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Since the 1970s, music librarians have been discussing the challenges of cataloging music media. In the 1990s, they began work on a Music Thesaurus to provide a multi-faceted approach to indexing, cataloging, and retrieving music media. In 1999 Indiana University proposed a digital music library, to allow for better indexing and retrieval in addition to content-based music retrieval. In 2000, a commercial venture, The Music Genome Project ©, began cataloging sound recordings of popular music by hundreds of musical characteristics and has created a user interface that allows listeners to enter the title and artist of a certain piece of music and receive recommendations for similar music to then purchase via Pandora.com. The following paper will address the question: how might current analyzing and classifying methods be used to provide additional indexing that facilitates retrieval and use of sound recordings by special populations, specifically professionals treating children with Asperger's syndrome?

Headings:

Content-based music retrieval, music libraries, digital libraries, cataloging, indexing, Asperger's syndrome, music therapy

Facilitating Retrieval of Sound Recordings for Use By Professionals Treating Children with Asperger's Syndrome by

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I. Music classification within physical libraries

Music librarians have often debated how best to catalog and store sound recordings in a library setting. Before the advent of compact disks, the size of LP records and care they needed was a big factor for librarians to consider, as was point of access from the card catalog. In 1976, most libraries used the Library of Congress subject headings for music retrieval. They also employed additional methods to organize music. The Library of Congress proposed assigning numbers in addition to the classification schedule, to facilitate cataloging. Gaeddert (1981) reports that a poll conducted about this proposal showed little enthusiasm for the feasibility and practicality of the Library of Congress assigning additional numbers. Even then it was evident that there would not be a one-size-fits-all way to address the issues of maintaining music collections.

Limitations of the Library of Congress subject headings are clearly defined in a number of different works. Because the LC subject headings were specifically designed for a card file system with minimal access points (Notes, 1989), they are too limiting, try to encompass too much information with too few headings, and do not allow for simultaneous descriptive cataloging and classification. Retrieval also becomes an issue, with the standard example being Schubert's "Der Hirt auf dem Felsen." Searching for any combination of the following should retrieve this work: high voice, piano, and clarinet. Under LCSH, the heading assigned is the generic "Songs (high voice) with instrumental ensemble." The issues for a music library are further complicated by the fact that one composer and title can have both print and recorded representations. These need to be cataloged both as separate and as the same work.

Duckles (1985) is the current standard for music cataloging in most academic libraries. Several works are listed in his 5^{th} edition, and each of those works presents different options for classifying print and recorded music material. Typical classification schemes seem to use composer/author, title, physical medium, and a section for notes. Bratcher (1988) proposes classifying by type of instrument (with sub-categories), topic, arrangement, pattern headings (with many subdivisions to avoid redundancy), ethnic group, style of music, and instrument. Gaeddert (1981) discusses arranging by accession number, alphabetically by composer, using Dewey and cutter numbers, arranging by size, and using broad musical form or broad instrumental categories. She mentions that descriptive cataloging and classification are discussed simultaneously and that service to the user needs to be the primary consideration in classifying print music and sound recordings.

Kaufmann (1983) discusses Library of Congress subject headings for Western non-classical music. They are provenance (place, ethnic or national group, language), medium of performance for jazz, country, folk, and national music (solo, group, combinations), number of performers, genre, and subject content. Kaufmann (1983) notes that it is difficult to keep genre updated because many new types of music are constantly emerging. Subject content is broken into topic, activity, performer, and character of text. For example, subject content might note that a song is about coal miners or a song is specifically for children.

Saheb-Ettaba (1969) describes the ANSCR alpha-numeric system for sound recordings. It contains twenty-three major categories and some subdivisions, which make a total of thirty-six subject areas (see Table 1). Regardless of method proposed prior to 1999, classification and retrieval remain significantly limited in comparison to what current computer technology will allow.

Table 1 Saheb-Ettaba (1969) proposed classification categories

Category	Subdivisions
Music appreciation	
Opera	
Choral	
Vocal	
Orchestral	General, ballet, concerto, symphony
Chamber	
Solo	Guitar, organ, piano, strings, violin, winds, percussion
Band	
Electronic	
Musical show	
Soundtrack	
Popular	Pop, country and western, jazz
Folk and ethnic	
International	
Holiday	
Humor	
Plays	
Poetry	
Prose	
Documentary	
Instructional	
Sounds/special effects	
Children's	Instructional, music recordings, spoken recordings

II. Music Thesaurus

Henrietta Hemmasi has written extensively on the Music Thesaurus project. The thesaurus would add something similar to a keyword search element to music retrieval.

The thesaurus proposes a standard vocabulary for music, hierarchical arrangement of vocabulary, faceted terminology, rich lead-in vocabulary, and complete syndetic structure. The Library of Congress subject headings were the starting point for the Music Thesaurus project. In addition to the standard subject headings, the project had seven root facets: agents, events, forms/genres, geo-cultural attributes, sound devices, texts, and other topics. Cronquin (2004) proposed possible improvements: time, style, audience/setting, physical form, extramusical associations, number of performers, arrangement, and excerpts.

The Music Thesaurus would allow for contextual searching, which helps the user to cope with retrieving too much or too little information. All facets and terms would be indexed in the thesaurus, so no one term needs to be predominant. The syndetic structure would incorporate all structural relationships: synonyms, related terms, and the hierarchical relationships, which have already been established by the Library of Congress. The terms are listed in a thesaurus, "which organizes them hierarchically according to facet, showing each term's relationship to other terms within the discipline" (Working Group on Faceted Access to Music, 1994). "A thesaurus is constructed using facet analysis to identify concepts and denote them by terms, and then to determine the relationships among those terms. The thesaurus makes these relationships among terms evident to the users of the thesaurus" (Working Group on Faceted Access to Music, 1994). Hemmasi (1994) noted that the Music Thesaurus was a collaborative effort in an area needed by all fields, not just music libraries. Music librarians were simply the professionals working on it at the time.

III. Indiana University Digital Music Library

In May, 1999, Indiana University made a proposal to the National Science Foundation and began phase two of a digital libraries initiative. The "Variations2" project set out to establish a "digital music library testbed system" using a variety of formats. The researchers wanted to develop "system architecture, metadata standards, component-based application architecture, and network services." The intent was to create something useful for a variety of subjects, and a music library was the first step (Indiana University, 1999).

Researchers in the Digital Music Library (DML) realized that any one musical piece could be represented in numerous forms. Not only would there be print music and sound recordings, but also there would be different artists performing the piece, various arrangements, different conductors, publishers, notations within the score, editions of the piece, digital recordings, analog recordings, live recordings….the list continues. Each of these different representations of the same piece needs to be linked together. They utilized track files containing descriptions of individual tracks on a single CD recording and start times for each track to allow for easy playback. The heart of the DML system architecture was to be a digital repository service that would allow searching for a recording using metadata, retrieving metadata for a selected, named item, and playback of a sound file. The proposal promised a design that would evolve to meet user needs.

IV. Music Genome Project ©

The Music Genome Project © began in January, 2000 when a group of musicians, led by Tim Westergreen (wikipedia, 2007) collaborated to create a comprehensive analysis of music at its fundamental levels. Because it is a commercial venture, specific details are not readily available. However, in essence, the project breaks music down into hundreds of component parts and uses those to describe characteristics such as melody, rhythm, harmony, instrumentation, orchestration, arrangement, and lyrics (Pandora, n.d.). Each piece of music is analyzed for 20-30 minutes by at least one analyst (wikipedia, 2007). Users are allowed to see something termed "focus traits" (wikipedia, 2007), and there are about two thousand of these. Focus traits are combinations of individual genes used to determine why a user likes a specific song. The individual genes are very detailed, such as amount of vibrato, amount of voice ornamentation, and octave range (wikipedia, 2007).

The Music Genome Project© technology is used by a service called Pandora.com, which provides recommendations and designs personal "radio stations" for subscribers. Unlike most collaborative filtering applications, which base recommendations on previous purchases by title or social recommendations (Starr, 2006), Pandora.com uses the Music Genome Project © technology to evaluate characteristics of the music and recommend music with similar characteristics.

V. User needs as related to cataloging

Even as early as 1978, music librarians were concerned about user needs. Gaeddert (1981) quotes Frost (1978) and Halsey (1976) along with several other authors who advocate for organizing media by the way it is used. The intention of organizing music is to assist patrons when they choose between various issues of recordings. Cronquist (2004) articulates one of the difficulties faced by music librarians with the following quote: “No matter how many salient intellectual and physical facets may be formulated for music materials it is clear that different users will seek the materials in different ways….depending on their purposes” Smiraglia, 1989, p. 64).

The needs of the user are further emphasized when one reviews the literature in the music therapy field. Specifically, one can find a number of applications of music and music therapy to children diagnosed with Asperger’s syndrome and other autism spectrum disorders, including attention deficit disorder. As music librarians continue to search for a solution to the difficulties of current indexing and cataloging schemes, they need to consider the needs of special populations and explore the use of digital technologies for characterizing music. When addressing the needs of music therapists and other health professionals utilizing auditory interventions for patients with disorders on the autism spectrum, special collections need to be developed. These special collections need indexing that combines standard LC subject headings, additional facets as proposed by the Music Thesaurus project, current digital technologies for classifying print music and sound recordings and allows additional, specific access points, such as characteristics of steady beat, rhythm, tempo, and tone.

VI. Asperger’s syndrome and sensory processing disorder

Asperger’s syndrome is a neurological disorder, part of the autism spectrum of disorders. It is commonly known that Hans Asperger, a Viennese physician, was the first to describe the symptoms of Asperger’s syndrome in the 1940s. Asperger’s syndrome is characterized by normal or superior intelligence and normal language development combined with autistic-like symptoms. Specifically, the autistic symptoms displayed are difficulty with social skills, communication skills (especially nonverbal communication), and social interpretations, difficulties with transitions or changes in routine, obsession with routines, perseveration (intense focus on one specific subject or topic), and sensory sensitivities.

Age of onset and cause of the disorder is still being debated. Diagnosis is difficult because there is not yet a standard for screening or diagnosis. Asperger's syndrome was first included in the DSM-IV (the diagnostic manual for mental disorders) in 1994, with a set of criteria for diagnosis. Many people are not diagnosed until adulthood, though they have displayed symptoms since childhood. There is a strong genetic component to the disorder. There is some evidence that thimerosal in vaccinations is responsible for some cases of Asperger's syndrome. At the writing of this paper, hearings are taking place to determine if thimerosal does play a role in autism spectrum disorders.

Treatment for Asperger's syndrome varies by patient, family, and severity of symptoms. Nutritional and medicinal suggestions are available mostly for co-existing conditions such as depression, anxiety, and attentional issues. Pragmatic speech language therapy and social skills groups are available for patients to learn and practice the art of give-and-take in conversation and the social expectations of friendships and interactions. For school-age children, using a "shadow" in school to encourage social interactions and teach social skills can be helpful. Counseling, cognitive behavior therapy, and parental support are effective in teaching patients to manage behavior and emotions and providing self-awareness which is crucial to individual success. Occupational therapy can assist patients with motor coordination, motor planning, and sensory issues.

The sensory sensitivities experienced by Asperger's patients have also been termed sensory processing disorder. Many individuals display symptoms of sensory processing disorder without showing any additional signs of Asperger's syndrome or other autism spectrum disorder. Sensory processing disorders are simply an inability to regulate sensory input. Some individuals are oversensitive to sensory input, thus withdrawing from smells, touch, noise, etc. Others are under-sensitive to sensory input and thus exhibit sensory-seeking behaviors such as needing loud sounds, seeking extra tactile sensation, and moving the body in ways to stimulate the vestibular sense (spinning, jumping, swinging). In general, whether individuals are over- or under-sensitive, they seem to lack the neurological ability to assimilate sensory input, and thus they struggle with appropriate interaction with their environment. Biel (2005) suggests music as an aide for children experiencing sensory processing difficulties (sensory integration dysfunction), specifically suggesting that music can improve focus and that children will most likely respond better to different types of music than will adults. Though she does not provide further explanation of why she believes this to be true, one can assume that children's attention is held by different music that adults'. Her suggestion is consistent with many of the therapies that have developed over the years to assist in the treatment of people with autism spectrum disorders.

VII. History of Auditory Interventions for Autism Spectrum Disorders

Frick (2001) describes the history of auditory interventions from the mid-1900's to present. Many investigators built on the early work of Dr. Alfred Tomatis, who, after World War II, began studying the effects of exposure to occupational noise (Sollier, 2006). Tomatis was interested in restoring voice as well as restoring hearing, because the two are connected. A person's speech is purely a reflection of what the individual has heard. Therefore, hearing and listening are crucial first steps toward speech and language. Tomatis' studies led him to discover that constant exposure to loud noise affects the muscles in the middle ear, thus causing them to prevent loud noise from entering the inner ear (Sollier, 2006). Tomatis experimented with retraining these muscles, first by having a person listen to music that was switched on and off and later by having the person listen to music that was switched between an ear canal that amplified low frequencies and one that amplified high frequencies (Sollier, 2006). This switching between frequencies is termed gating.

As Tomatis began experimenting with frequencies, he learned that different languages predominantly use different frequencies, thus the ear can be trained to listen only to certain frequencies and be deaf to others (Sollier, 2006). He also learned that the two ears are not identical. Because the right ear is connected to the left brain, which processes language, people who are right-ear dominant learn languages more easily than people who are left-ear dominant (Sollier, 2006). Thus his work progressed to retraining people to be right-ear dominant (Sollier, 2006). Tomatis then trained people to develop an "ideal listening curve" (Sollier, 2006). By filtering the music individuals listen to so only certain frequencies come through, the individual's ability to hear a variety of frequencies can be strengthened (Sollier, 2006).

The final progression of Tomatis' work resulted from researching the ability of the bones to transmit sound to the ears (Sollier, 2006). Listening with the bones, or whole body, is termed bone conduction, and it takes place when the bones are vibrated by an external sound and the bones transmit that vibration to the ears. Tomatis discovered that sounds that enter the ear directly are modulated by the middle ear, but sounds that go from the bones directly to the inner ear are not (Sollier, 2006). Therefore, listening with the whole body results in background noise being just as loud as the sound a person wants to hear (Sollier, 2006). This lack of discrimination between signal and background makes is impossible for an individual to focus and learn. Tomatis' response to this information was to devise a way to desensitize the bone conduction and thus restore the predominant listening pathway as the modulated middle ear.

Sollier (2006) reports that improved listening curves resulted in improved listening. In addition, people began to have more energy as a result of the brain being stimulated by the higher frequencies from the ear (Sollier, 2006). Sollier (2006) also notes that as the inner ear, which regulates body movements, is strengthened, motor skills improve. The result of the bone conduction desensitization was improved behavior and improved learning (Sollier, 2006). Autistic children experience specific improvements. As part of the Tomatis approach, they perform a series of listening and repeating exercises, after the bone desensitization phase. These exercises include self-listening, which eventually fosters communication (Sollier, 2006). Dejean (n.d.) notes that the Tomatis method incorporates a counseling aspect as well and results in improved skills in taking in information, receptive, expressive, and spelling language, organizational abilities, communication, and social behavior.

Guy Berard is a French surgeon who worked with Tomatis briefly and then began his own studies (Berard, 2006). Once he completed his training as an otolaryngologist, he began developing Berard auditory integration training (AIT). He believed the Tomatis method focused too strongly on emotional issues and wanted to develop an ear training technique that was more like physical therapy (Berard, 2006). Berard (2006) reports that his method of AIT uses music stimulation that is more powerful than the Tomatis system and thus able to reorganize the system in ten hours of listening for retraining, as compared with the Tomatis thirty hours. Details about how Berard modified the Tomatis approach are not available, as Berard AIT is still a commercial venture.

Frick (2001) reports that Ingo Steinbach developed a method termed SONAS, System of Optimal Natural Structure. Steinbach is a German sound-engineer who has a background in music, physics, and electronics. His method maintains "elements and structure of natural sounds throughout the entire process of recording, processing and reproduction" (Frick, 2001, The Samonas Method section, para. 1). Most music is classical, some includes natural sounds, and the choices are based on principles of music therapy. The SAMONAS recordings only use natural instruments so the tones in the recordings are rich in harmonics. At times the recordings have intense filtering so that only harmonics are heard, thus training the ear to pay attention "to the upper ranges in the sound spectrum. The higher tones are the parts of the sound spectrum that captivate attention and hold interest. These recordings are identified as SAMONAS, which stands for Spectrally Activated Music of Optimal Natural Structure." (Frick, 2001, The Samonas

Method section, para. 2) There are many applications of the SAMONAS system, and it can be highly personalized. (Samonas, n.d.) The SAMONAS company invites individuals to set personal goals and then contact the company for assistance in creating an individual listening protocol. It is not recommended for use without the assistance of a professional. The SAMONAS website reports goals of stimulating, integrating, and organizing the human system in addition to assisting with higher levels of discrimination. Private users are offered assistance in creating a protocol to help with relaxation, winding down, increasing energy level, and improving ones "sense of harmony."

The SAMONAS filtered CDs have several levels of intensity. Those of lower intensity can be used in a program called Therapeutic Listening®. "Therapeutic Listening® " is an evidence-backed protocol that combines a sound-based intervention with sensory integrative activities to create a comprehensive program that is effective for diverse populations with sensory challenges" Trained therapists in homes, schools, and clinics use Therapeutic Listening ® to create an individualized sound training program. The Therapeutic Listening ® program is usually used as a part of a complete treatment for sensory processing disorder (Parent, 2005). It incorporates the whole body in listening and improving motor skills. Because it is an individualized program, there is no set protocol. However, it does not use the sophisticated equipment that the Tomatis or Berard methods use, and therefore can easily be used in non-clinical settings (Parent, 2005). It has been shown to "impact sensory modulation, attention, behavior, postural organization, and speech and language difficulties" (Vital Links, 2007, What is Therapeutic Listening ® section, para. 1).

Hall and Case-Smith (2007) published results of a study using Therapeutic Listening. Their study involved ten children, ages five to eleven. Each of these children met the criteria for sensory processing disorder in at least three sensory areas. The children were treated with sensory diet, a combination of sensory activities individually designed to help with sensory modulation. The children were then treated with eight weeks of sensory diet combined with Therapeutic Listening ®. Results showed improvement in mean scores for the Evaluative Tool for Children's Handwriting, the test of Visual Motor integration, and total sensory profiles. Each of these is a standard test used by occupational therapists for assessing sensory processing disorders. In addition, parents reported improvements in attention, interaction with peers, transitions, listening, self-awareness, communication, sleep patterns, and following directions.

Interactive Metronome (Interactive Metronome, n.d.) therapy, another auditory-based therapy, was developed in the 1990s. It "is a cutting-edge edge neurological assessment and treatment tool that is redefining traditional expectations for pediatric and adult therapy outcomes." (Interactive Metronome, n.d., Overview section, para. 1) It was initially used to help children with developmental disorders, including sensory processing disorder and autism spectrum disorders. Its uses have expanded over the years, and it is now used for a variety of adult neurological disorders.

Interactive Metronome (IM) involves neurosensory and neuromotor exercises, challenging the patient to synchronize a range of extremity movements. The structured process utilizes the brain's ability to "repair or remodel itself through a process called neuroplasticity." Alpiner (2004) suggests that IM augments processing speed and affects the cerebellum, prefrontal cortex, cingulated gyrus, and basal ganglia.

The most obvious function of the cerebellum is coordinating voluntary movement. In addition, it enables memory and is responsible for learned response, a type of nonverbal learning. The prefrontal cortex controls planning and judgment. Emotion processing, emotion formation, learning, and memory, are the primary functions of the cingulated gyrus, which works as part of the limbic system, part of the brain associated with emotions and basic drives, such as those for food and sex. Basal ganglia are a set of nuclei in the brain and are also associated with learning and emotions in addition to motor control and cognition. In people who struggle with motor planning and social-emotional issues, amplifying processing speed and laying down new memories for motor activity is beneficial. Their brains are given the ability to adapt and adjust, increase response speed, and learn new muscle memories.

When a patient is undergoing IM therapy, the patient wears headphones to hear computer-generated tones (sometimes called cowbells) in a steady beat. The therapist instructs the patient to perform certain movements with the extremities, for example hand clapping, toe tapping, marching, and knee bending in time with the "cowbells." The patient wears sensors on different parts of the body, allowing the computer to determine if the movement was performed at the same time that the cowbell sounded, earlier, or later. The computer provides auditory feedback to the patient, and the patient is expected to adjust the movement according to the feedback. The goal is to have the movement take place at the same time the cowbell is heard.

According to Interactive Metronome (n.d.), patients learn to " focus and attend for longer periods of time, increase physical endurance and stamina, filter out internal and external distractions, improve ability to monitor mental and physical actions as they are occurring, and progressively improve performance" (Interactive Metronome, n.d. How It Works Section, para. 5). Frustration tolerance is an added benefit patients can learn as they are practicing interactive metronome therapy, especially if the therapist is sensitive to the patient's frustration tolerance and teaches calming techniques. This therapy is now in use by a variety of medical professionals, including occupational therapists, physical therapists, athletic trainers, neurologists, and chiropractors.

Each of the above-described therapies is still in use today. They each offer similar goals: improved listening curves, improved language skills, improved organization, and improved motor skills. Because they are highly individualized, each therapy will be more or less effective with a particular patient. The Tomatis, Berard, and SAMONAS systems take frequency of music into account through their filtering techniques. Therapeutic Listening ® also takes frequency into account and begins to also consider beat, rhythm, and tempo in each individualized program. The Interactive Metronome focus shifts more to beat and rhythm than frequency.

VIII. Music Therapy

Music therapy is the realm where frequency of music can be combined with beat, rhythm, and tempo to provide patients with a different method for working on issues of coordination, behavior, and listening skills. In contrast to the auditory methods described above, where the emphasis is on listening to existing sounds or music, most traditional music therapy is primarily active or participatory in nature, where patients are actually making some type of music. Many studies note positive effects of music on mind and body healing. Music educators in schools are beginning to realize the significant value in extramusical goals, as described by De l'Etoile (2005) and Martinson (2006).

De l'Etoile (2005) writes about teaching music in an inclusive setting with children who have learning disabilities, attention-deficit/hyperactivity disorder, and emotional and behavioral disorders. She describes teaching techniques, which use cognitive behavior modification strategies: operant learning, social learning, and cognitive training. De l'Etoile (2005) notes that the neural network process that normally takes place during learning is disrupted for children with learning disabilities. Thus they need more specific techniques to assist with their learning. She encourages the development of metacognitive strategies, such as advance organizers and mnemonic devices that will help them with organization and compensation for academic deficits. De l'Etoile (2005) promotes operant learning techniques for children with ADHD, specifically a "predictable, consistent, and structured classroom" which minimizes distractions, highlighting material to assist student focus, and incorporating more movement into the class setting to provide needed additional stimulation. De l'Etoile (2005) suggests a token-economy or self-monitoring as a method of cognitive behavior modification for children with behavioral disorders, pointing out that until the child's basic needs are met, the child will not be able to attend to other information. Therefore, the best approach is to simply address the behavior in the learning environment. Overall, de l'Etoile reminds the reader that during music therapy children are not only learning music but also learning how to learn, so music is a vehicle to other forms of development.

Martinson (2006) discusses inclusive music education. She enumerates three categories of extramusical goals accomplished by music therapy within the school system. These goals include physical goals such as eye-hand coordination and other fine and gross motor skills necessary to play instruments, cognitive goals, such as listening, counting, and pattern recognition, all of which are necessary for comprehension of musical concepts, and emotional goals such as developing self-esteem, coping skills, and decision-making skills which are necessary for students to participate in class and in group music sessions. Martinson (2006) notes that music educators often feel frustrated in an inclusive music class (one that includes students with learning disabilities) because they lack training and experience. She describes the typical special education team and suggests ways a music educator and music therapist can work with the team for the benefit of the student and to support the music teacher in gaining experience with special needs students. She gives suggestions about how to work as a team to develop a student plan, even going so far as to give sample conversations to facilitate information exchange and sample lesson plans. In addition, Martinson (2006) recommends that the music educator create lessons using different sensory modes to appeal to the student and choose specific music that offers opportunities for expression of feelings and incorporates interesting elements of rhythm and tempo, thus incorporating some techniques from occupational therapy.

Montello (1998) compared active music listening and passive music listening. Her study consisted of sixteen special education students (diagnosed with emotional disturbances, learning disabilities, and/or ADD), ages eleven through fourteen, in a public middle school in New York City. Low frustration tolerance, poor emotional control and academic performance, depression, hyperactivity, short attention span, and impulsivity were included in their list of symptoms. Almost half of them were taking medication. The students were divided into three mixed-gender groups, which were given active and passive music therapy in twelve-week blocks. None of the three groups was given only passive therapy, but one group was given only active therapy. The sessions were once per week for forty-five minutes each. Active music therapy was mostly percussion instruments for rhythm training and improvisation. They were taught to take music dictation, play the written rhythm while verbalizing it, and improvise, using modeling, repeating, rhythmic grounding (joining in after the therapist started the group with a basic beat), storytelling while playing, and solo improvisation. The passive groups listened to various types of music and discussed their opinions and responses to it. Teachers used a specific report form to rate the students before and after the twelve-week sessions. The results showed improvement in the area of hostility for the groups that received both active and passive therapy. Cripe (1986) discovers a reduction in hyperactivity when boys listened to rock music (as cited in Montello, 1998), and Bruscia (1987) reports that keeping a steady beat is believed to help clients to control impulses and bring order (as cited in Montello, 1998). Though Montello (1998) cites these two studies, she does not address the issue or effect of the active therapy sessions focusing on rhythm while the passive sessions did not. It is possible that passive therapy would be just as beneficial as active therapy if both were rhythm-based. However, her results do show that any music therapy can be effective for children with learning disabilities.

In her paper, Montello (1998) cites numerous articles describing the positive effects of listening to music on behavior, the physical effects of music, and the role of maintaining a steady beat in fostering a feeling of security and in synchronizing physiological functions and coordinating mind and body. One study she cites is by Thaut (1989), who found that “three different treatment approaches, that is, (a) passive, listening music therapy; (b) active, instrumental improvisation; and (c) passive, listening and relaxation, were all successful in improving self-perceived behavioral change, such as relaxation, mood/emotion, and thought/insight of psychiatric prisoner-patients" (Montello, 1998, abstract, para. 5). Her conclusions state that her research points "to the importance of discerning which types of students within the emotionally disturbed/learning disabled population will benefit most from music therapy and which type of music therapy intervention would most meet the needs of particular personality types" (Montello, 1998, Recommendations, para. 1). The indexing proposal below would facilitate these types of studies.

Muller (1993) studied the effects of music therapy on autistic children and whether or not maternal involvement enhances the effects of the therapy. Her study involved nine autistic children, aged three to fourteen years old, and their mothers. Each child received twenty sessions of in-home music therapy, and the mothers' participation in the session alternated from week to week. The child played with the mother for fifteen minutes before and fifteen minutes after each therapy session. Each play session was filmed. Muller evaluated short-term effects by noting differences in the before and after play sessions, and she evaluated long-term changes by comparing tapes from the second and third sessions of the study with those from the ninth and tenth sessions. Muller assessed the following social interaction behaviors: approach, asking for something, and negative behaviors by mothers and children, and coded the behaviors for statistical analysis. Muller's (1993) results showed an increase in mothers' requesting behavior after participating in the music therapy session. This increase resulted in an increase in avoidance by the children. Otherwise, no significant changes in avoidance were noted.

Additional results show an increase in turn-taking by the children, some increase in musical activity, and a decrease in stereotypic behavior as a result of music therapy. Muller's results along with her reminder that it is generally known that autistic children respond well to music indicate that continuing with music therapy and trying new approaches is warranted for children with Asperger's syndrome.

IX. Recent proposals for music searching/indexing

Several researchers have proposed various indexing and retrieval methods for digital music libraries. Buchanan (2002) describes functional requirements for bibliographic records as a way to index creative works in digital libraries. He lists four elements: work, a creative piece with a distinct identity; expression, the edition or variation of the work; manifestation, the format of the expression; and item, the specific example. As an example for a sound recording, the work might be Beethoven's Fifth Symphony, the expression would be as performed by the Boston Philharmonic in 1976, the manifestation would be an analog recording, and the item would be the LP in the library connection. Buchanan (2002) notes that a critique of a piece of work would be considered a separate work yet still related to the original piece. Thus considerations need to be made to link critiques, recordings, and print music.

Medina (2003) proposed one of many content-based index schemes, a computational method for building an index from a collection of musical scores. While many other researchers described a large-scale query-by-humming (QBH) process, Medina (2003) only captured themes, motifs, or variations of themes, noting that exhaustive searches will not work for large collections. He chose to narrow the content indexed to themes because those are most recognizable by users and therefore most likely to be entered as a query.

Rauber (2002) proposes an alternate form of indexing and retrieval, based on music genre. His work uses analysis of the acoustic wave signal and an automatic organization based on sound similarity, using a neural network. Downie (2006) takes a slightly different approach, discussing the value of connecting opinions to objects in music digital libraries. His work is based on user-generated reviews and based on opinions of good or bad. If Downie's suggestions are combined with Buchanan's and the IU digital music library project, there is a minimum of four separate works all relating to one composer/title entry. Therefore there would be four text access points plus additional access points provided by QBH.

Dovey (2001) discusses integrating query-by-humming and textual systems using a protocol called Z39.50. He notes that most music libraries already have an electronic catalog of their collections based on MARC format and AACR2 cataloguing format. Dovey (2001) notes that Z39.50 is rich in functionality and allows a third party system to query an external database. Dovey (2001) notes that in 1998 he

> "successfully proposed adding 'musical phrase' to the standard as a potential search point. This allows a music library catalogue to respond to queries which include traditional textual search terms as well as a query by musical content. Most library systems at present cannot cope with queries which include music content. Although some systems do provide music content query, e.g. the MELDEX system, these typically do not have rich metadata or detailed holding/circulation information as in library systems" (Dovey, 2001, pp. 249-250).

Medina (2003) points out several problems with content-based searching. Specifically he notes that inaccuracies are probable when a musical pattern is not correctly entered by a searcher, a musical pattern is inaccurately captured by the system, there are coding mistakes in the database, or a user variation is different than the one in the database. Meek (2001) used an automatic theme discovery system, Melodic Motive Extractor (MME) algorithm, to detect repeating themes and cut down on mistakes caused by human error. Maddage (2006) notes that different songs may have similar melody contours, and a program like MME would not resolve these issues. Maddage's proposed solution is to implement degrees of match. However, this would not alleviate all similarities either. One example of a shared melody is Billy Joel's "This Night" and the second movement of Beethoven's sonata number 8, opus 13 in C minor. Even degrees of match will be found between these two songs. Therefore, textual and bibliographic information must be included, even in a QBH search.

The point of combining bibliographic information, textual information, and musical information is best illustrated by the example of the following exchange that took place in searching for the Billy Joel song and Beethoven piece that share a melody:

> "Which Billy Joel song has the same melody as the second movement of Beethoven's "Pathetique" sonata?"
> "It's on the <u>Innocent Man</u> CD, the song right after 'The Longest Time,' I think it's the fourth song. You mean the one that goes….[humming]?"
> "I'll get the CD and listen to it."
> "I think it's called 'This Night.'"
> "Which Beethoven is it?"
> "It's the second movement of the "Pathetique."
> "What number is that, number 6?"
> "I don't know."

Neither searcher was satisfied until both songs and complete bibliographic information had been confirmed. The need for bibliographic information is further supported by the work of Cunningham (2003). His results showed that for known-item searches, shoppers depended on bibliographic information, thus "indicating the importance of including quality bibliographic data in a music digital library" (Cunningham, 2003, p. 8).

The proposal most relevant to the specific user group targeted with this research is one by Maddage (2006). He

> "proposes a novel framework for music content indexing and retrieval. The music structure information, i.e., timing, harmony and music region content, is represented by the layers of the music structure pyramid. We begin by extracting this layered structure information. We analyze the rhythm of the music and then segment the signal proportional to the inter-beat intervals. Thus, the timing information is incorporated in the segmentation process, which we call *Beat Space Segmentation*. To describe *Harmony Events,* we propose a two-layer hierarchical approach to model the music chords. We also model the progression of instrumental and vocal content as *Acoustic Events.* After information extraction, we propose a vector space modeling approach which uses these events as the indexing terms. In *query-by-example* music retrieval, a query is represented by a vector of the statistics of the *n*-gram events. We then propose two effective retrieval models, a hard-indexing scheme and a soft-indexing scheme" (Maddage, 2006, p. 67).

He points out that his indexing and retrieval framework can be used with query-by-humming, aka query-by-example. This type of query allows searchers to retrieve songs with similar tones and semantics. Potential problems he notes are accurate representation of the query, indexing that allows for quick searching, and a retrieval model that can rank the results with a relevance score.

Cunningham (2003) studied the searching and browsing techniques used in public libraries and music stores, noting that current "digital library systems are being developed based on anecdotal evidence of user needs, intuitive feelings for user information seeking behavior, and a priori assumptions of typical usage scenarios" (Cunningham, 2003, p. 5). The methodology used in the study was individual interviews, focus groups, and observations. Market research tactics and predictive factors for purchasing music were not studied. Cunningham reports that people in the music information retrieval (MIR) field need to know how groups prefer to locate music, strategies employed to search or browse, and uses once music is located. Specifically, there is a need for information about motivations, success and failure in search, strategies used and what additional "search facilities, document media, browsing support" (Cunningham, 2003, p. 5) that users might need.

X. Conclusions regarding indexing and retrieval for professionals treating Asperger's syndrome

Cunningham (2003), Frost (1978), Halsey (1976), and Smiraglia (1989) each convey a similar message: different user groups will search and use music in different ways, and those user needs must be paramount when designing a music information retrieval system. In fact, Cunningham (2003) reports "We concur that usability and conformance to user understandings of the music world are paramount: the point here is classification *per se*, not according to what principles or parameters" (Cunningham, 2003, p. 9).

Auditory interventions for patients with Asperger's syndrome have been available since shortly after World War II. The methods employed indicate the importance of frequency and beat in auditory interventions. Music therapy has also been used for Asperger's patients, though to date active music therapy has been more prevalent than passive therapy. Anecdotal evidence suggests that the uses of background music and passive music therapy are now being explored, and this new exploration has generated a different set of user needs that needs a new type of classification.

For the group of professionals who use music to treat patients with Asperger's syndrome, the needs are unique and documented only anecdotally. The lack of retrieval based on needs is likely one reason that the needs are not documented with more scientific studies. Because elements of frequency, beat and rhythm are crucial to many music therapy applications and because music is not indexed by those characteristics, the objective information is not available for studies. When this information is readily available, the professionals will be able to conduct the studies that illustrate which musical elements are most crucial to which therapeutic goals.

For the purposes of music therapy for Asperger's patients, the most significant aspect of Maddage's (2006) work is the "Layer-wise information representation allowed us to describe a music signal quantitatively in a descriptive data structure" (Maddage, 2006, p. 71). Professionals using music for therapy are mostly concerned with the quantitative representations noted in the second and fourth layers of Maddage's music structure. These layers contain timing information (bar, meter, tempo, notes) and music regions (instrumentation). When music is classified, retrieved, and evaluated based on these elements, professionals will be better able to determine which descriptors are most useful for particular patients.

Therapeutic Listening ® uses modulated music and special equipment. It is an effective direct therapy, which, like Interactive Metronome, incorporates beat, but also adds more musical elements to the process. Therapists who use Therapeutic Listening ® have created their own lists of non-modulated music for patients to use as background music. Some have categorized the non-modulated music into groups based on the sensory area they expect to improve from the music, for example, music for balance, music for organization, and music for regulation. One musical feature on which therapists seem to base their use of music is instrumentation, i.e. frequency of tones.

The techniques employed by Maddage (2006) and the Music Genome Project© can be refined for use in indexing therapeutic music. Timing elements of the music can be grouped to allow the user to search by steadiness of beat and tempo. For example, if a therapist needed a slow, syncopated piece, s/he could enter tempo as a search category and retrieve a list of songs with syncopated rhythm and a slow tempo. Table 2, below, shows examples of how the rhythm and tempo elements can be grouped for easier searching.

Maddage (2006) currently classifies music as pure instrumental, pure vocal, instrumental mixed vocal, and silence. This analysis can be more detailed (and most likely is via the Music Genome Project ©) to provide more information about instrumentation. Indexing (and allowing retrieval of) music by instrumentation and/or frequency of instrument would allow music therapists to find music with different frequencies, which can be grounding or irritating to a particular patient. For example, a therapist can enter a particular frequency range into the search engine and thus retrieve a list of songs that predominantly use those frequencies (see Table 2). If the rhythm search can be narrowed first by beat and then by frequency, then the therapist can find songs to meet two of his/her main goals.

The classifications already employed by professionals using music for therapy can be continued to allow for searching by sensory area targeted or by expected/desired result. The areas usually identified by therapists who use background music are music for: vestibular system, body, and posture; self-regulation and timing; oral and respiratory;

language; and expression and emotion. Music for calming and sleep needs to be added to that list. If these categories can be entered as search terms, a therapist can retrieve a list of music that usually helps one of these sensory areas. Table 2 lists the categories along with the other two proposed search features.

Table 2 Groupings/search fields for Indexing/Retrieving Characteristics

Music Characteristic	Field 1	Field 2	FIeld 3	Field 4	Field 5
Predominance of steady beat	Very	audible	mild	No beat	syncopated
Tempo	0-40 bpm	40-80 bpm	80-120 bpm	120-160 bpm	160-200 bpm
Main Instrumentation	Voice	Strings	Brass	Drums	Guitars
Predominant music frequencies	0-250 Hz	250-500 Hz	500-750 Hz	750-1000 Hz	1000-1250 Hz
Affected Sensory Area	Vestibular/body/posture	Self-regulation/Timing	Oral/respiratory	Language	Expression/ Emotion
Helps with relaxation and sleep?	Yes	no			

It is important to note that the use of something like a music thesaurus will be crucial to successfully indexing music for therapy. Developing a controlled vocabulary for this type of work will be extremely difficult, as terms are constantly changing. For example, over the past four years accepted terminology has changed from sensory integration dysfunction to sensory processing disorder and from Asperger's syndrome and ADHD to autism spectrum disorder. In addition, different professionals may refer to the same sensory characteristics with different words. In general, people are reluctant to ask for help when searching for music. Cunningham (2003) notes that his test subjects gave verbal support for search techniques involving entering lyrics or humming part of the tune but reluctance to ask for help while searching. People prefer more independence when looking for information, so they need to be provided with tools, which allow them to be independent. A controlled vocabulary and natural language are two tools that can be implemented for this search process. Examples of controlled vocabulary and accompanying natural language are in Table 3. The natural language area will need to be frequently updated based on input from the professionals using the system.

Table 3 Proposed controlled vocabulary for therapeutic music retrieval

Controlled vocabulary	Natural Language
Emotion	Happy, sad, interactive
Expression	Talking, exchanging
Self-regulation	Hyperactivity, clumsiness, energetic
Vestibular	Balance, hearing, sensory-seeking
Oral	Mouthy, sucking
Language	Talking, words, speech
Rhythm	Beat, syncopation, steady beat, jazzy, march-like
Tempo	Slow, fast, moderate
Frequency	High pitch, low pitch, bass, soprano, alto
Relaxation	Rest, sleep, calming

When considering commercial projects like Pandora.com and amazon.com, it is evident that many people like to read about other peoples experience and views with a product. Cunningham (2003) notes “On balance, it would appear that facilities providing support for users to annotate music documents with ratings and reviews could be useful in a music digital library" (Cunningham, 2003, p.11). This feature will be particularly useful for professionals using music for therapy, especially if there is a mechanism where they can note success or failure of a particular piece of music for a particular purpose with a particular type of patient. Patient diagnosis, targeted sensory area, and effective or ineffective can be quantified to allow users to search by those fields. Additional comments can also be added. An example of how data might be used for review entries:

> Patient diagnosis: Asperger's syndrome=1, sensory processing disorder=2, autism=3
> Targeted sensory area: Tactile=1, vestibular=2,
> Effective or ineffective: effective=1 ineffective=0
> Comments: This patient responded well to this music, as he particularly likes songs about hippopotamuses.

In reviewing the suggestions of wikipedia contributors regarding the Music Genome Project ©, it is evident that a number of users would like the ability to select particular musical attributes, weight attributes when selecting new songs, and organize music based on attribute rather than simply by genre or existing controlled vocabularies. Thus, it is likely that infrastructure to allow for the above recommended indexing and retrieval strategies are already in place. In addition, when considering digital music, listeners appreciate the opportunity to download a short clip of music before making a choice. This is a timesaving feature over downloading an entire song.

It is important to note at this point that retrieving music based on basic characteristics is only one piece of music selection for therapeutic purposes. Patient preference is a significant component. Current classifications by genre, artist, title, etc. need to be continued in addition to classification by musical characteristic. This would allow a therapist to choose music with appropriate beat and frequency characteristics and then refine the search to a particular genre, artist, composer, or character of song (i.e. songs about hippopotamuses). As these techniques are implemented, each database system or library will have to make decisions about which bibliographic data to include and which further classifications schemes to use. Gaeddert (1981), Kaufmann (1983), and Saheb-Ettaba (1969) each make recommendations about music classification. Some will be relevant to a particular database and others will not. For example, a digital music library similar to Indiana University might need to continue to use Dewey numbers to link sound recordings with scores, thus providing a music therapist with a means to use the same music for both active and passive therapy. However, a system more like Pandora.com may prefer to use Kaufmann's (1983) classification of provenance and Saheb-Ettaba's (1969) classifications of music type (orchestral, choral, electronic, etc.) to provide information relevant to their users.

XI. Complications

Satisfying every potential user group with one system is likely an impossible task. As different user groups are identified and their needs articulated, venues for addressing their needs should be developed and revised as necessary. The technology is now available to meet diverse needs. The next step in the process is identifying specific groups and locations to meet their needs, polling the groups to confirm the need, and then developing a system to meet their needs.

For the group of professionals who use music in treating Asperger's patients, several complications may arise. Determining who will select the music to be part of the subset classified as proposed and who will monitor the complexities of identifying the features of the music are two areas where continuous monitoring will be required. Kim

(2002) notes "participants asked to describe specific classical pieces rarely used formal (bibliographic) terms, but instead used words describing other features not currently supported by MIR systems (most frequently, the emotional impact of the song)" (as cited in Cunningham, 2003, p. 5). Kim's findings indicate that further complications will arise in determining what type of syndetic structure will be employed to combine current LC subject headings, developing a controlled vocabulary specific to these purposes, and incorporating natural language. Cunningham (2003) notes that it is difficult to assign a single genre classification to a given work, and this will certainly continue to be an issue in music used for therapy. While a "music therapy" genre might be beneficial, the integrity of the individual genres needs to be maintained as part of the selection process that includes patient preference. Most of these challenges will be successfully navigated when the users themselves give input and feedback about the mechanisms, the music, and the vocabulary. The project will be most successful as a truly collaborative effort.

XII. Ways this project will help the designated user group

Title, composer, genre and instrumentation are already search fields listeners can use to retrieve music. Digital libraries are already linking sound recordings with print music. Companies already exist to recommend music based on listener preference. Researchers are already analyzing the timing aspects of music. If these cataloging and classifying systems are combined and retrieval by music characteristic is allowed, then therapists can find music of a genre pleasing to the patient with the necessary characteristics for therapeutic purposes. In addition, both sound recordings and print music for a particular song can be retrieved, thus enhancing the ability of a music therapist to engage a patient in both active and passive therapy. When characteristics of a certain musical piece have already been analyzed and are readily available, researchers can begin to objectively study the effects of certain characteristics and improve the effectiveness of music therapy for specific purposes. For example, a study might be conducted on the differing response in relaxation between a song with a steady beat of 40 bpm as opposed to one with a steady beat of 140 bpm. Eventually researchers may learn how to determine optimal beat and tempo for individuals, thus expanding the capabilities of music therapy. Users can select genre, instrumentation, and song, based on personal preference and then adjust beat and tempo to meet the patient's needs.

An online digital library utilizing a subset of music for therapeutic purposes is the best place to begin a database and implement and refine techniques for this novel music-cataloging scheme. Music libraries in universities with a music therapy or occupational therapy program would be the best places to classify music and encourage more research studies. Eventually hospital libraries might like to employ these techniques to assist all patients with music for healing. Lastly, public libraries in places like The Triangle Area in North Carolina, where there is a high concentration of people with autism spectrum disorders, would likely find patrons interested in learning more about music therapy and interested in having access to a database that allows specialized music selection.

XIII. Conclusion

Current analyzing and classifying methods can be used to provide additional indexing that facilitates retrieval and use of sound recordings by special populations, specifically professionals treating children with Asperger's syndrome. Music therapy and auditory interventions have been employed for treatment of Asperger's for a number of years. Music librarians have long been concerned about the limitations of current

Library of Congress subject headings for music cataloging. Commercial ventures and digital technologies have offered new solutions for music cataloging and retrieval. When professionals are offered the ability to index and retrieve music based on characteristics useful for therapeutic purposes, more studies can be conducted to determine optimal music choices and therapeutic delivery methods for Asperger's patients.

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