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INTEGRATIVE (COGNITIVE/PHYSICAL/EMOTIONAL) EDUCATION IN THE 21ST CENTURY

A theoretic summary by Jim Cassily © 1995.

AUTHOR'S NOTE: While designing and field testing the world's first physically and aurally interactive metronome I quickly realized I was witnessing a phenomenon. A brief history follows this summary. It chronicles the events, training sessions and learning process that gave me the sincere belief that this high tech, yet simple to use, teaching tool is only the first of many that will soon help our schools provide all children with an equal opportunity to reach their full potential in 21st century.

THE DECADE OF THE BRAIN

Centuries ago Descartes' said; "I think, therefore I am", suggesting that the brain is the 'center' and the body just serves it.

In his acclaimed book '*Frames of Mind - The Theory of Multiple Intelligences*', Howard Gardner challenged the prevailing notion that an individual's potential to succeed in our society can be assessed by a single paper-and-pencil test. He argued that we are all born with potential to develop a multiplicity of intelligences, most of which have been overlooked in our testing society, and all of which can be drawn upon to make us competent individuals. His theory, first published in 1983, helped ignite extensive interdisciplinary scientific brain research that is responsible for the 1990's being called "The Decade Of The Brain". The results of this ongoing research will dramatically alter how humans will be educated, employed and enjoy life in the 21st century.

In April 1995, many of the world's leading neuroscientists, doctors, educators, physical trainers, athletes and artists participated in an event called; Sports, Dance, Movement and the Brain: A Symposium. It was the third in a series that began in 1988 to stimulate research concerning the relationship between movement and brain function, particularly at the cognitive level. Jacques d'Amboise, Founder and Director of the National Dance Institute, aptly summarized to the 1995 Symposium participants what was learned as a result of the years of scientific investigation on the subject: "Kids who learn to control their body can control their lives."

THE DECLINE OF EDUCATION: A BLIP IN THE LEARNING CURVE

History has aptly demonstrated that the ability of humans to create often precedes our ability to fully understand the long term ramifications of what we create. Computer technology, developed by our society's most creative minds, is yet another example. Because computer automation can dramatically increase how much each human can produce in the work place, many people hoped it would provide us with more free time to raise our children and enjoy life. Instead, it was used to put millions of people out of work. Computer technology thereby lowered our overall standard of living and forced both parents of millions of small children to go to work just to survive.

Computer technology also led to humans becoming more the observers of the world around us, rather than participants in it. Televisions became 'electronic nannies' which hypnotized and addicted the children of western culture, and helped turn baby-boomers into a generation of 'over-weight couch potatoes'. The participatory toys that used to help children learn fundamental body control and coordination were replaced by mass produced plastic replicas of their favorite TV cartoon characters. Yo-yos, rubber balls connected to paddles with elastic bands, stick ball, neighborhood sandlot sports and other healthful physical toys and games were replaced by video games that do little to improve a child's overall physical self-control, coordination or learning abilities.

With both parents having to work, more responsibility was thrust upon financially strapped school systems; and computers then became the high tech educational panacea. Money saved by eliminating "non-essential" (fun) type programs such as music, dance, arts and physical education was diverted toward buying more and more computers in an effort to increase the cognitive test scores that schools were being "judged" upon.

The results of making broad scale educational decisions based upon "Descartes' Error" are now painfully obvious. It isn't any surprise to school therapists, special ed teachers and social workers that six percent of all school children now have a marked impairment in their motor coordination, coded in the current American Psychiatric Association *Diagnostic and Statistical Manual* (DSM-IV) as 315.4 - Developmental Coordination Disorder. This represents only the tip of the iceberg regarding our children's control over their own bodies. Much more telling are the facts that, today, less than half of all students in the U.S. have a positive emotional desire to learn in school, the school drop out rate is soaring, and our streets are no longer safe for our children to play in.

Like with so many other of man's creations, the time lag between inventing computer technology and understanding how to use it to benefit our whole society has been costly, especially to our children. However, we are finally learning how to use computers to augment human abilities, rather than focussing on replacing people.

In his book, *Flow, The Psychology of Optimal Experience*, Mihaly Csikszentmihalyi recognized that: "Although in its present state the human mind cannot do what some people would wish it to do, the mind has enormous untapped potential that we desperately need to learn how to use." However, it was J.S. Mill who prophesied just how to do it: "No great improvements in the lot of mankind are possible, until a great change takes place in the fundamental constitution of their modes of thought." What once seemed impossible, our creativity is now helping us to achieve. By helping us unlock the mysteries within the human brain that created it, computers will soon help mankind take a positive quantum leap forward.

A NEW UNDERSTANDING OF THE HUMAN LEARNING PROCESS

Only recently have high speed computers, electromagnetic scanning equipment and color monitors allowed neuroscientists to actually 'see' what activities are taking place in the brain and body during the human learning process. Being able to view, in real-time, the electromagnetic activity that takes place while a 'skilled' human subject is learning a new complex integrative task (such as learning to smoothly copy someone else's signature) has given us a much better understanding of the human learning process.

A normal brain starts the learning process by subconsciously (logically) breaking down each new complex task into very simple subcomponents that are easier to learn. The resulting subtasks are learned in a sequential order. A number of areas of the brain become very interactive while each subtask is being learned. Multi-sensory feedback signals are also sent back and forth between the brain and the parts of the body and senses involved. As each subtask becomes correctly learned through repetition, fewer and fewer two way feedback signals are sent between the brain and body parts, and fewer parts of the brain are activated in order to accomplish that particular subtask. Eventually it becomes fully automated; the correct synaptic connections between brain cells are thereby created for that subtask.

Each time that automated subtask is needed in the future, its correct brain synapses will subconsciously trigger it about 300 milliseconds in advance of when the actual event is scheduled to take place. That short stored delay of the signal gives the conscious mind 1/3 of a second to veto an automated event. [e.g., this safety delay mechanism allows you to pull your hand back from a hot pan at the last instant before you subconsciously grab

its hot handle.) If there is no conscious veto, the precise chemical/electrical signals will be dispatched and the subtask will occur.

A properly trained normal human has the amazing ability to subconsciously break down and sequentialize a complex task, and then automatically sort, select and smoothly string together incredibly large quantities of stored correct subtasks in order to carry it out. The stronger the foundation of correct automated subtask synapses, the better the selection to choose from; and the easier each new complex task is to learn. This unique sequencing and automating ability dramatically increases the human brain's overall capabilities and allows us to learn extremely complex mental and physical tasks that would otherwise be impossible. It also frees up important parts of the brain that can then be utilized to creatively alter our own future, as well as the environment we live in.

On the other side of the coin, an improperly trained normal human, with a weak foundation of correct automated subtask synapses, has fewer to choose from. This results in their having more difficulty correctly learning new complex tasks, and also having much less of their brain and emotional energy available for creative activity.

INFANCY: BUILDING THE FOUNDATION FOR SEQUENTIAL LEARNING

Scientists now believe that, regardless of their genetic strengths or weaknesses, most humans are born with the potential to develop a multiplicity of 'intelligences' which can enable them to become productive members of society. However, whether or not a person reaches their 'productive' potential depends on a number of critical experiences, situations and events that occur prior to their gaining deliberate mental self-control.

Significant others must help an infant develop a healthy emotional desire to learn, and adults must give children the opportunity to do so. Even with the hereditary ability, proper desire and opportunity, many children are still unable to ever reach their full potential. Like everything else, humans are also subject to the universal 'laws of chaos'. Fundamental 'bad habits' that are formed as a result of learning experimentation during a child's first year of learning often result in lifelong functional inabilities if they are not properly detected and corrected.

Humans are born with a number of genetic proclivities, such as swimming and walking. However, at birth most babies basically can only suckle and cry, and almost every other physical and cognitive skill they obtain must be learned. Their initial acquired skills usually involve the control of singular body part movements. The most basic of those movements, such as moving their tongue in and out or moving a hand up and down, are learned by mimicking the important people in their lives.

Each new simple movement task is repeated over and over until a baby learns to do it automatically. Synapses and connections are formed in the baby's brain to automatically trigger each new task learned in this manner, and the baby's attention can thereby be concentrated on learning other tasks. Thus a child begins the process of building its foundation of stored gross and fine motor movement synapses. These initial movement learning experiences also form the footing for their future cognitive abilities.

Learning to crawl is a child's first complex learning task that involves moving all four of their limbs in a precise sequential order. Because there are seldom visual crawling role models to mimic, each child must 'internally' figure out how to automate a number of simple body movements and string them together into a crawling sequence. During this critical learning process a child's brain builds its initial foundation for subconsciously breaking down and sequentializing complex tasks.

The 'solitary' process of learning to sequence all four limbs in order to crawl typically requires a considerable amount of random experimentation. Because they have more fundamental control over their arms than they do their legs, many babies initially learn to crawl backwards, then have to relearn the motion sequences in order to move forward (face first). Some succeed after only a few experimental attempts. A few seem to get frustrated by their inability to coordinate their arms and legs and quit trying; they bypass the crawling stage completely and instead concentrate on learning to walk on two legs.

The primary external feedback a child receives during its first multi-limb sequence learning process comes in the form of the encouragement, or lack of such, from its important others. Regardless of the efforts and intentions of others, each child will make fundamental synapse connecting errors within its own young brain due to random experimentation. Some of those movement and sequencing errors are quickly corrected during the process itself, while others become reinforced through repetition and may last a lifetime.

The route each child takes and the encouragement they receive varies dramatically; and each child develops its own unique body control and sequencialization 'style'. Each child's brain thereby forms the primary brain synapses and connections which control how their brain breaks down complex movement and cognitive tasks, and how it automates and sequences the resulting subtasks. Successes and failures during this critical learning experience, and the encouragement received from important others, help form each child's emotional foundation, self-image, and its fundamental desire to learn. Thus each child adds its own unique acquired learning strengths and weaknesses to the biologic ones it inherits. Mind, body and emotions integrate into a partnership and the child emerges from this critical learning period as a uniquely integrated individual being. It will spend the rest of its life building upon and refining that foundation.

Our recently expanded scientific understanding of the human brain has helped us recognize that fundamental synaptic flaws that become deeply imbedded during the child's initial complex task learning experiences can wreak havoc on their lives (and the lives of others) without them ever realizing why. We now know that many of our most detrimental motor, cognitive and emotional problems are just simply 'bad habits' we developed as babies; and they are not written in stone. To the contrary, the more fundamental the acquired synaptic flaws are, the easier and faster they often are to correct. Making such fundamental corrections can quickly bring about dramatic changes in a person's learning abilities, self-image and overall enjoyment of life.

Humans are extremely flexible and adaptive beings that have the ability to compensate for many of their inherited biologic and acquired weaknesses. A physically handicapped child may not be able excel at professional sports or as a micro-surgeon. However, if that child develops the emotional desire and is given the correct learning opportunity, it still may become a great neuroscientist, painter, teacher, or almost anything that its genetic body and brain structures are capable of accomplishing.

HIGH TECH TEACHING METHODS OF THE 21ST CENTURY.

As we approach the beginning of a new millennia, computer technology is finally being recognized for what it is, an extension to our brain's incredible capabilities. On a wide scale basis computers are now being used to do many of our most repetitive and time consuming tasks. The speed and precision at which they perform these tasks is helping the human brain to make quantum leaps in understanding and creativity. After a long period of industrial and high tech transitional gloom, many are beginning to see a much brighter future for all of humanity, and therefore also for our troubled home planet.

Accepting and implementing the use of high tech teaching methods into fundamental education has been very difficult, slow and expensive. It is now apparent that, in the short term, our rush to use computers primarily to increase cognitive test scores was not only costly in dollars, it was costly to our children. However, our knowledge of how to program and use computers correctly has increased dramatically, and they now cost a fraction of what they did only a few years ago. We have finally reached a point in the learning curve where high tech teaching methods have become an integral and beneficial part of quality public education. As a direct result of high tech aided human creativity, our children will soon be provided with a more equal opportunity to become healthy, happy and highly productive citizens of the 21st century.

HIGH TECH PHYSICAL PROFICIENCY SCREENING IN OUR SCHOOLS

Today more than ever, the primary responsibility of preparing children to be productive citizens shifts to the pubic education sector upon their entering school. The biggest challenge facing public education stems from the fact that when children first enter the public education system they already possess a wide variety of physical, mental and emotional strengths and weaknesses, both genetic and acquired. However, the recent implementation of high tech methods into our schools will soon dramatically expand our education professionals' diagnostic abilities, and allow them to create and institute much more personalized and effective teaching programs.

At the 1995 Chicago symposium on movement and the brain, Jacques d'Amboise and the world's leading neuroscientists agreed that teaching our children fundamental coordination and control over their own bodies is absolutely critical to their ability to "control their lives." Unlike correcting human genetic flaws, we already possess the knowledge and technology necessary to begin that process. Implementing fundamental Coordination And Motor Skill (CAMS) training in our schools is a scientifically logical way to help children correct their fundamental synaptic body control 'bad habits'; and thereby improve their overall desire and ability to learn in school.

Optimally, our schools should begin the process by analyzing each child's existing coordination and motor skill proficiency during pre-screening before they enter kindergarten. The earlier we can diagnose problems and initiate corrective steps the better, however, such universal screening procedures will take time to implement. Meanwhile, the children with the most apparent coordination and sequencing (marked writing difficulty) problems should be tested, and those with the greatest needs should have prioritized access to corrective CAMS training.

Students who have already been diagnosed as having Developmental Coordination Disorder obviously should be given first training priority. To be diagnosed as having DCD-315.4, children must perform "substantially below that expected given the person's chronological age and measured intelligence." The six percent estimated to have this functional disorder represent only the extreme aspect of the spectrum for which insurance companies will pay the cost of their treatment. It is obvious that the vast majority of all 'average' school children today possess significantly less than their optimal coordination and body control proficiency, considering the amount of time they spend doing non-physical activities such as watching television and playing video games.

Less than one percent of all humans are currently believed to be performing at their genetic peak potential level of coordination and motor skill. The few people that are capable of excelling at professional sports, popular music and other lucrative high motor skill related careers are indicative of this estimate. How mass institutionalized CAMS training will impact these highly competitive occupations is of little concern to our educational systems. All children deserve the opportunity to reach their full cognitive,

physical and emotional potential; and, by schools providing them with a more equal opportunity to do so, there is no doubt that society as a whole will strongly benefit.

CAMS EDUCATION CLASS 001: FUNDAMENTAL COORDINATION AND SELF-CONTROL

According to our current understanding of how the human brain learns, our schools can dramatically simplify and speed up the process of providing all children with an adequate foundation of coordination and body control skills by incorporating high tech CAMS learning tools and methods which are:

1) systematically 'fun' (to help create the emotional desire to learn),
2) mentally, physically and emotionally interactive (to help synchronize and integrate),
3) able to provide real-time multi-sensory feedback (to assure direction and indicate progress),
4) repetitious (to ensure the creation of correct automated synapses), and
5) sequentially challenging, yet realistically achievable (to help children improve their sequencing skills, and to keep the learning process 'fun' for them).

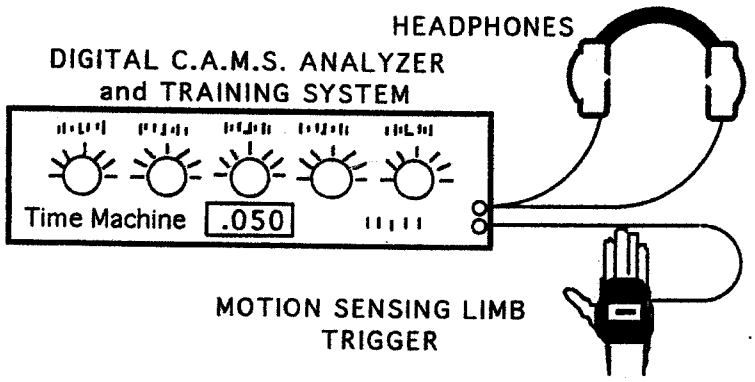
THE 'TIME MACHINE': A FRONT RUNNER OF 21ST CENTURY PHYSICAL EDUCATION

Breakthroughs in computer chip and digital audio technology led to the development of the first physically and aurally interactive metronome by Kinesthetic Training Systems of Grand Rapids, Michigan. Although its development was coincidental to recent neuroscientific human learning research, the Autonomic Time Training System (ATTS) is considered by many to be the first of a new generation of integrative high tech teaching tools that will enhance public education in the 21st century.

The ATTS's original purpose was to help musicians and dancers master the rhythmic timing critical to their artistic craft. However, it quickly became obvious to its inventors, experts, therapists, educators, sports trainers and users alike, that this simple to use, yet high tech, learning tool has 'profound' human training and diagnostic capabilities that go far beyond its original intent. For the first time, it brings the now well known benefits of high tech computer interactivity to the physical, motor planning and sensory integrative related aspects of providing quality education.

The Time Machine (as it is called by children) allows human's to quickly correct their acquired fundamental movement synaptic flaws and expand their foundation of stored correct automated motion subtask synapses. More simply stated: it helps people to gain precise gross and fine motor control over their own bodies. A few hours of CAMS training on the ATTS can bring about dramatic changes in a person's learning abilities, self-image and overall enjoyment of life.

The Time Machine is simple, inexpensive and a lot of fun to use. As a coordination and motor skill digital analyzer it is numerically accurate (to 1 millisecond) and repeatedly precise. As a CAMS training system it is systematic and self-administrable; and it is incredibly fast and effective. School systems that are already acclimated to high tech teaching methods will find it very easy (and inexpensive) to implement teaching programs which utilize this new tool.



Patents Pending

ATTS THEORY OF OPERATION

The ATTS uses the 'tapping' of each limb, individually and together, as fundamental body control and coordination catalysts. When the user physically taps or moves a limb in time with the consistent metronome type reference beat sound heard in the headphones, the trigger attached to that limb sends a signal to the ATTS computer processor which:

1) analyzes exactly when in time the tap occurred in relation to the reference beat,
2) transposes this timing information into an easily recognizable 'pitch' sound that precisely changes according to its exact placement in time, the earlier the tap the lower the pitch, the later the tap the higher the pitch, and a special reward tone when it is within the currently set 'right on' millisecond range of either side of the beat,
3) moves that sound to a right to left 'location' that also represents the tap's exact spatial location in time; left for before, right for after and center for 'right on',
4) instantaneously amplifies the sound and its location and feeds it back to the user in the headphones, and
5) in real-time, this exact aural representation of the user's timing is perceived simultaneously by the user's conscious mind and autonomic hearing mechanism.

THE ATTS 'KEY' TO INTEGRATIVE LEARNING: IT MAKES IT FUN

The Time Machine's internal program automatically adjusts to each trainee's abilities and optimum speed of CAMS learning, and it promotes success rather than failure. It systematically helps each trainee increase their motion accuracy and the number of correct movement repetitions they can do in a row. Its real-time positive aural feedback regarding improvements continually encourages the user to do better. Above all else, its most important single feature is simply that it is a lot of fun to use.

SCIENTIFICALLY EXPLAINING THE NEUROPSYCHOLOGIC ATTS TRAINING 'EFFECT'

Our understanding of mental phenomena, even more so than the physical universe, is still in the emerging stage. Roger Penrose received the 1988 Wolf Prize for physics, for his joint contribution to our understanding of the universe. In his most recent book, *Shadows of the Mind, A Search For The Missing Science of Consciousness*, he points out that we may never fully understand how the human organism works: "Biological systems indeed tend to have a subtlety of organization that far outstrips even the most sophisticated of our (often very sophisticated) physical creations."

Many new physical 'effects' have been discovered way before their theoretical explanation was developed. The long term potential benefits of some have been so 'obvious' that society is willing to invest whatever is necessary to make it technically possible to put them to practical use. For example, the 'effect' of superconductivity was originally observed by H. K. Onnes in 1911, nearly 50 years before its quantum-theoretic explanation was found. The 'effect' of high temperature superconductivity was discovered in 1986 (cf. Sheng *et al.* 1988), but it may be 2011 before it's potential benefits will be fully realized by society. Even after 100 years of searching, it is likely that we still won't be able to theoretically explain exactly what's causing this 'effect'.

The exact neuropsychological process causing the dramatic ATTS training results, or the rapidity of such results, may take many years to scientifically explain, if ever we can. However, unlike superconductivity, the resulting ATTS training 'effect' was observed while utilizing a functionally complete operating system that is mass producible with today's technology. Also, 'some' of the ATTS positive training results were expected when that system was originally designed. It's surprisingly broad scale potential became obvious due to the magnitude of its 'effect'; and the consistent rapidity of achieving it.

POTENTIAL BENEFITS vs POTENTIAL RISKS

The ATTS 'effect' discovery has come at a time when scientists (and educators) are beginning to understand the negative impact that too much television and too little physical activity has had on humans, especially children. We are also painfully aware of the long term impact that our educational emphasis on cognitive test scores has had on our children's desire and ability to learn. The immediate need for the CAMS training the ATTS can provide is readily apparent. However, implementing any new technology into our schools must be done with great caution; potential benefits must be carefully weighed against any potential negative side effects.

Although the ATTS is new technology, we already know that there are little or no potential physical or psychological side risks attached to its separate functional components, e.g.: a) metronomes have been around for centuries, b) cognitive and physical interactivity [via computers and video games] is well documented, and c) consciously listening to changing [musical] sounds through headphones is now a standard part of everyday human activity. The ATTS is just the first to put them all together into a innovative combined teaching package.

Unlike the introduction of teaching computers, implementing ATTS CAMS training into our schools would be inexpensive and could be easily accomplished without interfering with, or eliminating, other programs. Based upon our current understanding of the ATTS's fundamental component processes, and its obvious ability to increase a student's desire and abilitiy to learn, its potential broad scale benefits far outweigh any potential long or short term negative side effects that could possibly be associated with it. Therefore, ATTS coordination and motor skill screening and training is logically a safe and very cost effective method of augmenting existing school curriculums.

WHY THE ATTS IS DIFFERENT THAN PREVIOUS COORDINATION TEACHING DEVICES

Properly pieced together, the interdisciplinary brain research ignited by Gardner's *Theory of "Multiple Intelligences"* creates a much more complete scientific picture of the human learning process. Even though it still doesn't explain exactly 'how' the ATTS neuropsychologically works, this new knowledge helps us understand 'why' it differs so dramatically from the relatively ineffective coordination training devices of the past; and why any improvements previously achieved with them were typically temporary.

The ATTS 'effect' has created 20-20 scientific hindsight regarding previous coordination training devices. Those devices failed because they followed traditional scientific dogma based upon "seeing is believing"; their related teaching methods primarily relied upon the users' sense of vision, and not their sense of hearing. The ATTS's real-time physical interactivity is seen as innovative. However, most experts now agree that its unique use of changing sounds as real-time conscious feedback, and how those sounds bring the autonomic human hearing mechanism into the motion learning process, are the keys to its effectiveness.

Scientists still have different theories as to 'why' using the human hearing mechanism in motor control training is so much more effective than using vision for the same purpose. One theory says that human hearing is, by nature, more independent of conscious manipulation than the other senses. Most creatures have a specialized 'hunting' or 'safety' sense (e.g., the predatory sense of vision in eagles and the defensive warning sense of smell in deer), and hearing may be the human 'safety' sense. Thus, the ATTS sounds are more correctly acted upon because our hearing is genetically more independent of biased 'habits'.

The other theory says we just haven't created 'as many' biased hearing habits that deal with how we learn motions. It goes on to say that during early childhood the human brain quickly forms habits and preconceptions regarding the visual and tactile feedback usually associated with body movement. Since physical motions in space and time rarely make sounds that can provide precise directional feedback, sound has traditionally played a very minor role in our motor skill learning process. For this reason humans form 'fewer' habits regarding how sound is creatively perceived and/or utilized in our motion learning process.

Regardless of either theory, the ATTS's interactive aural feedback literally allows trainees to precisely hear exactly where in space and time their motions are occurring. It also allows them to correctly respond to their fundamental gross and fine motor control errors in real-time. This new ability to hear and respond in real-time dramatically simplifies and speeds up the process of correcting deeply imbedded motor control and subtask sequencing 'bad habits' developed during early childhood.

Positive self-realizations and understandings seem to accompany a trainees success at mastering precise control over their limbs and movements. They are apparently responsible for the marked improvements in overall mental self-control and self-image noted by many of the ATTS trainees subsequent to completing their training.

BRIEF HISTORY OF THE WORLD'S FIRST "TIME MACHINE"

As partners in EXR Corporation in the 1970's, Jim Lagerkvist and I pioneered psychoacoustic audio processing in the professional recording and broadcast fields worldwide. Our unusual combined experience in audio synthesis, psychoacoustics, audiology, computer programing, recording engineering and musical production enabled us to develop and successfully market unique audio products and methods which aurally enhance how audio information is perceived by the human hearing mechanism.

Our extensive recording studio experience indicated there was a real need for a method of analyzing and teaching natural timing to musicians. In the mid-1980's digital audio and computer chip technology finally became affordable, and Jim and I began developing the world's first real-time interactive metronome. Because of our knowledge of psycho-acoustics, sound was "our" logical choice for the ATTS feedback medium, regardless of its scientifically undocumented history in human skill training. We knew we were again breaking tradition, and that, like many of our previous audio innovations, it would be difficult to pioneer this new concept.

My college major was child psychology, and Jim and I often discussed the importance of teaching children music and performing arts in school. We hoped our new 'teaching tool' would also be used by music, gym and special education teachers in schools. However, we originally did not intend to introduce the ATTS into the educational or therapy arenas right out of the hole. It was coincidental that, due to their initial skepticism (and perhaps inflated 'egos'), none of the original ATTS trainees were pop musicians. The first sincere interest in the ATTS's human training potential came from concerned professionals who worked daily with handicapped children.

Being a co-inventor and the initiator of its field trials, I was the first to witness the dramatic impact that this interactive metronome has on children with severe motor impairments. I immediately realized I was witnessing a phenomenon. However, the Time Machine's unprecedented real-time aural feedback, interactive training approach, and its rapid digital analytic capabilities were also viewed with strong skepticism by the scientific community dealing with human motor skills. Since I couldn't technically explain how or why it actually worked to scientists (and they couldn't either), I initiated my own extensive learning process. This paper is the result of that long process.

The ATTS training results ('effects') were so obviously dramatic that it was only a matter of time until hearing, seeing and feeling became 'believing'. In consultation with motor learning related professional organizations, doctors, therapists, university researchers and other experts, I thereafter began the process of creating statistical procedures and standardizing the use of this new human development tool.

Before initiating the ATTS beta training sessions, over three hundred individuals, with differing backgrounds and motor skill capabilities, were analyzed to establish average ATTS numerical CAMS norms typical of (non-ATTS trained) humans. The test battery analyzed each subject's motor control over each of their limbs and took about ten minutes to complete. Some of the initial results were as follows:

- The average ATTS CAMS test battery accuracy of the initial 330 untrained subjects was approximately 85 milliseconds.
- The subjects' left and right limbs were typically 10 ms. or more out of sync with each other, and their feet were much less accurate that their hands.
- Successful motor skill related professionals, such as athletes and music teachers, typically tested at 32 ms. or better (a baseball pitcher and tennis player tied for lowest at 15 ms.).
- Children and adults with severe motor skill impairments (including DCD) typically tested at 175 ms. or worse (several tested well above 250 ms.).
- 99.7% of all subjects over-anticipated the beat and consistently stayed ahead of it.
- Typically, the worse a subject's motor development impairment, the farther they were out in front of the beat.
- Prior to testing, most subjects accurately predicted what their own coordination abilities would be on a scale of: good, above average, average, below average or poor.
- A majority of subjects said their coordination was 'below average' or worse.
- A surprisingly high number of subjects said they avoided playing sports, dancing and most other skilled physical activities altogether, because they were embarrassed about their lack of coordination.

ATTS BETA TRAINING PROGRAM

A representative sampling of children and adults completed the CAMS training program developed for the ATTS. The trainees included normal individuals, as well as those with a diversity of genetic, developmental and motor planning impairments. In addition, a number of individuals with highly developed motor specialty skills were also trained.