

Mirror Neurons and “Mirroring”:

The Missing Scientific Link

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Introduction

What is dance? To some, it is an art form composed of steps and rhythms accompanied by music. To others, dance transcends the technique and vocabulary associated with it and becomes an expressive outlet—one that is used for creativity and the communication of feelings and experiences. Still others identify dance as a medium to escape from the pains and stresses of daily life and to connect to others. The relationships built when connecting with one's own self and with others are particularly interesting to explore because these relationships are complex and multifaceted; to understand them, however, we need not merely a dance and movement background, but also a background in science.

Dance/movement therapy (DMT) can help to explain how dance is a relationship-forming or a connection-building outlet. Since its inception in the 1940s, DMT has been widely used for therapeutic purposes in various settings, such as schools, hospitals, and nursing homes. Some of these therapeutic implications include emotional and cognitive problems, stress, depression, and autism. The success of DMT is that it uses the body as the medium for healing, which sets it apart from other types of therapies such as psychotherapy and talk therapy.

What is particularly unique to DMT is that *through* the process of observing the client's movements, delving into his or her internal thoughts, feelings, and emotions, the dance therapist is able to build a strong relationship with the client. This relationship is thought to accelerate and stabilize the client's healing, and several studies empirically demonstrate the importance of building a relationship between the therapist and the client so that the client experiences healing

effects. However, empirical evidence does not fully convey what physical and psychological processes occur when the therapist and client interact. We need scientific reasoning to complete the story. In turn, this fuller understanding will allow DMT to cross the barrier of skepticism about its therapeutic benefits in the medical field and, thereby, find its way into clinical settings.

Despite the absence of scientific underpinning, recently, DMT has become a burgeoning topic in the field of neuroscience. Modern-day neuroscience recognizes that DMT has the ability to engage the human brain through body interventions that affect an individual's physical and psychological functioning. Specifically, neuroscientists are interested in the concept of empathy, or "mirroring," that is fundamental to DMT. This is because "mirroring" is thought to parallel the functioning of specialized neurons in our brain, called "mirror neurons." Although currently tangential, this observation, if confirmed, can help to identify the specific parts of the brain involved when engaging in DMT, and how empathy, in light of the mirror neuron system, facilitates the healing process in DMT.

Also in light of DMT, mirror neurons have been found to have additional psychotherapeutic implications, many of which are clinical and involve the impairment of the mirror neuron system. By understanding how the mirror neuron system operates, and how DMT facilitates its activation through empathic mirroring, treating diseases such as autism and Parkinson's disease may be possible.

On a more practical level, however, I will begin by thinking about how the scientific literature suggests that mirror neurons account for the success of DMT. I want to explore the science "behind" how and why DMT is indeed therapeutic. Questions such as "what parts of the brain are activated when engaging in DMT" and "why is it that DMT has shown healing

potential for several neurological/psychological disorders—what defects are common in these disorders that DMT can be generically useful for?” are intriguing to me, as these questions are contextualized in both dance and in medicine. These questions contribute to the larger question of how DMT can be given some type of scientific underpinning. How can DMT be supported scientifically, as a therapy that seems to work empirically?

My research will trace the empirical success of DMT, focusing on techniques related to “mirroring” used clinically in treating diseases and disabilities, and how these applications have newfound interest in the field of neuroscience. Using the mirror neuron system rooted in our brains, I will take a “behind the scenes” scientific approach to explain how and why DMT works, so that the scientific and medical communities can accept it as a beneficial therapy. This acceptance will help draw people not only from dance and movement backgrounds, but also from more scientific backgrounds such as psychology, biology, and neuroscience.

As a dance major passionate about medicine and holistic therapies, I knew I wanted to integrate my science and dance backgrounds when writing my thesis. I was confident about exploring DMT as my umbrella topic, but I was unsure how I would approach DMT from a scientific perspective—until I saw a NOVA video called *Mirror Neurons*.

The video begins with a question, “Why do people get so deeply involved, with such anguish, such pain, such nail biting tension, over football?” (Cort, 2005). It is common knowledge that emotionally invested sports fans react to each play in the game as if they are playing the sport themselves. But such emotional investment is not limited to sports. We all have been, at some point in our lives, emotionally moved playing video games or watching movies or a dance recital. Even when watching a close family member or a friend cry, we too, are able to

feel their sorrow. Why is this? How is it that we can feel what others are feeling simply by watching them?

The answer to these questions seems to lie in a special circuitry in our brains that, through brain imaging, suggests that humans are continuously “acting out” and impersonating what we see. The circuitry, in particular, alludes to specialized neurons, called “mirror neurons,” on either side of our brains that “help us whenever we look at each other,” or in other words, help us empathize with other people (Cort, 2005).

The video’s mention of the word *empathy* immediately caught my attention, because the success of the DMT technique is grounded in the therapist’s ability to express empathy for his or her client. Although the reasoning behind this success is not yet confirmed at a cellular level, the concept of empathy, in the context of mirror neurons, may be the missing link between the success of DMT and scientific evidence for its success.

The *Mirror Neurons* video depicts a different way of looking at the DMT material already available. Holding this up to scientific examination, the video suggests that there finally seems to be scientific support to explain DMT concepts and techniques. By investigating the missing link between DMT and its healing manifestations, I hope to be able to show how and why DMT is indeed therapeutic, and therefore, why it should be given scientific and medical credibility in equal respect to therapies such as psychotherapy.

Background: Neuroscience

The nervous system is a communications network that carries messages to and from the brain to different parts of the body. The nervous system includes the brain, spinal cord, and nerves, and can be divided into the Central Nervous System (CNS), which includes the brain and spinal cord, and the Peripheral Nervous System (PNS), which connects the CNS to other parts of the body. The cells that make up the various parts of the nervous system are called neurons. Neurons are the functional unit of the nervous system and are of three types:

- (1) Sensory neurons, which carry messages from the sensory receptors to the CNS;
- (2) Motor neurons, which carry messages from the CNS to muscles or glands;
- (3) Interneurons, which carry messages from neuron to neuron, and are only found in the CNS.

A neuron consists of three key parts:

- (1) Cell body, which contains the nucleus and other cell parts;
- (2) Axons, which carry signals away from the cell body;
- (3) Dendrites, which carry signals toward the cell body.

Neurons are “excitable” cells, meaning that their membranes can reverse normal (resting) electrical polarities, or in scientific terms, generate an action potential, when transmitting a signal or message. When the message is transmitted along the length of the neuron, an action called propagation, we say that the neuron “fires” or is activated (Russell, 2007).

The ability to determine which regions of the brain are activated when engaging in specific feelings, emotions, and actions can reveal key facts about how these operate. Several regions of the brain are involved during movement and emoting, and the following lists those regions with a brief summary of their functions (Berrol, 2006):

- (1) Pre-motor and motor cortex, which coordinate motor actions and speech articulation;
- (2) Insula, which is involved in autonomic (non-voluntary) functions;
- (3) Limbic System, which controls emotions and behavior;
- (4) Brain Stem, which filters incoming signals either to potentiate (accelerate) the signal for further neural networking or to inhibit the signal.

The pre-frontal motor areas of the cerebral cortex, which converts the incoming signal into motor instructions, and the insula are also important because they are involved in the activity of “mirror neurons.” Broadly, “mirror neurons” are neurons that are perpetually engaged in a process of simulation (Berrol, 2006). More specifically, they are neurons in the pre-frontal motor areas that fire when performing an action or expressing emotions *and* when observing someone else perform that same action or express that same emotion. To fire, the mirror neurons require social and physical recognition and cognitive understanding. As a result, attributes such as empathy are linked to the mirror neuron system: the ability to show empathy is an abstract concept that cannot be proven, but the activation of the mirror neurons is a way to confirm that an empathic communication took place. Empathy is of particular interest, since it is one of the basic constituents of dance/movement therapy.

Background: Dance/movement Therapy

The American Dance Therapy Association (ADTA) defines DMT as “the psychotherapeutic use of movement as a process which furthers the emotional, cognitive, physical, and social integration of the individual” (ADTA, 2009).¹ This mode of mind/body intervention therapy uses the body as the vehicle for both assessment and healing, and is grounded in the belief that the mind and body are reciprocally integrated with each other. The mind/body connection forms the basis of DMT as formalized by Marian Chace² in 1946, and it continues to characterize the essence of DMT today as well.

Currently, DMT is practiced in a variety of settings, including medical, educational, and private settings, as well as in day care centers and nursing homes. Dance/movement therapists work with patients of all ages, either on an individual or group basis. Over the past sixty years, DMT has grown in popularity and is utilized with greater seriousness for mental and physical conditions. Initially, DMT was used to heal patients who suffered from developmental, social, physical, and psychological disorders. Today, DMT is used for more clinical applications to treat diseases such as autism, Parkinson’s disease, Alzheimer’s disease, dementia, anorexia, bulimia, anxiety, and depression.

Because individual needs differ from person to person, there is no “typical” DMT session. What is consistent from session to session, however, is the use of modern dance as the fundamental dance form to encourage movement that is spontaneous and creative

(Panagiotopoulou, 2011). Also common to DMT sessions are the concepts of empathy and

¹ The ADTA was founded in 1966 as an organization to support the emerging profession of dance/movement therapy and is the *only US organization* dedicated to this profession. For more information about ADTA, visit <http://www.adta.org/>.

² Marian Chace (1896-1970) was one of the founders of dance/movement therapy. She also founded the American Dance Therapy Association (ADTA) in 1966 (ADTA, 2009).

mirroring, the use of music, and the tripartite session structure of: warm-up, theme development, and closure.³ Although the primary mode of interaction between the therapist and the patient(s) for both prognosis and healing is nonverbal, accomplished through movement, touch, rhythm, and spatial interaction (Goodill, 2005), the therapist does verbally intervene during a session to enhance the patient(s)' movement. Because DMT utilizes both nonverbal and verbal cues by the patient and client, this form of therapy differs from the traditional verbal psychotherapy. Moreover, DMT is accessible to a broader range of individuals, especially those whose fundamental problem may be the inability to verbally communicate.

The human brain is a highly complex organ that processes all of our interactions with the world, including those with other people. These dynamic interactions are continuously evolving and assuming new forms because of our response to others, based on *our* sense of what is happening in *their* (the others') minds (Homann, 2010). Many parts of the brain are involved in experiencing our own and others' movement and emotions, and also when connecting with other people. As a starting point to empathy research, neuroscientists have refined their search to the limbic system, which includes structures in the pre-cortex and sub-cortex regions of the brain. Recently, they have focused on the pre-motor cortex, where a set of pre-motor,⁴ or mirror neurons resides (Berrol, 2006). These neurons are thought to play a role in the connection-

³ The three phases in a group dance/movement therapy session include warm-up, theme development, and closure. During warm-up, the patients form a circle. The therapist develops the patients' movements to integrate them emotionally and physically in an environment that is safe, so that the patients can release their stresses. At the same time, the group members take turns leading the group through activities such as breathing, stretching, and mirroring, which promotes interaction and communication. The theme-development stage builds on the emotions and feelings generated in the group that surfaced during the warm-up phase. Here, patients explore movement range and quality of movement within the context of the exercises the therapist provides, which can vary from trust-building to exploring the sense of oneself. The closure phase is a reflection phase for the patient, in which each group member verbally processes and acknowledges what he or she experienced in the session to the therapist as well as to the other group members. At the end of this phase, the patient is left grounded and in control of his or her self (Chaiklin, 1975; Schmais, 1981).

⁴ Pre-motor neurons are different from general motor neurons in that the pre-motor neurons are localized just in front of the general motor neurons in the brain.

building process between people, with the underlying concept that the mirror neuron system is activated in relation to a stimulus outside of the self, which is to say, in a relationship to another.

Mirror neurons were discovered when experimenting with Macaque monkeys. There were certain neurons in the monkeys' brains that always “fired” when they grabbed for a peanut. These same neurons were activated when the monkeys *observed* a scientist grabbing for a peanut. This study illustrates the coinage of the term “mirror neurons,”⁵ in that the brain appears to mirror the movement it sees, and also that the mirror neurons cannot differentiate between seeing something and doing something—watching somebody else doing an action is just like doing the action yourself (Homann, 2010; NOVA 2005).

This mechanism of the mirror neuron system is thought to coordinate perception of nonverbal communication through visual and even auditory pathways. Therefore, by tracing the movement and expression in others, the mirror neuron system can provide a neurophysiological foundation for various psycho-affective responses, including empathy, morality, and awareness, also known as social cognition (Berrol, 2006). Because these responses are particularly rooted in scientific evidence and support, the mirror neuron system provides for a concrete understanding of DMT and, therefore, is especially applicable to it.

The chief focus of DMT is on movement, because movement is a means of assessment and the intervention for therapy; from movement, a therapeutic relationship develops between the patient and the therapist (Winters, 2008). From a therapeutic standpoint, DMT is a more beneficial form of therapy to use when psychotherapy, talk therapy, and other verbal means are not accessible, as in cases of children with autism (Homann, 2010). This is because through

⁵ A group of Italian neuroscientists reported the discovery of these pre-motor neurons. See Umiltà et al. (2001); Gallese, Keysers, and Rizzolatti (2002); Gallese (2005a, 2005b); Gallese, Fadiga, Fogassi, and Rizzolatti (1996).

movement, an individual's thoughts, feelings, and emotions can be expressed and communicated in ways that do not require verbal communication.

Although empirical evidence for healing through DMT has been accepted in recent neuroscience literature, the cellular mechanism behind what is happening in the individual's brain and body while engaging in DMT is not clear. Recent studies indicate that DMT engages the brain through body interventions that positively affect⁶ an individual's physical and psychological functioning, particularly, the emotional (somatic) and perceptual processes (Berrol, 2006).

In a given DMT session, the dance/movement therapist strives to achieve an attuned awareness and connection with the patient's emotions. This concept of "mirroring," which involves imitation of the patients' movements, emotions, or intentions, by the therapist, is central to enhancing empathy and essentially the therapeutic component of DMT (Koch, et. al., 2011; Winters, 2008; Berrol, 2006). Empathy is paramount to DMT interventions, which involve the concept of non-verbal mirroring as a means to impart a sense of feeling understood by another. The dance movement therapists' ability to be empathetic and somatically attuned in interactions with their clients has been recently found to catalyze the development and activation of the limbic system, specifically activating the mirror neurons residing in the pre-frontal cortex (Homann, 2010). This finding, in turn, can help to identify which parts of the brain, in addition to mirror neurons, are responsible for affecting DMT, and how empathy, from the perspectives of both neuroscience and DMT, can facilitate the healing process of DMT.

⁶ Affect, as used here, means improving the condition of, or healing.

DMT as a Mind/Body Intervention Therapy

The National Institute of Health (NIH) describes mind/body interventions as, “employing a variety of techniques designed to facilitate the mind’s capacity to affect bodily functions and symptoms.”⁷ Mental functions include thinking, communicating, intentional behavior, beliefs, and expression of emotions, while bodily functions include physiological, kinesiological, neurological, hormonal, and immunological systems (Goodill, 2005). According to mind/body interventions, if only the physiological part of an individual’s condition is examined and addressed, then the best possible treatment result cannot be achieved since the mind and body are connected, and therefore, there must be an underlying mental aspect contributing to the physiological manifestation that is left unaddressed. Because the hallmark of DMT is to address all the factors contributing to an individual’s disease or debilitation as one system instead of isolated problems, DMT is categorized and used as a mind/body intervention therapy.

Understanding that DMT operates at the integrated mind/body level is crucial to a patient’s healing because “if DMT brings about a change in the body’s behavior, there should be a corresponding change in the mind” (Rosen, 1957) and vice versa. This suggests that in DMT, healing happens concurrently at both a mind and body level, and therefore is able to provide a more comprehensive approach to a patient’s needs and healing process than other forms of mind/body interventions such as yoga or meditation, which provide corporeal or mental healing only. But can one know that the mind/body integration is *indeed* able to guide the therapist’s ability to address the patient(s) needs and healing process? The answer to this question is twofold and will be given in the next section.

⁷ <http://nccam.nih.gov/grants/types/r13>

Healing Through the Mind/Body Connection: DMT Perspective

Though the concept of mind/body integration may not seem obvious in dance, it is inherent and ubiquitous: dance requires the continued and simultaneous use of the mind and body. David Iverson, a dancer at the Mark Morris Dance Center, affirms: “dance requires mind and imagination, focus and physicality”⁸ (PBS, 2010). In a DMT session, however, the mind/body connection moves beyond the individual to the interactive level. This is seen through the therapist’s high degree of focus and awareness when trying to embody how the patient feels mentally, emotionally, and physically. Similarly, when patients take part in group exercises led by each other, they too, use the physical cues of others in the room to capture what they are feeling mentally and emotionally.

What seems to be happening at both the individual and interactive levels is that through the attentive observation of one’s own, or another person’s movement, the unconscious mental states of the patient—thoughts, emotions, feelings, intentions—unravel and surface in the consciousness of the patient and/or therapist. As described by dance/movement therapist Kaila B. Homann,⁹ “awareness comes from observing subtle shifts in posture, eye contact, breath patterns, and voice changes” (Homann, 2010). Such awareness is pivotal for the process of healing to commence, because by accessing the unconscious through movement, the *root cause* for the disease, illness, or debilitation is at last discovered. For patients who are not able to communicate their needs adequately, DMT may be more useful than going to a physician. This is because

⁸ David Iverson, special correspondent on PBS News Hour, reports on a unique program at the Mark Morris Dance Center that uses dance/movement therapy for people with Parkinson’s disease, now called “Dance for Parkinson’s.” Retrieved from http://www.pbs.org/newshour/bb/health/july-dec10/parkinson_12-09.html.

⁹ Kaila B. Homann, MA, LPC-S, BC-Dance/movement therapy. In her private practice in Austin, Texas, Homann supervises interns and trains professionals at the graduate and post-graduate level in DMT, expressive arts therapy, and counseling. For more information about her, see (Homann, 2010).

verbally handicapped or inept patients will often not be able to report their distress, pain levels, and conditions accurately and, as a result, will not be given the proper medication or treatment they need. By contrast, through analyzing the patient's movement in a DMT session, the therapist can absorb information about the patient's thoughts, feelings, and emotions, and therefore, can customize a healing program specific for *that* patient—without prescribing medication.

However, “if DMT can increase body awareness, leading to better [pain] reporting, it will be influencing pain at an indirect level” (Goodill, 2005), which essentially is the path to healing. But, what is the dance/movement therapist's role in the process of increasing awareness of the body? When therapists first begin to work with the patients, they guide their body awareness through “conscious tracking of sensations such as the rhythm of breathing, relaxing into the support of gravity, or bringing awareness to sensing the body one part at a time” (Homann, 2010). The resulting awareness is similar to the awareness that results from practicing meditation, in that the patient feels “safe, relaxed, and held.” Moreover, this awareness serves as a platform for patients to assess their own and others' experiences in the DMT session, and eventually heal themselves by self-regulating their own bodies.

Yet, according to the definition of mind/body integration, awareness—through movement—about one's own body, alone, will not provide complete healing. There needs to be a corresponding mental awareness functioning simultaneously; and, it is called *emotional awareness*. Joan Chodorow¹⁰ (1995) states that “emotions motivate and shape the way we move. An emotion is at once somatic and psychic...In the depths of the unconscious, it is the emotions

¹⁰ Joan Chodorow is a dance/movement therapist and Jungian analyst in Fairfax, California. She has a MA in psychology and dance/movement therapy from Goddard College, and was one of the first dance therapists in California. She is also licensed as a marriage, family, and child counselor.

that mediate between the realms of the body and psyche, instinct, and spirit” (Winters, 2008). If emotions inspire the way humans move, it is first important to understand how movement inspires the *awareness* of emotions.

Active movement is thought to allow powerful emotions like rage or joy to be “more consciously experienced and expressed, making them more available for verbal processing” (Homann, 2010). Tracking the body’s experiences through these emotions and “sensing and responding to them through movement can be used to regulate or contain emotion.” In a global sense, outside of the DMT session, awareness and regulation of emotion through movement can provide a means for healing, as they allow patients to access their own mind/body connection and explore new choices for responding to complicated situations in a more composed manner. Therefore, not only will patients have greater self-control, they will also have the confidence to attempt new movement and response patterns, specifically when interacting with others. Dance/movement therapist Claire Schmais¹¹ describes her personal observations about how heightened movement awareness positively affects emotion in a given DMT session:

When powerful feelings are expressed as part of the dance, patients learn that expressing emotions does not necessarily lead to disaster. Even murderous feelings symbolically enacted can be controlled...As they engage in creating a dance, patients discover that their movements are acceptable and that their contributions are valued...some of the most important information that people can glean from the group experience is the knowledge of how they relate to others and the reactions they evoke (Schmais, 1985).

¹¹ Claire Schmais, Ph.D, ADTR Professor, Coordinator of the dance/movement therapy program that used to exist in Hunter College, NY. For more information about her personal experiences as a dance/movement therapist, see (Schmais, 1985).

While these observations are illustrative of how DMT can heal, they often remain subjectively descriptive and lack a more grounded explanation of *how* healing actually occurs. Nevertheless, modern science is more receptive to the concept of mind/body integration and how it facilitates healing at a physical and mental level concurrently. The science behind the healing that occurs through the mind/body connection, in the light of DMT, will be explained in the next section, specifically in terms of neuroscience.

Healing Through the Mind/Body Connection: Neuroscientific Perspective

Healing, as seen in the previous section, is embedded in the patient's ability to connect with himself and with others. In the process, new ways of moving, responding to situations, and creating new meaning are developed. This section will examine the healing process that occurs in DMT through the lens of neuroscience.

That the human brain is “well integrated with the rest of your body at a molecular level,” (Homann, 2010) is a belief shared by neuroscientists and neurobiologists. The way in which the immune system communicates with the circulatory system and likewise with the endocrine system via neurons and other neural structures, illustrates the integration of the brain with the body. Supposing that during each second the communication that takes place elicits a specific emotion, then the “interrelationship of the mind/body in the experience of emotion can be understood by the biophysiology¹² of emotion” (Damasio, 1999). This suggests that what the mind perceives as emotion may actually be its decoding of bodily cues such as digestion, hormone regulation, and metabolism; many brain structures are involved in processing these cues into the human experience of emotion.

¹² Physiology is the branch of Biology that deals with how cells, organs, and muscles of living organisms interact and function.

Although the discussion of all the brain structures involved in the processing of bodily information is beyond the scope of this paper, the most important structures will be addressed. The limbic system is associated with emotions and behavior. Complex axonal connections¹³ (see Figure 1 below)¹⁴ to the neocortex and the brain stem mediate the functions of the limbic system, while neural “hook-ups” with the basal ganglia (in the cerebral cortex) integrate thought and emotion in motor behavior. The hippocampus and amygdala, comprising a part of the limbic

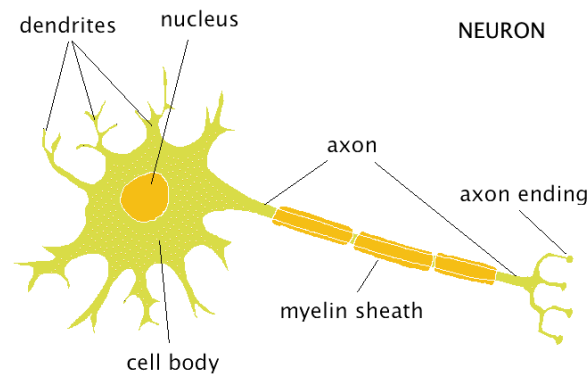


Figure 1: Diagram of the key parts of a neuron: cell body, axon, and dendrites.

¹³ An axon is a thin and long projection of a neuron that conducts electrical impulses away from the neuron’s cell body.

¹⁴ Diagram was accessed through Google Images on November 8, 2012. It was originally retrieved from: <http://webspace.ship.edu/cgboer/theneuron.html>.

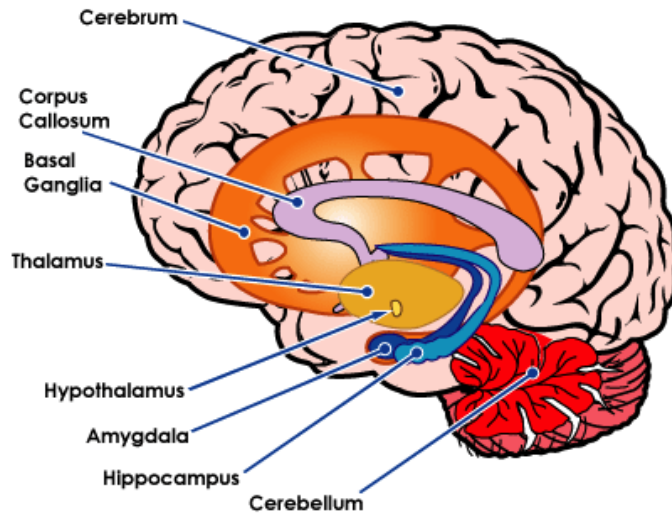


Figure 2: Diagram of the key brain structures involved in emotional regulation (limbic system, primarily the hippocampus and amygdala) and integration of emotion and motor behavior (basal ganglia).

system, are often called the “emotional brain,” and regulate the autonomic nervous and endocrine systems (see Figure 2 above)¹⁵. Fear, anger, sadness, joy, disgust, and aggression are all housed in the limbic system (Berrol, 2006). These brain structures encompass portions of both the left and right brain hemispheres.

Figure 2 above highlights the dominant structures involved in human emotions and behavior by focusing in on the limbic system. Understanding the role of this system serves as a foundation to better understand mirror neurons and their functions and implications in DMT in the following sections. It is important to note that while the brain does have two hemispheres, each with many intricate parts and special functions, the brain really operates as a whole, highly complex system. The simple act of lifting your arm involves millions of neurons firing and the activation of multiple brain regions. It is necessary to understand that this “whole system”

¹⁵ Diagram was accessed though Google Images on November 8, 2012. It was originally retrieved from: <http://americantribune.org/>.

approach to the scientific understanding of mind/body integration is also of recent consideration, in order to then understand the biological/physiological benefits of mind/body interventions.

Empathy and Mirroring Driving the Success of DMT

As mentioned earlier, the success of DMT is rooted in the therapist's ability to show empathy for the patient, which is largely achieved through the technique of mirroring. In this section the concepts of empathy and mirroring will be defined first individually in terms of their roles and functions in DMT, and then will be analyzed conjointly.

The dictionary definition of empathy is the "ability to understand and share the feelings of another." Yet, from a cognitive and therapeutic perspective, empathy has a larger and deeper meaning. The definition of empathy that will be used for this paper is that it is "a visceral and cognitive understanding of another's emotions or motivations. It allows a person to take another's viewpoint to understand the intentions behind their actions more fully, feeling what the others feel without actually moving"¹⁶ (McGarry, 2011). Psychoanalyst Daniel N. Stern¹⁷ elucidates the idea of cognitive understanding: "in that cognition and emotion are integral to the involvement of empathy, the presumption is that neuronal connectivity between the prefrontal cortex (thinking part of the brain) and the limbic system (emotion and behavior regulating part of the brain), serve as vital conduits" (Berrol, 2006). These vital conduits are currently thought to be a class of neurons found on either side of the head, called mirror neurons, and will be explored more fully in the following section.

¹⁶ This definition is originally obtained from Wispe Lauren, 1986. "The distinction between sympathy and empathy: To call forth a concept, a word is needed." *Journal of Personality and Social Psychology*. 50(2) 314-321.

¹⁷ Daniel N. Stern is a renowned psychiatrist and psychoanalytic theorist, specializing in infant development. He has written several books about this topic, the most notable being: *The Interpersonal World of the Infant* (1985).

While the therapeutic aspect of the neuronal connection between the two brain regions may not be obvious to those without a scientific background, the average care-giver can attest to the therapeutically healing effect of “empathic behavior,” or imprinting,¹⁸ which begins at birth and elucidates the basic model for how humans learn. From common insight, it is obvious that humans learn by watching and copying others, especially at the infant stage of life; and “once you’ve looked, copied, and learned something, you not only have them in your head, but you can share the experience when seeing someone else do it” (Cort, 2005).

In neuroscientific terms, the relationship among the copying, learning, and sharing phases is “the visual stimulation from the dyadic interaction—as in mirroring—imprinting specific areas of the brain, and promoting neurobiological maturation by facilitating an increase in dendritic¹⁹ connections among areas that share patterns of behavior” (Berrol, 2006), and these areas are primarily the pre-frontal and motor cortex,²⁰ the insula,²¹ and the limbic system²² (see Figures 3, 4, and 5 on the following page). This suggests that despite the lack of verbal communication between the infant and the caregiver (primarily lacking by the infant), gestures, postures, and facial expressions create “a shared framework of meaning” (Berrol, 2006); if this is so, then the same shared framework of meaning can be produced in DMT as well, fundamentally through mirroring.

¹⁸ Imprinting: the genesis of the dyadic interplay between infant and a primary caregiver (Schore, 1994).

¹⁹ Dendrites are one of the key parts of the neuron that carry signals (messages) toward the cell body.

²⁰ Diagram was accessed through Google Images on November 8, 2012. It was originally retrieved from: <http://www.scienceinseconds.com/blog/Hate-Love>.

²¹ Diagram was accessed through Google Images on November 10, 2012. It was originally retrieved from: http://thebrain.mcgill.ca/flash/d/d_06/d_06_cr/d_06_cr_mou/d_06_cr_mou.html.

²² Diagram was accessed through Google Images on November 10, 2012. It was originally retrieved from: http://www.daviddarling.info/encyclopedia/L/limbic_system.html.

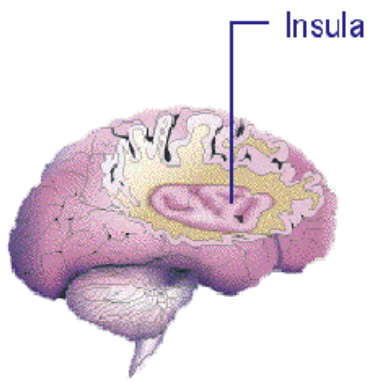


Figure 3: Location of insula in the brain.

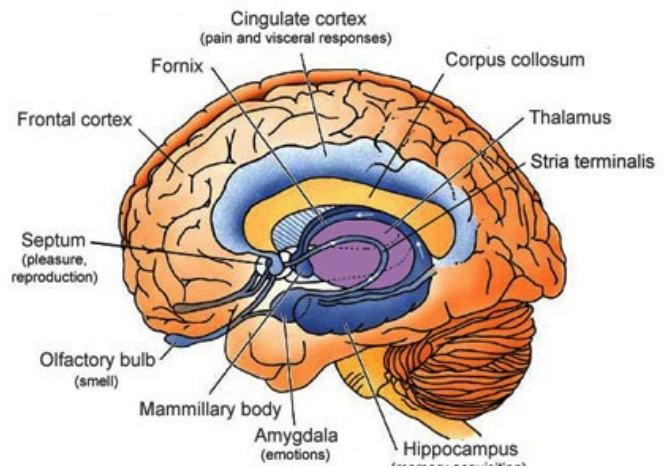


Figure 4: Brain regions of the Limbic System. Of importance to this discussion are the frontal cortex and amygdala.

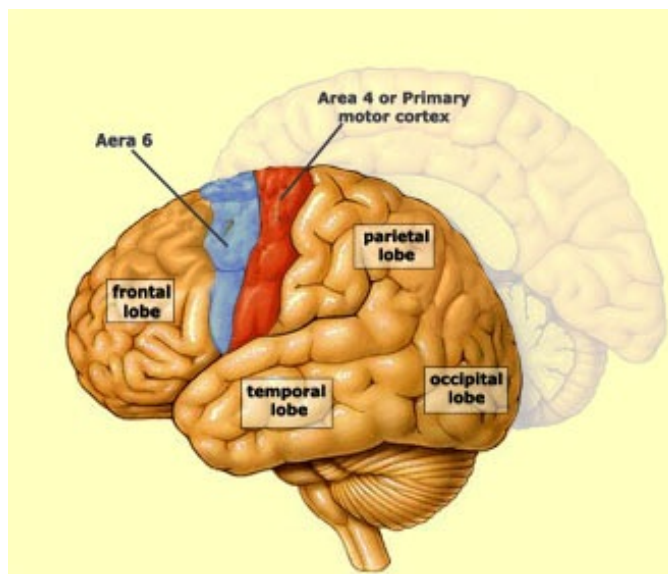


Figure 5: Primary motor cortex highlighted in orange.

Mirroring, as used in the context of DMT, involves “imitating qualities of movement... to enhance emotional understanding between a therapist and a patient, or among members of a group” (Mc Garry 2011). Marian Chace, one of the first dance/movement therapists to use the mirroring technique, used it when working with World War II veterans in the 1940s who could no longer express themselves and form relationships with others effectively. By “reflecting their moods, movements, and sounds, Chace created an intersubjective union with the patients—

mirroring not simply *what* they do, but the qualitative dynamics of their movements” (ADTA, 2009). As a result of the mirroring, the veterans were not only able to regain a sense of self-expression, but were also able to reconnect with the world from which they felt completely withdrawn.

Chace’s positive experience of healing through mirroring, though empirically subjective, can be scrutinized further to understand *how* the healing occurs. As seen with Chace, dance/movement therapists can mirror qualities of their patients’ movements that reflect their underlying emotions, and by doing so, the therapists can establish a dialogue of empathy between them. However, therapists can also employ the mirroring technique by “echoing exact movements...mimicking the intentions behind one’s movements, as when a therapist mirrors a posture or a general emotional quality behind a set of movements, rather than exact motor movements themselves” (Mc Garry, 2011). It is hypothesized that to understand the intention behind another’s emotional actions, a representation of another’s action has to be created within our own brain, as if we were engaging in the experience ourselves (Carr, et al; 2003). The brain seems to mirror what it sees, and therefore is able to create such representation, through the mirror neuron system.

The Mirror Neuron System in Relation to Mirroring and Empathy in DMT

As touched upon in earlier sections of this paper, the mirror neuron system is housed in the limbic and motor cortex regions of the brain. Specifically, it spans the pre-motor cortex (which is a supplementary motor area), primary somatosensory cortex, and the inferior parietal cortex. Current research on the mirror neuron system suggests that the brain areas involved in perception and production of movement overlap (McGarry, 2011). This suggestion offers a basis

for linking the success of engaging empathy in DMT through the mirror neuron circuitry. With further research, this may well provide the neurological evidence for “mirroring.”

Unlike talk therapy and psychotherapy, which focus on the analysis of specific problems rather than on connecting with the patient, DMT largely rests on the ability of therapists to express empathy toward their patient, or for the patients to be empathetic toward other patients in the group. This key route to such recognition at the level of emotions “involves a neural simulation of another’s emotional actions in order to infer the intentions behind those actions, and empathize with them” (McGarry, 2011). This means that the same brain areas involved in the perception and production of movement are also involved in understanding the movement intention. The study performed with the Macaque monkeys referred to earlier, makes concrete how movement intention, perception, and production can be linked.

Recall that in the study of Macaque monkeys, regardless of whether the monkeys themselves reached for the peanut or *observed* the scientist reaching for the peanut, the same set of neurons in the monkeys’ brain fired (Cort, 2005 & Homann, 2011). Subsequent studies revealed that different movements producing the same results (such as reaching for a glass using a pincer or a palm grip) were correlated with similar firing patterns in the same neuron, supporting the hypothesis that mirror neurons are involved in processing intention. The similarity in the firing patterns within the mirror neuron system “leads to stronger action-observation connections between the limbic and motor areas” (Berrol, 2006; McGarry, 2011), and thereby leads to stronger mirroring-empathy connections. These connections are perhaps what account for healing in DMT.

From the monkey and infant-imprinting examples, it is clear that evolution has progressed toward living in a highly social system, in which communicating and connecting with others is key. However, for this ability to identify with others to exist, there must be a wiring mechanism that coordinates our emotions and behaviors. This wiring has been explored in terms of the mirror neuron system and the brain regions in which it resides, but only in the context of monkeys. Since humans are more social creatures than primates, it is crucial to contextualize the connections found in primates in light of humans, especially if these connections may have clinical implications.

To emulate the studies performed with monkeys, numerous neuroimaging studies, many using fMRIs,²³ have been performed on humans to see whether a similar pattern of brain activation exists. In one study, an individual was exposed to three types of olfactory stimuli, namely, malodorous (“disgusting”), pleasant, and neutral, in order to elicit disgust, pleasure, or a non-specific reaction. At the same time, fMRI scans were performed on a second person, who merely observed the facial expressions of the individual exposed to the stimuli. The scans revealed that for both the malodorous and pleasant scents, but not the neutral stimuli, the amygdala and the insula of the *observer* were activated (Berrol, 2006).

This study confirms that a similar mirror neuron wiring mechanism found in monkeys also exists in humans. But how is it that a simple facial expression is able to activate the same neurological response and emotional identification in an observer who is *not* making the expressions? As current researchers postulate, during motor simulation, another person’s

²³ fMRI is an image scanning technique that maps the brain during different types of somatosensory activity. Increased blood flow in activated areas of the brain is revealed on the fMRI scans (Berrol, 2008; Smith, Retrieved March 2006).

“emotional movements in similar motor areas of our own brain are re-created. This recreation allows us to project how we feel during execution of a simulated movement onto the person being simulated, allowing us to make inferences about that person’s emotions” (McGarry, 2011). These inferences, consequently, allow the observer to feel empathy for the individual exposed to the stimuli. While this empathic response is subconsciously always in action—why we cry when watching an emotional scene in the theaters or feel so much joy when our favorite football team scores a touchdown—it is specifically therapeutic in DMT, because it operates in the consciousness in the presence of a stimulus.

The FMRI studies lend greater credibility to the subjective experiences reported about the success of DMT as a result of mirroring and the expression of empathy. Although more scientific studies are required to *prove* such success, it can be said with greater confidence that “the neural correlates of empathy can be found in activation patterns of human mirror neurons” (Carr et al., 2003). When applied to DMT settings, the therapist will be able to activate his or her patients’ mirror neurons, thereby creating a stronger, more therapeutic relationship (Winters, 2008). Such a relationship is not merely formed between a patient and a therapist, but also between the patient and his or her surrounding community; this is imperative for adequate verbal communication with other members of that community and, in turn, leads to a sense of belonging. Verbal communication in DMT is enhanced by nonverbal communication in which there is a transfer of energy from the therapist to the patient (Homann, 2010), particularly when mirroring. This energy, evoked when working directly with the body, becomes shared among the group members, and becomes the medium for transforming the struggles and challenges experienced by group members into a validation and recognition of their self and relationships with others.

DMT in the Medical Setting: Case Studies

This section will trace the practice of DMT in Parkinson's disease and autism, two diseases that are currently thought to have a "break" or obstruction in the mirror neuron pathway.

In Parkinson's disease, the symptoms parallel changes in the body due to aging. The disease is a progressive neurodegenerative condition, and at present, affects over one million older adults in the US, making it an epidemic. Parkinson's disease occurs on a spectrum; there are various types of the disease, which can range from mild to severe and produces different symptoms in different people—rendering this disease complex to understand and treat. One symptom that is characteristic of both mild and severe forms of Parkinson's is reduced mobility because of gait and balance difficulties. In normal aging, gait changes, including decreased speed, decreased stride length, and increased use of base support, are also characteristic, limiting mobility and leading to increased incidence of falls (Hackney, 2007). In one study, it was hypothesized that "functional mobility and gains of life associated with Argentine tango dance will be higher than traditional strength/flexibility exercise gains" (Hackney, 2007).

In the study, the effects of Argentine tango dance, seemed to offer promising results for balance and gait problems because of the form's particular use of "movement initiation and termination, rotation, and movement in close proximity to another individual" (113). This applied to individuals with and without Parkinson's disease. Numerically, the results showed that the Parkinson tango group improved in all the measures of balance, falls, and gait, and experienced more gains in balance than a comparable Parkinson group performing traditional exercise.

Although many more studies will have to be conducted to validate the therapeutic and healing effects of movement for diseases such as Parkinson's, this study highlights several key concepts that account for healing. For instance, "learning new concepts has been revealed to retard mental decline. In a traditional exercise class, exercises become repetitious" (Hackney, 2007). Not only can they be repetitious, but they can also be less engaging of the mirror neuron system than Argentine tango. Because tango is a partnered dance form, the partners become "mirrors" for each other, allowing for an empathetic relationship to form between them; such relationship does not exist in traditional exercises.

Additionally, the use of Argentine tango dance (instead of the modern dance elements in traditional DMT) allows the "[dancing] partner to provide helpful sensory information and stabilizing support that leads to improved balance and gait" (122). Therefore, the tango is especially well designed for individuals who face these problems. Finally, because practicing this dance form divides the dancers' attention between space navigation and balance, the dancers develop cognitive skills such as maintaining rhythm and improving functional mobility, regardless of whether their impairments are due to aging or to Parkinson's disease.

Maintaining rhythm and improving functional mobility, however, assume the functional integrity of the mirror neuron system. This is because they each require patients' voluntary thought and movement response to the dance therapist who mirrors their movements.

Researchers interested in knowing if the mirror neuron system is intact in patients with Parkinson's have postulated that "If the mirror neuron system itself is affected in Parkinson's Disease, action-observation related activity may not be potent enough to interfere with intended actions" (Albert, 2010). This suggests that if patients with Parkinson's show improvement in maintaining rhythm and functional mobility, either their mirror neuron system has always been

intact or has possibly been remedied through DMT. While further research using clinical trials is needed to confirm either conjecture, that Parkinson's compromises the mirror neuron system and that DMT may help to mitigate this compromise, remains a possibility.

Research on the link between autism and mirror neurons is also burgeoning today. Decreased empathic understanding of others is a characteristic of autism, and autistic patients often lack the imprinting behavior from early childhood. The Macaque monkey test for performing and observing movement reveals that brain waves in autistic children are different from those of "normal" children (Cort, 2005). The dysfunctional activation in the mirror neuron system suggests that autistic individuals may have a "break" in their mirror neurons.

Recent studies have shown that autistic children show greater pro-social behaviors merely when someone else mirrors them and, in turn, are better able to mirror themselves. "On a neural level, even when autistic children play video games designed to reward them for suppression of a rhythm pattern that resembles mirror neuron activity, pro-social behaviors are again enhanced" (McGarry, 2011). This implies that at least for autistic children, the dance/movement therapist's mirroring and encouragement of the children to mirror, can be successful in increasing the children's ability to empathize via "less broken" mirror neuron system activity.

In one study, the researchers used multi-modal interventions for autistic children, whose their movement initiations were reflected through the therapist responding in rhythmically synchronized sounds (Homann, 2010). While this study is more qualitative than quantitative, it suggests that empathic mirroring of movement can be used to "repair" the "broken" mirror neurons that overlap with the limbic system. More importantly, this and similar studies suggest

that if utilized from an early age, DMT can potentially help re-seal the “break” in autistic children’s mirror neuron system.

Conclusion

The human brain is a highly complex system that processes all of our dynamic experiences, emotions, and interactions, which are constantly evolving and assuming new forms because of *our* sense of what is happening outside, and even inside, ourselves. Starting with the therapeutic relevance of the mind-body connection to DMT, then exploring empathy and mirroring as fundamental elements of this therapy, the importance and applicability of DMT have been traced through both the dance/movement and neuroscience perspectives.

That DMT is a successful therapy is well established. Its success assumes that humans have both psychological and biological needs because the body is a superimposition of movement and emotion; what affects the mind is reflected in movement and vice versa. Evolution traces the human as a mind-body unity and describes that dance and movement are its manifestations. The need for DMT ranges from simply reconnecting with one’s self to overcoming trauma to possibly even reducing the effects of disease. For over five decades, the benefits of DMT have not achieved greater credibility than mere observation. Today, neuroscience has begun to quantify the observed benefits.

Through the lens of neuroscience, this paper seeks to explain from a scientific perspective the *how* and *why* behind the success of DMT. By focusing on the mirror neuron system that parallels the “mirroring” technique, the healing process in DMT can be better understood, and, in turn be given greater credibility. The therapist’s ability to mirror emotions or intentions, implied by the patient’s movement, produces an empathetic relationship between

them. Yet, empathetic behavior is only a part of how and why DMT is successful; it is the mirror neuron system that seems to complete the story.

The benefits of DMT are not exclusively attributed to “mirroring” and the mirror neuron system, however, and can contribute to improving an individual’s quality of life. The key DMT concepts of mind/body integration can have healing effects from something as basic as improving communication between family members to something as complex as mitigating the symptoms of autism and Parkinson’s disease. Patients who have a difficult time verbally communicating can benefit from the largely nonverbal DMT intervention. Communication is essential for any patient to receive adequate treatment. If patients cannot communicate their needs adequately, how will they be given the correct medication or treatment options? How will they recover?

Interventions such as DMT that build congruence and link verbal and nonverbal modes of expression, while operating largely in the nonverbal mode, may be superior to traditional verbal psychotherapy and even traditional medicine, since health care providers in traditional settings do not have a nonverbal assessment and treatment component to respond to the needs of individuals unable to communicate verbally. Moreover, because DMT “customizes” treatment based on individual needs, the patient experiencing communication barriers will be given the space to be mirrored by the therapist and to interact with other patients. Although change cannot be expected to occur overnight, an improvement in communication ability *can* be expected after several DMT sessions.

The benefits of nonverbal communication and empathetic behavior are relevant in the clinical setting as well. In her book, Sherry Goodill says, “principles borrowed from DMT can also inform and enhance the work of other health care professionals by increasing sensitivity to these subjective, sensed components, of the patients’ condition, and by improving the patient-caregiver relationship through better communication skills in the nonverbal dimension” (16). This suggests what while physicians may not directly perform DMT techniques, they can recommend DMT when medication and other treatment options may not be adequate. This may occur when a patient has multiple physical complications to combine medications or has ceased to experience relief from medications.

Applying DMT clinically will allow physicians to help patients suffering from serious medical conditions. Although full DMT applications in the science and medicine fields await further study to confirm therapeutic healing, some applications do exist today. With greater acceptance and scientific underpinning, this doctor-patient relationship can be transformed into a successful mind/body intervention within the medicine realm. As GI specialist, Dr. Ellen Scherl, explains, “the Complementary and Alternative Medicine (CAM) interventions have accomplished what we physicians have been striving to do for years, not only reducing the symptoms, but also improving the overall well-being of the patient as well (personal correspondence, October 15, 2012). Thus, the transformed doctor-patient relationship, can in turn, help draw health care providers not only from dance, movement, and complementary medicine backgrounds, but from scientific and medical backgrounds as well. By working together, health care providers from their respective backgrounds can holistically treat patients, especially when medical treatments cannot address their physical symptoms.

The discussion of the benefits of DMT as a systems approach combined with a survey of current clinical uses and applications of DMT help answer the larger question of how DMT can be given some type of scientific underpinning. With neuroscience finally giving importance and acknowledgement to the sixty-year-old DMT technique, and with numerous studies supporting the empathetic role-play of mirror neurons, it is clear that DMT is a beneficial avenue worth pursuing and for establishing scientific support. While data does not support the use of DMT as the only treatment, it does support in conjunction to other medical treatment plans. The creation of new relationships between health care providers on both sides of the dance-medicine interface can yield innovative treatment plans and research findings that support not only the medical component of treatment, but also complementary, mind-body interventions.

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