale graded each element of each task and repetition, in every session. Rating scale consisted of zero to five points: 0 = did not/would not undertake; 1 = hand-over-hand prompting, but incomplete task; 2 = completed sequence but only with hand-over-hand prompting; 3 = will undertake but requires some prompt or role modeling; 4 = independent but requires occasional indication of sequence structure through some role-modeling; 5 = execution of full sequences entirely independently, requiring no prompting, role-modeling nor sequence indicators. Highest available score was 100% = 420 total points *per session* (if student received all 5's). Scores served to indicate ability to execute tasks with or without prompting, and levels of skills progress per task, per session. Anecdotal contributions of information by aides, caregivers and faculty were encouraged, though limited, and not applied to final research data.

Sessions were held in a small designated room within the school building, familiar to the research subjects. The room housed a ceiling-mounted video camera, a small table for the keyboard, several small chairs, a bin for drums, mallets, tambourine and cymbals, and a pitcher of water provided by therapist to further relax and center the subject. Each subject was escorted by his/her aide of the day, who remained in the session. Adjoining the "research" room, an office housed a computer, video tapes (VHS) and recorder for video taping session, a 2-way mirror, and a time clock to monitor precise task times in order to guarantee uniformity and consistency per study subject. Two student research assistants with whom subjects were familiar, maintained the time clock and video taping responsibility, and were also responsible for the *Lifeshirt* portion of the research (dressing the student, attaching the various components and portable computer belt, suction cups, etc., and transferring the information to the desk computer). All sessions were held on successive Thursdays between 8:45 am and 3 pm, and subjects were accompanied by his or her school aide, who remained in the session to assist with task prompting or role-modeling (if required). This schedule remained consistent throughout, with subjects attending sessions at approximately the same times each week, except for the final, 8th session, a *Lifeshirt* session, when severe inclement weather required rescheduling (this change and resulting stress appears to have take its toll on student performance, as indicated by rating scale and some heart-rate data).

All interventions, except marching task, were executed in seated position. In cases where subject could not undertake the movement/march intervention, it was executed in seated position (with multiple prompting as needed). Sessions commenced with a brief greeting and instruction provisions (what, how, etc.), a few minutes of "quiet time" (total 4 preliminary minutes) in sitting position, for baseline data in Lifeshirt sessions. Then session continued as shown in the following.

Intervention 1 (recorder)**.** (64 total counts; repeated four times)

8 short exhales (quarter-note blows, one per each beat @ 60-bpm);
4 two-beat slow exhales (half-note blows held through 2-beats each);
1-minute (60-seconds precisely) rest, drink water, wait;

REPEAT Entire sequence 3 *more times.*

Intervention 2 (hand/feet clapping sequence)**.** (64-count tot. Rondo form)

8 hand clapping (quarter-note claps, one per each 60-bpm)
8 lap claps with parallel arms (1-per beat)
8 repeat hand clapping (1-clap per each beat)
8 lap claps with alternate arms (1 clap per each beat)
8 repeat hand clapping (1 per beat)
8 alternate feet stomps (1 stomp per beat)
8 repeat hand clapping (1 clap per beat)
8 alternating lap claps crossing right arm to left lap, left arm to right lap (for mid-line crossing; 1-clap per beat)
1-minute rest, drink water if necessary, wait;

REPEAT Entire sequence 3 *more times.*

Intervention 3 (marching/beating tambourine)**.** (Yankee Doodle; 40-beats)

Keyboard programmed to play tune at 60-beats per minute; subject marched round to total of 40-beats (five 8-beat phrases in all) while simultaneously clapping pulse on tambourine (or hand cymbals). (If subject unable to stand and march, task done in seated position, with marching feet and beating instrument on hand-held instrument)
1-minute rest, water, wait;

REPEAT Marching 3 *more times.*

Intervention 4 (drumming using two drums)**.** (32-beat sequence)
Two drums, positioned in from of body

8 beats (1-per beat) on two drums, with *parallel arms*.
8 beats (1-per beat) on two drums, *alternating right/left arms*.
8 beats (1-per beat) on two drums, as before, with *parallel arms*.
8 beats (1-per beat) on two drums, *alternating arms, crossing* left arm to right drum, right arm to left drum.
1-minute rest, and so forth;

REPEAT 3 *more times*.

Session conclusion (2–4 minute rest/wait period and departure)**.** *Instruments provided by therapist included: two small table drums with two special, weighted mallets, recorders gifted to research subjects for their use, tambourine and hand-held cymbals, small chairs, bin for instruments, a pitcher of water, and Casio Electric Keyboard in which three simple rhythm patterns were programmed, different for each of three interventions, and programmed "Yankee*

For recorder blowing:		
(Wood blocks)	**/.** /’ / /	(dotted quarter, 8th, quarter, quarter)
(Brushes)	/ / / / / / / /	(8th notes)
(Bass drum)	/ / / /	(quarter note pulse)
For clapping:		
(Claves)	/ / / /	(quarter-note pulse)
(Clap sound effect)	/ /	(clap sound on 2nd & 4th beat)
(Brushes)	/ / / / / / / /	(8th-note pulses)
For drumming:		
(Wood block)	/ / / /	(quarter note pulse)
(Brushes)	/ // / // / // / //	(boom-chucka, boom-chucka)
	A *A*	
Tuba sound:	*G* *G*	
	C **C**	(tune rhythm equivalent to quarter – eighth-eighth-quarter)

Figure 1: Keyboard programmed rhythms at 60 bpm.

Doodle” tune, all at 60*-beats per minute. Rhythm selections were pulsations with simple rhythm patterns (see Figure 1). Each of the above interventions had a different pattern, but each session presented the same pattern for the same intervention.*

Pattern selections were based on rhythm ability to stimulate instinctive pulsation. (Brain tends to tune out metronomic ticks, thus simple rhythmic pattern is preferred as a way of keeping the brain interested.) In drumming intervention, the repetitious Tuba sound of low **C**, followed by **A–G** two-8th note descending pitches, has, in other clinical circumstances, demonstrated that the instinct to stay in touch with the pulse and to beat accurately, seems to be influenced by the Tuba input.

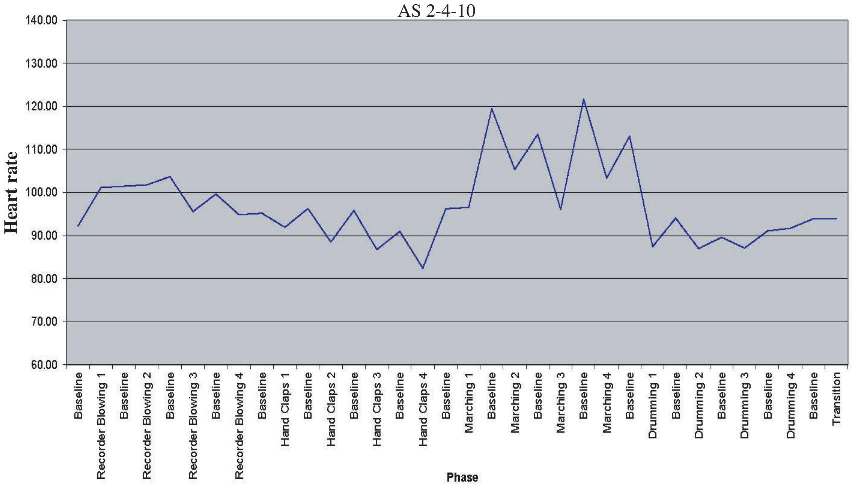
This project satisfied three major areas of music-based treatment concerns: **(a)** analysis of effectiveness of selected interventions in achieving predictable outcomes: four specific interventions tasks based on tempo pulse, investigated to determine the efficacy of tempo, and specific tasks for rhythm internalization, pacing and coordination of movements, and breath control; **(b)** development, refinement and testing of music-based treatment theory and hypothesis concerning issues of physiological sensory aspects that cause perpetual “fear” fight-or-flight arousal responses observed in autistic chaotic and uncontrolled repetitive behaviors; **(c)** examination of application of technology to clinical music-based practice and research; the use of *Lifeshirt* for obtaining specific physiologic data in music treatment interventions.

4 Results and discussion

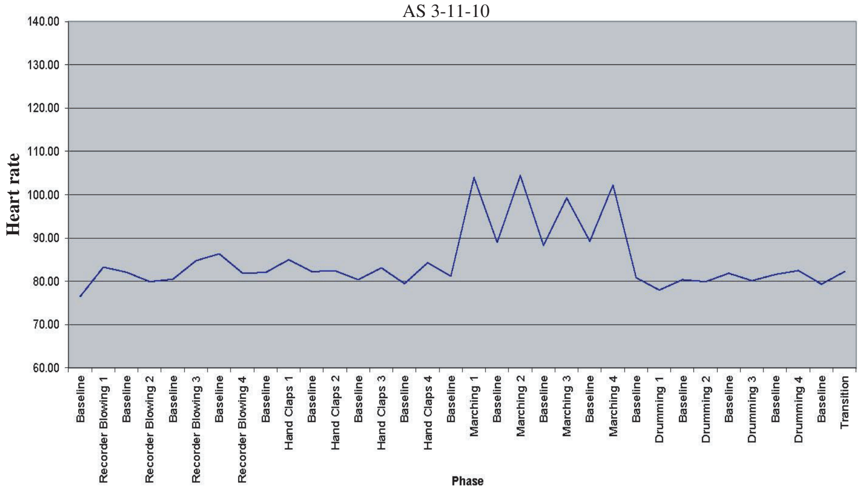
Preliminary viewing of the data appeared to demonstrate that indeed there was attainment of entrainment as suggested by the heart-rate graphs to indicate “controlled arousal”, that is, a movement from baseline at the beginning and end of sessions and between repetitions of task sequences to very consistent and repetitive peaks and valleys of heart-rate activity directly related to the particular task being undertaken. Arousal will occur, of course, when the body is undertaking movement, but the graphs indicate a *“controlled”* arousal (i.e. controlled by the activity), in which smooth transition returned the rate to its rest level. This infers that the system was able to pace and organize itself sufficiently to execute tasks without undue stress and anxiety.

In Figures 2(a), 2(b) and 2(c), “resting heart” valleys represent the 1-minute rest periods (baselines) between execution of repetitions; peaks represent rate during execution of activity. From observing the basic stability of the peaks and valleys in the above graphs during each task and repetition of task, one could infer that (a) interventions were impacting physiologic function, since the heart-rate always returned to its baseline during each 1-minute break between repetitions and (b) interventions were addressing and maintaining levels of entrainment and “controlled” arousal. In task execution rating scale for this research subject, Figure 3 indicates the subject’s task scores in session one, which included *Lifeshirt*.

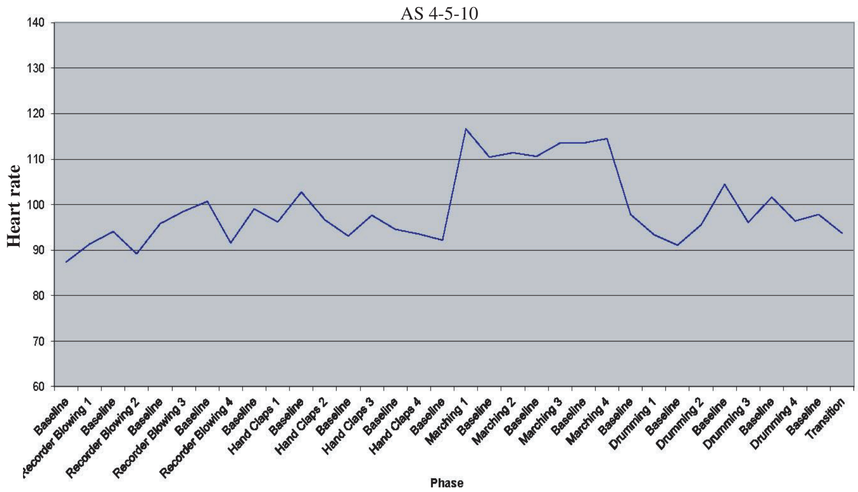
The subject of Figures 2(a), 2(b), 2(c), 3, and 4 represents function data examples from one of the six research subjects, an 11-year-old male diagnosed with ASD and functioning on a “moderate” level, with limited expressive language abilities and several repetitive behaviors such as hand-gazing. His first session scores (Figure 3) began at a 75% score in this first session, but continually increased over the remaining sessions (Figure 4), reaching the score of 100% from the 4th through 8th session, This subject also reduced his repetitive behavior (hand-gazing) until by session eight it was no longer used. By sessions seven and eight, this subject took it upon himself to alter the



(a) Session 1



(b) Session 5



(c) Session 8

Figure 2: Sample of one subject's heart-rate indicator of task impacted on function. Seen here are charts (a – session 1), (b – session 5), (c – session 8) of research subject ID#2 AS in sessions 1, 5, 8. Heart-rate indicates rhythmic entrainment per task. Baseline indicates 60-second rest between each of the four task repetitions, and 2-minute rest between change to next task (valleys). Indications are that interventions impacted upon heart-rate (peaks) in a "controlled arousal" manner.

GC subject ID#2 2/4/20 session 1	Rep 1	Rep 2	Rep 3	Rep 4
Recorder blowing (160)				
Rating: 0–5, Reps 1, 2,3,4				
8 short blows	3	3	3	4
4–2/count blows each	3	3	3	4
8 short blows	3	3	4	4
4–2/count blows each	3	3	4	4
8 short blows	3	3	4	3
4–2/count blows each	3	3	4	3
8 short blows	3	3	3	4
4–2/count blows each	3	3	3	3
Did not undertake/complete task				
Task total (66%)	24	24	28	29
Clapping (160)				
8 hand claps	3	4	5	5
8 lap claps – parallel	4	4	4	5
8 hand claps	4	5	5	5
8 lap claps – alternating arms	4	4	4	5
8 hand claps	5	5	4	4
8 foot stops – alternate legs	3	5	5	5
8 hand claps	5	5	0	4
8 cross-over lap claps	2	3	4	5
Did not undertake/complete task				
Task total (83%)	30	35	31	38
Marching (20)	Rep. 1	Rep 2	Rep 3	Rep 4
Sitting/tambourine – w/prompt				
Sitting/tambourine – no prompt				
Marching w/o tambourine – prompt				
Marching w/tambourine – prompt	4	4		
Marching w/tambourine non prompt			5	5
Number of reps to full tune				
Task total (90%)	4	4	5	5
Drumming (80)				
w/prompt; w/o prompt; w/role model				
8 beats parallel arms	4	4	5	5
8 beats alternating arms	4	4	5	5
8 beats parallel arms	4	4	0	5
8 beats cross over	3	4	5	5
Task total (%)	15	16	15	20
Repetition sub totals:	73	79	79	92
Ratings: (420 = 100%)				
0 = did not/would not undertake	X	X	O	X
1 = hand-o-hand prompting but incomplete				
2 = complete; hand-over-hand a must	2	X	X	X
3 = will do with some prompt or role model	33	27	12	9
4 = independent with role-model only	28	32	32	28
5 = full sequences entirely independent	10	20	35	55
repetition score totals:	73	79	79	92
Grand total rating score:	323			
Percentage of successful task execution:	76%			

Figure 3: Sample task performance rating sheet for subject ID#2 AS.

tasks rhythmically by blowing and clapping “double time” (meaning 2-eighth notes pulses per beat rather single pulse). This indicated to me that not only did he internalize the pulse of 60-bpm, but could sustain the accurate pulse even when blowing or clapping twice as fast. The heart-rate of the 8th session (Figure 3(c)) indicates this task deviation, although still within a “controlled” arousal state.

The total scores per rate seen in Figure 3 indicate a break-down of how the majority of scores were attained. As can be seen, between the first and fourth *repetition* of the task, this subject attained most of his high score with 5’s – full sequence execution completely independent of prompt or role model. In actuality, this particular research subject had the routine and sequences completely memorized

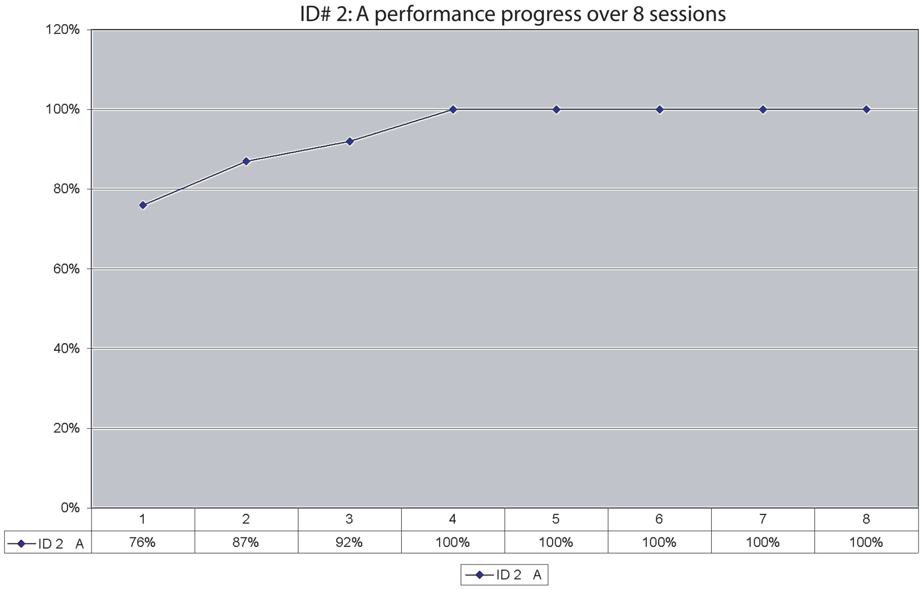


Figure 4: Subject ID#2 AS: performance rating increase over 8 sessions.

by the fourth repetition and was able to sustain task attention with limited prompting. This increased over the 8 sessions (see Figure 4). Similar results were attained by all of the research subjects, although score attainment per task varied according to physical ability to execute adequate motor planning and breath control. The aide accompanying this subject to the sessions, anecdotally offered that throughout most of the week following each session, he was presented with the recorder for redirection of anxiety and "melt-downs", which apparently he was given to having. According to the aide, the blowing helped to calm him down, and he also enjoyed marching and blowing simultaneously in transitioning to other areas of the school. (This had been one of my suggestions to help reorganize this subject under stressful conditions.)

Results for four of the other subjects (3-males, 1-female) indicate an increase in performance abilities (indicated by their ratings) by at least 20% over the eight sessions. A fifth subject, male diagnosed ASD with mixed expressive/receptive language disorder, increased his rating from 30% in the first session, to 50% by the 8th. In the overall behavior scale ratings for task execution, as a group, all six subjects performed at an average 56% rating level – representing a group average rating of approximately 235 points of the available total 420 (see Figure 5). For all subjects, the *repetitious* nature of each intervention resulted in an increase in execution scores. This was seen in four of the six subjects (67%) per sessions, regardless of initial abilities.

Figure 5 demonstrates that the majority of steady progress was made between sessions 2 through 7, with most subjects reaching a peak during sessions 5 (*Lifeshirt* session) and 6. Since session 1 was the first time any of these subjects had experienced music therapy, and the first time subjects officially greeted and became acquainted with clinician, tasks and routine of donning *Lifeshirt*, it might be appropriate to eliminate the first-session data from the overall indications, since as "first encounter" it might not be entirely reliable in scoring. This first session included much hand-over-hand prompting, which subsequently decreased and was eliminated altogether as the sessions progressed. Thus, the scoring of sessions following the first more accurately indicates function. The final session, session 8, which also included *Lifeshirt*, was unfortunately the session that required rescheduling due to weather disasters necessitating additional school closures and disruption of routines and schedules. These factors may have precipitated anxiety which may have contributed to the overall lower scores in this last session, since progress was otherwise consistent. Therefore, when results of sessions 1 and 8 are excluded from calculations, then sessions 2 through 7 clearly indicate sustained progress, positive changes in abilities, redirection of repetitive behaviors, and bringing about a more functional adaptation.

Figure 5 graphs each student's progress and task ratings per session, across the eight meetings. The dark green line in the center (3rd from the top) tracks the group progress, while the other lines indicate per student curve. Noticeable is the decline in curve between sessions 1 and 2, since the second meeting began to reduce hand-over-hand prompting in order for the physiologic systems to begin self-organization, pacing, and undertake redirection of repetitive behaviors more independently and without prompt. The downward curve between sessions 7 and 8 indicates disruptive changes

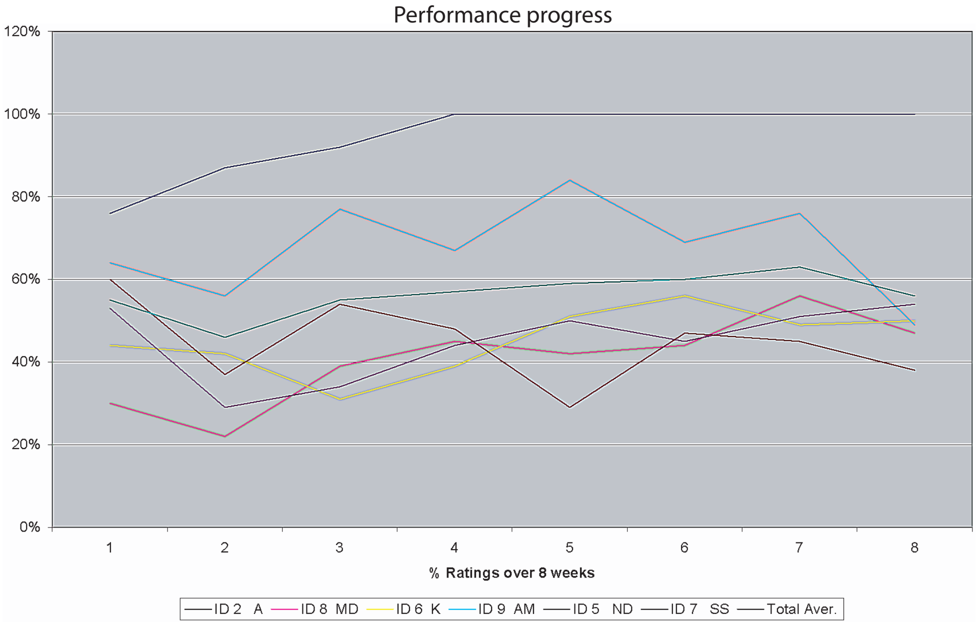


Figure 5: Performance progress of six research subjects over 8 sessions. Dark green line (3rd down from the top) indicates group progress average over the 8 sessions.

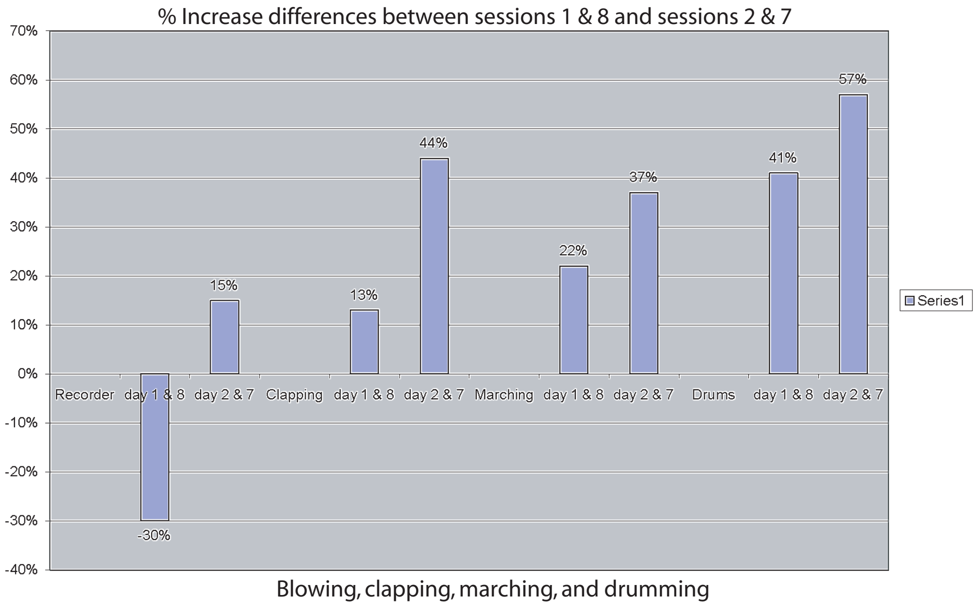
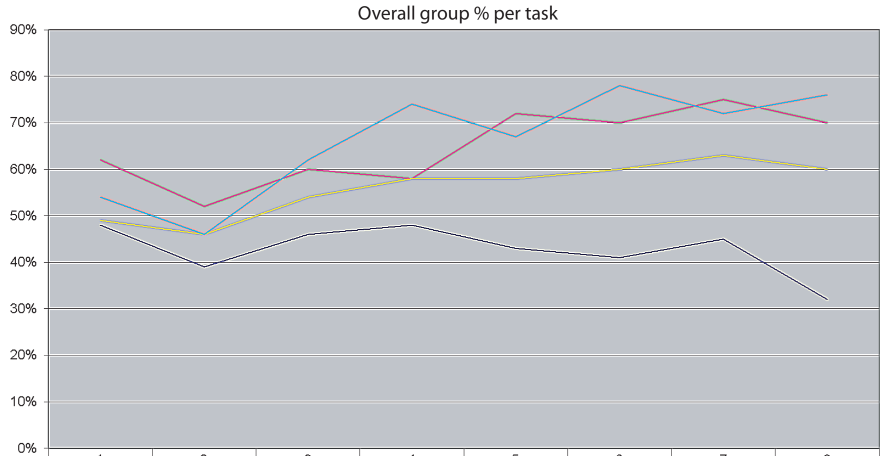


Figure 6: Progress differentiation between sessions 1 and 8 and compared with sessions 2 and 7.

of schedules, school closure, change of meeting days, and some stress with wearing of *Lifeshirt*. Although on two previous occasions, *Lifeshirt* was worn, somehow this final session created a bit of discomfort for several of the subjects, particularly AM (purple line) (age 7) who had great difficulty and distraction in wearing *Lifeshirt*, and SS (turquoise line) (age 11), who had some family difficulties the week-end prior to this session. Both subjects were very capable of undertaking the music therapy interventions with minimal prompting, thus their final session function might be attributed to extenuating external circumstances beyond even the control of music therapy.

Figure 6 looks at the differences in progress between the 1st and 8th session, as compared with the progression from sessions 2 through 7. The negative score represents the predominant inability of five of the six subjects to blow the recorder, and to move in the marching task while simultaneously beating the tambourine. These two tasks reduced



	1	2	3	4	5	6	7	8
Recorder	48%	39%	46%	48%	43%	41%	45%	32%
Claps	62%	52%	60%	58%	72%	70%	75%	70%
March	49%	46%	54%	58%	58%	60%	63%	60%
Drums	54%	46%	62%	74%	67%	78%	72%	76%

Figure 7: Per task progress curve. Indications are that three of the four interventions sustained increased progress of the 8 weeks, while one, the blowing of recorder (breath control), presented one of the most difficult tasks.

the scores in the first session, and was the most difficult to sustain in the last session. Both sessions included *Lifeshirt*. By the 7th session, four of the five subjects were able to execute the recorder-blowing sequences more consistently across the four task repetitions, and all six subjects marched or attempted to move rhythmically (even if only by swaying from foot to foot in tempo) in a standing position. By session 5, which included *Lifeshirt*, subjects were completely engaged and comfortable by this time, in engaging in task execution while ignoring the wearing of the vest.

Individual task curves (Figure 7) indicate that the two most difficult tasks across the board were (a) *the blowing of the recorder* – an entirely new activity for all research subjects. As an observation, there also seemed to be a correlation between non-verbal subjects or those with limited expressive language, and their inability to regulate breath control for blowing pulsed rhythmic sequences on the recorders. The second most difficult task, as shown in Figure 8, was (b) the *marching* (movement) task with simultaneous clapping of tambourine or cymbals, implying limited upper/lower body movement control, and vestibular sensory problems. Two of the six subjects undertook this activity in a seated position, with aide and therapist double-prompting arms, and legs, in earlier sessions, but prompting decreased as later sessions deemed it less necessary, and subjects were able to move legs rhythmically. Of the four who were able to march (or rhythmically move in standing position) two required some upper-body (arm) prompting in order to coordinate sustaining the pulse on tambourine while moving legs. Indications here were that these two tasks were not only directly addressing motor planning and breath control, but also would require many more repetitions in order to achieve a level of adaptive upper/lower body coordination and vestibular security.

The two tasks that more immediately helped the system entrain, embody pulse, and which were best executed by all six subjects were the hand-clapping and the drumming. During the hand-clapping task, with or without the assistance of prompting, all six subjects displayed central visual focus, attention to task, and visual attention to therapist and/or aide role-modeling (when required). The drumming resulted in similar sustained task focus, visual attention, calm execution, relaxed response, excellent imitation abilities and enjoyment (many smiles during task).

Breath-control curve (recorder task, dark line above) is the only task indicating a decrease in basic progress in sessions 1 and 8, although across eight sessions, this function remained at a basically stable ability level for the group. The three other tasks greatly increased in ability of execution, across the group, over eight sessions, with the drumming task indicating the most increase (approx. 71%). This serves to support the factor of upper body motor-planning skill development, since physical prompting was very minimal and, in some instances, completely extinguished beginning with session 4.

Figure 8 is another view of individual task progress overall, made by the group of six subjects. These indicators further serve to reinforce the thesis that breath control is an important feature for systemic regulation, and that the task of blowing the recorder needs to become an intervention in music-based treatment. Given the observed correlation between expressive language and rhythmic blowing, it is

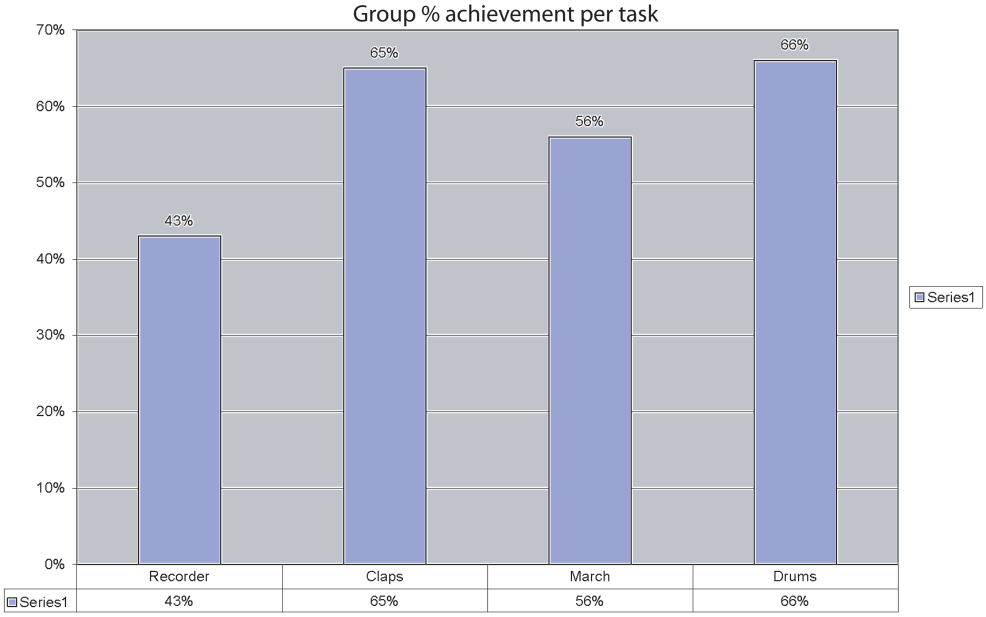


Figure 8: Another view of group achievement per tasks. Here again, there is a clear indication that breath control, through recorder tasks, will require many more blowing opportunities in order to begin to develop increases in control. Recorder-blowing is therefore an important intervention for this and similar populations.

conceivable that training in breath control could influence expressive language abilities. That is to say, learning to regulate one's inhale and exhale in a rhythmically paced manner could further enhance the breath control for attaining expressive language skills.

In the overall heart-rate data of research subjects, there is indication of consistency and stabilization in heart-rate, with lower peaks and valleys in the recorder blowing tasks. This might represent a level of *entrainment* with some internal calm and restfulness, as sampled earlier in Figures 2(a), 2(b) and 2(c) of subject "AS". The hand-clapping and drumming tasks seemed most able to yield entrainment stability, while the marching task indicates "*controlled* arousal" showing more symmetrical high peaks and valleys.

Behavior rating-scale indicators of group percentages accrued over the eight meetings, as indicated in Figures 7 and 8, are summarized as follows:

(i) group average percent attainment in *recorder blowing* task = 49% (an average of 78 out of 160 total task points per session). This is an increase of approximately 1 point from the first session group average of 48%;

(ii) group average percent attainment in *hand clapping* task = 65% (a group average attainment of 104 out of 160 available task points per session). This is an increase of 3 points over 8 sessions, from first session group average of 62%;

(iii) group average percent attainment in *marching* task (upper/lower body coordination) = 56% (an average score of 11 out of 20 total task points available per session). This is an increase of approximately 7 points over the first session average of 49%;

(iv) group average percent attainment in *drumming* task = 66% (a group average attainment of 53 out of the 80 available task points per session). This is an increase of 12-points from the first session group average of 43%.

In all, there is an indication of gain in the ability to execute each of the four interventions presented in the study. It is surmised that by learning to execute a task, the system must be gaining a degree of organization that involves task attention, focus to details, regulation of movement (motor-planning), cognition skills relative to sequential processes, and obtainment of *entrainment* to embody (internalize) pacing of movement and thinking, coordinated with expectations and motivation to achieve. To *"learn"* is to become *"disciplined"* in undertaking a task. Any trained musician will attest to the fact that proficiency in executing a musical skill is attained through *repetition* (practice). This "practice" idea was a critical element in this research study.

Gains in breathing task execution, although slight, also indicate that learning to blow *sequential* rhythmic patterns on a recorder also draws upon systemic organization. This supports clinician's instinct that *breath control* tasks are perhaps the most important when dealing with anxiety and language delays, and would require the most work, over longer periods of time (eight weeks may be too brief). As an observation, we note that when language abilities appeared minimal or non-existent, the regulation of inhale/exhale was also deficient, and recorder blowing ratings were the poorest with this intervention. This was the only intervention that met with resistance to undertaking. As for overall progress, indications are that the most upward progress was made between sessions 2 and 7, (Figure 6). Although the first session would be unlikely to yield very high scores, being a first encounter with this treatment modality, it still yielded "respectable" scores and cooperation with the donning of the *Lifeshirt*.

5 Conclusion

Since all aspects of this study were tightly controlled – time span per task, ratings per task elements, day and session schedules and so on, it might be considered that, based on the fact that the 8th session appeared less successful than others, the external variables and disruptions of continuity would play an important role in any treatment. The dose-response aspect presents another variable and the following questions: (i) how long should the time allotment per intervention be in order to attain entrainment and regulation? (ii) how should (or should not) intervention(s) be altered per child? (iii) how many sessions might be required before physiologic progress and change can be observed and logged definitively? (iv) are the specific interventions of this study valid? (v) is the sequential flow of the interventions workable? (vi) how, if needed, might the sequence of interventions be altered per child, without altering the tasks? (vii) is the metronomic 60 bpm pulse effective in slowing a racing system? (viii) can these interventions be undertaken uniformly regardless of the level of function of a subject, or must certain tasks be completely altered per subject? and if so, how? (ix) how much prompting is, or should be, involved, including hand-over-hand and role-modeling? (x) what are the auditory sensitivities involved? (xi) does gender play a role? (xii) what are the impacts of external conditions, if any, on results? These and many more questions arise as a result of this work, suggesting the need for more research in this area. The positive is that such a study *was* begun, indicating progress in the right direction. Further research of this nature is needed.

Appendix

Brief sketch of six selected research subjects

There is no prior experience with music-based treatment or music classes, in or out of school. Subjects were scheduled in Occupation Therapy, Speech Therapies, Activities of Daily Living (ADL) at the time of study. Subjects were familiar with research room and *Lifeshirt*. At clinician request, all "behavior rewards" were eliminated pre, during, and immediately post music sessions.

Subject 1: ID#2 (AS)

An 11-year-old male; diagnosed ASD (Autism Spectrum Disorder); Medications include Prozac (SSRI), Seroquel (Atypical antipsychotic), Clondine (Antiadrenergic). Limited expressive language; responds well to "choice" questions, "yes", "no", displays sense of humor; decent eye-contact; excellent sequential memory; excellent rhythm; displays "tick-type" repetitive behaviors (hand-gazing, vocalization); has "melt-downs".

Subject 2: ID#8 (AM)

An 8-year-old male; diagnosed ASD; not medicated; moderate expressive language skill; difficulty with upper/lower body coordination involving vestibular (unable to march in standing position; required prompt to stomp feet (in sitting position) while simultaneously beating tambourine); difficulty with mid-line crossing; required physical prompting for cross-over clapping, and cross-over drumming.

Subject 3: ID#6 (KK)

A 9-year, 10-month-old female at time of research; diagnosed Global Developmental Delays (with cerebral palsy-like behaviors). Medications include Clonazapam (long-acting Benzodiazapam); Depakote (mood stabilizer; anti-convulsant); cheerful person; good sense of self, likes and dislikes, moderate but erratic expressive language; loves music; seeks independence. Tried hard to blow and sustain breathing pace, although short blow was difficult; early sessions required consistent physical prompting, but progressed to independent hand clapping, drumming and moving in time with the march.

Subject 4: ID#8 (MD)

A 12 1/2 year old male; diagnosed ASD, Developmental Mixed Receptive-Expressive Language Disorder; medications include Methylphenidate (Stimulant), Focalin XR (Stimulant), Clonidine (Antiadrenergic); language deficits correlated with inability (or lack of interest) in blowing recorder; unable or unwilling to blow recorder; unable to organize, coordinate upper/lower body for marching task; required much prompting; difficulty crossing mid-line, requiring physical prompt for cross-over portions of tasks; abilities increased with minimal prompting in the last several sessions; displays extreme auditory processing sensitivities; loves music.

Subject 5: ID#5 (ND)

An 8-year-old male; diagnosed ASD; no medications listed; moderate to fair expressive language; breath-control limited; disliked blowing; hand-clapping good, but crossover required prompting; drumming crossover done well; unable to coordinate upper/lower and vestibular in marching segment; inconsistent in task execution; enjoyed being playful displaying a level of defiance for following interventions directives as an avoidance of his inability to undertake a sequence independently.

Subject 6: ID#7 (SS)

A 10-year, 8-month-old male at time of study; diagnosed ASD, PDD_NOS, Mood Disorder-NOS; lives ingroup home; mother professional Rock singer away much of the time; medications: Risperdal (Atypical antipsychotic); Zoloft (SSRI); Depakote (Mood stabilizer, Anti-convulsant); information unavailable regarding medications he was on at time of music treatment; good language and communicative skills; labile and volatile emotionally; good recall of song lyrics; inconsistent cooperation with task undertaking; prominent inability to cross mid-line or remain on task, inconsistent though capable in delivering task sequences accurately and unprompted; seeks continuous attention from aide.

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