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Mirroring in Dance/Movement Therapy: Potential mechanisms behind empathy enhancement

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ABSTRACT

Mirroring, an exercise practiced in Dance/Movement Therapy (DMT), is considered by practitioners and patients to enhance emotional understanding and empathy for others. Mirroring involves imitation by the therapist of movements, emotions, or intentions implied by a client's movement, and is commonly practiced in order to enhance empathy of the therapist for the client. Despite enthusiastic claims for its effectiveness, a clear theoretical framework that would explain the effects of mirroring on empathy has not yet been presented, and empirical research on the topic is generally lacking. In this review, we propose that mirroring in DMT enhances understanding of others' emotional intentions through enhanced use of mirror neuron circuitry. Research on the mirror neuron system (MNS) suggests that the brain areas involved in perception and production of movement overlap, and that these brain areas are also involved in the understanding of movement intention (Rizzolatti & Craighero, 2004). One important route to emotion recognition involves a neural simulation of another person's emotional actions in order to infer the intentions behind those actions, and empathize with them. Future research is proposed in order to systematically explore the effectiveness of mirroring in dance therapy, the neural mechanisms behind it, and its applicability to patient populations who have problems with empathy.

Introduction

It has been hypothesized that unconscious and automatic imitation of another's motor processes, referred to as mimicry, modulates emotional understanding through muscle feedback to the brain (Berrol, 2006; Dimberg & Petterson, 2000; LeDoux, 2003; Levenson, Ekman, & Friesen, 1990; Livingstone, Thompson, & Russo, 2009; Molnar-Szakacs & Overy, 2006). Mirroring, which involves imitating qualities of movement, is an exercise employed in Dance/Movement Therapy (DMT) to enhance emotional understanding between a therapist and client or among members of a group (Adler, 1970; Berrol, 2006; Mills & Daniluk, 2002). DMT is a form of therapy which focuses on movement behavior as it emerges in the therapeutic relationship, in order to promote emotional, cognitive, physical, and social functioning (ADTA, 2010). Mirroring occurs when two people make similar body movements that are coordinated or slightly echoed in time. The therapist may echo the exact movements of a client, or may imitate the quality of the movement; for example, if a client is moving with a slumped posture, the therapist may adopt these movement qualities as well. The DMT is trained in movement analysis, and is able to study a client's movements, and extract and imitate particular movement qualities. At the finest level, the client may be unaware that imitation is occurring, and at its most obvious level, exact movements are imitated or movement themes are exaggerated. The end result is an enhanced degree of somatic and emotional understanding in the therapist for the client. The client may also be encouraged to engage in mirroring for the purpose of enhancing empathy in the client for others. The effects of mirroring on empathy enhancement are considered important by DMT therapists, but have not been extensively researched (Berrol, 2006; Mills & Daniluk, 2002). A critical examination of the underlying mechanisms involved in mirroring and empathy has the potential to provide insights that may be used to enhance the effectiveness of DMT.

Growing research suggests the presence of neural circuitry called the mirror neuron system (MNS) that is activated to a similar extent when an individual performs or simply observes an action (Rizzolatti & Craighero, 2004), leading some researchers to believe that the same processes underlie movement production and perception. This system appears to be sensitive to the intentionality of movement (Rizzolatti, Fogassi, & Gallese, 2001), responding similarly for different movement patterns where the intention is unequivocally the same. The present paper proposes a neuropsychological model, involving motor simulation and the MNS, which can elucidate the benefits of mirroring in DMT on empathy. This model leads into suggestions for future research and possible clinical applications.

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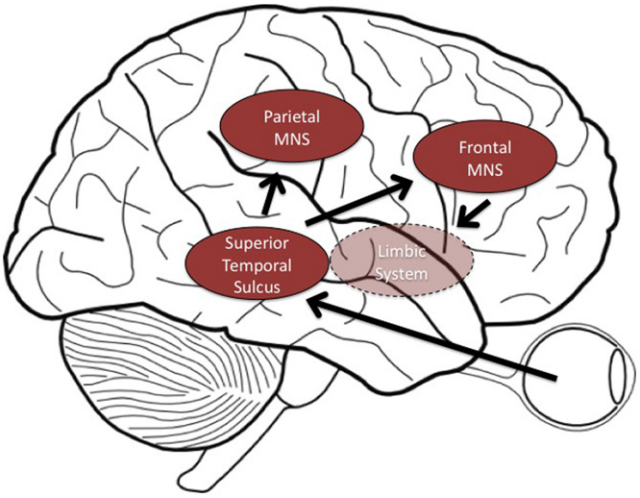

Fig. 1. The human mirror-neuron system. Sensory input is relayed to the premotor cortex and parietal cortex via the superior temporal sulcus. This activity leads to greater activation in the limbic system during observation of and participation in emotional action.

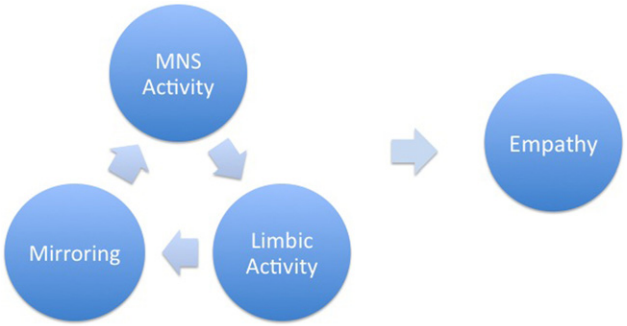

Fig. 2. Schematic figure depicting the proposed relationship between MNS activity, mirroring, limbic activation, and one's capacity for empathy. We suggest that practice engaging in mirroring enhances MNS functioning, which in turn supports greater capacity for empathy.

Empathy, mirroring, and the mirror neuron system

In the present paper, we choose to define empathy using the parsimonious definition of Wispé (1986). Empathy, for our purposes, is a visceral and cognitive understanding of another's emotions or motivations. Empathy allows a person to take another's viewpoint to understand the intentions behind their actions more fully; in other words, "feeling what they feel". Along these lines, Titchener (1909) originally referred to empathy as using "the mind's muscle" as a tool to project oneself onto another in order to understand his or her feelings (Wispé, 1986). Thus, from its conception, empathy has been closely tied to motor mimicry, though research has only recently begun to support this relationship (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003; Dimberg & Petterson, 2000; Livingstone et al., 2009; Riskind & Gotay, 1982).

Recent research postulates that the MNS plays a critical role in this action-simulation process (Rizzolatti & Craighero, 2004). First discovered in single cell recordings of area F5 in the monkey premotor cortex (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996; for a review see Rizzolatti & Craighero, 2004), numerous neuroimaging studies suggest that a similar system of mirror neurons is present in the human brain, involving the posterior inferior frontal gyrus, adjacent ventral premotor cortex, and the inferior parietal lobule (Buccino et al., 2001; Rizzolatti & Craighero, 2004; see Fig. 1). In monkeys, different movements leading to the same endpoint (e.g., reaching for a glass using a pincer or palm grip) are correlated with similar firing patterns in the same neuron, supporting the assumption that mirror neurons are involved in intention processing (Umilta et al., 2001).

Carr et al. (2003) assert that the neural correlates of empathy can be found in activation patterns of human mirror neurons. In their study, human participants either observed or imitated an emotional facial expression while brain activation was measured using functional Magnetic Resonance Imaging (fMRI). Observation and imitation of emotion activated corresponding brain networks involving the MNS, as well as areas associated with emotion, such as the insula and amygdala. In a related study, Wicker et al. (2003) found that the insula and amygdala were activated to a greater extent when participants smelled a pleasant or disgusting scent compared to a neutral scent. The same pattern of activation was seen when participants viewed someone else smelling the same scents. Carr et al. (2003) hypothesized that in order to understand the intention behind another's emotional actions we need to create a representation of that action within our own brain, as it would be created if we were engaging in the experience ourselves. This generation of emotional action presumably causes feedback via the MNS to the limbic system, a primitive belt-like structure that forms the inner border of the cortex, including the amygdala and other areas involved in processing and regulating emotions (LeDoux, 1992; LeDoux & Phelps, 1993).

DMT therapists engage in a mirroring process with their clients, sometimes mirroring or echoing exact movements, and at other times echoing qualities of movements that reflect their emotional tones. For example, two people might walk using the same steps, but one may engage in stiffer movements while the other's may be more fluid, reflecting more anxious or relaxed emotional states. In a DMT session, the therapist mirrors the quality of a client's movements in order to relate to the client and open an empathic dialogue. The therapist is trained to pay attention to the client' movements on a very subtle level. Mirroring can also take the form of mimicking the intentions behind one's movements, as when a therapist mirrors a posture or general emotional quality behind a set of movements, rather than exact motor movements themselves. It seems feasible that both types of mirroring in DMT may lead to shared activation in MNS networks between a therapist and client, and be responsible for reported enhancement of emotional connections following a DMT session (Berrol, 2006; Mills & Daniluk, 2002). As depicted in Fig. 2, we propose that practice engaging in mirroring leads to enhanced MNS functioning in the person mirroring, as well as in the mirrored individual. In turn, MNS activity during the observation or execution of emotional movement will enhance activation in the limbic system, leading to a greater empathic response.

A body-movement feedback system

The facial feedback hypothesis states that generation of an emotional facial expression can lead to a visceral experience of the emotion associated with that expression (Zajonc, Murphy, & Inglehart, 1989). While most research and discussion of this hypothesis has involved facial musculature (Dimberg & Petterson, 2000; Levenson et al., 1990; McIntosh, 1996; Zajonc et al., 1989), Riskind and Gotay (1982) demonstrated that embodying postures can also influence emotion. Researchers have suggested that this process occurs through feedback from motor areas in the brain to emotion areas, influencing our experience of the expressed emotion (LeDoux, 2003; Levenson et al., 1990). During motor simulation, we re-create another person's emotional movements in similar motor areas of our own brain (Dimberg & Petterson, 2000). This process allows us to project how we feel during execution of a simulated movement onto the person being simulated, allow-

ing us to make inferences about that persons' emotions (Stern, 1985/2000).

While simulation research has primarily been conducted on overt movement simulation (Dimberg & Petterson, 2000; Livingstone et al., 2009), mirror neuron research suggests that simply viewing another person being emotionally expressive while remaining still will activate the same movement areas in the viewer's brain, which will in turn activate emotion areas due to the emotionality of the movement (Carr et al., 2003). This means that it is not necessary to move in order for mimicry to occur at a neural level – this would explain why individuals are able to understand the emotions of others without visibly moving. However, facial feedback research (Levenson et al., 1990; Zajonc et al., 1989) also suggests that overt movements enhance emotional experience, which could contribute to greater emotional understanding. Individual differences in empathy are likely mediated by efficiency of the neural circuitry underlying an empathic response. Overt movement may enhance this efficiency, particularly in individuals who have difficulty empathizing. Chartrand and Bargh (1999) demonstrated that individuals who have a greater tendency to engage in automatic mimicry in social settings score higher on an empathy questionnaire, supporting the idea that mimicry enhances the propensity to empathize. It is possible that mirroring practice could be employed as a therapy in itself, in order to benefit individuals who have lower tendencies to engage in natural mimicry.

It has been hypothesized that people also perceive emotion conveyed in music by simulating the movement or movement intentions of the musician (Livingstone et al., 2009; Molnar-Szakacs & Overy, 2006). Not only does viewing a moving musician during performance enhance the viewer's understanding of the music (Thompson, Graham & Russo, 2005; Thompson & Russo, 2007), but observers tend to imitate the facial expressions of performers. In a study by Livingstone et al. (2009), when singers were asked to imitate a song excerpt, they demonstrated mimicry of the emotional facial expressions of the performer they were trying to imitate, even before engaging in their own musical imitation. It is hypothesized that the degree of motor imitation during song perception mediates emotional understanding of the music (Livingstone et al., 2009).

While the available research allows for a strong case to be made about the necessity of either MNS-based or movement-based mimicry as a mediator to emotional understanding in social contexts, it may still be unclear why one would need to simulate an expression in order to understand it. The traditional viewpoint regarding facial expressions is that facial movements occur after, and in response to, an emotion, primarily for emotional communication. However, when Adelmann and Zajonc (1989) reviewed evidence supporting the facial feedback hypothesis, they preferred to call facial expressions "facial efference" in order to avoid using a term that presupposes a function of facial musculature that has not been proven.

It has been suggested that emotional expressions did not primarily evolve as a way of communicating emotions to others (Darwin, 1872; Susskind et al., 2008). The nonverbal expressions that we now use in social communication may have evolved for other adaptive reasons, such as to influence our own emotional responses. For example, making a fear face widens the airways and visual field, preparing a person to react to danger (Susskind et al., 2008). Social communication functions may have come later, developing from a shared understanding of what certain expressions mean (Susskind et al., 2008).

Individual differences

Research on individual differences in empathy supports our theory that activation in the MNS, the tendency to mimic other's movements in daily social exchange, and one's capacity for empathy, are all inter-related (as suggested in Fig. 2). In addition to being more likely to mimic others in regular social interaction (Chartrand & Bargh, 1999), individuals scoring higher than average on empathy scales have higher than average activation in mirror neuron areas during emotion perception (Gazzola, Aziz-Zadeh, & Keysers, 2006). People with autism, a disease involving decreased empathic understanding of others, demonstrate mimicry deficits from an early age (Williams, Whiten, Suddendorf, & Perrett, 2001). They show corresponding dysfunctional activation in the MNS compared to normal individuals (Williams et al., 2001). A nonpsychiatric sample of individuals demonstrating psychopathic tendencies showed decreased motor empathy in the MNS, as measured by motor evoked potentials, toward videos known to normally evoke sensory-motor neuron areas for pain (Fecteau, Pascual-Leone, & Theorét, 2008). These results suggest that psychopathy, a disorder involving decreased empathy, may also involve dysfunctional MNS functioning.

At present, mirroring is practiced by the therapist in DMT as a way to enhance emotional resonance between a therapist and patient, and sometimes is used between patients in group therapy to promote group cohesion (Mills & Daniluk, 2002). While mirroring a client enhances empathy of the therapist for the client, it is also likely to enhance a feeling of connectedness in the client for the therapist (Mills & Daniluk, 2002). In addition to gaining greater understanding for the client, when a therapist mirrors the client's emotional movements, the therapist is communicating this understanding and acceptance nonverbally. We propose that the neural mechanisms involved in this feeling of nonverbal connectedness on the part of the client comes from enhanced MNS activity from viewing one's own movement qualities (conveying mirrored emotional tones/intentions) mirrored back at him or herself.

In addition, we propose that if a patient with a disorder involving empathy were to participate in mirroring practice, and perhaps learn movement analysis in order to aid in mirroring effectiveness, practice mirroring could have rich and extensive clinical applications, in terms of empathy enhancement (Berrol, 2006; Mills & Daniluk, 2002). We propose that mirroring in the context of a therapeutic relationship enhances empathy by increasing activation in the MNS, leading to stronger action-observation connections between motor and limbic areas. As a result, mirroring practice may lead to enhancements in empathy that go beyond the dance session with consequences in everyday life.

Mirroring in DMT versus social mimicry as therapy

Simply practicing mimicry in social interaction may also be an effective form of therapy; however, we suggest that mirroring therapy within the context of a DMT relationship will be more effective for the purposes of enhancing empathic skills in clients. In DMT, the therapist is trained in movement analysis and mirrors not only the exact movements of a patient, but also selects movements that reflect the quality of a patient's mood or disposition and either engages in mimicry of these movements or responds to the patient with different movements that reflect a more global emotion or disposition. In addition, mirroring in DMT occurs in the context of a trusting, therapeutic relationship. In the socio-cognitive neuroscience literature, there is evidence that individuals are more likely to engage in mimicry of each other's movements to enhance social understanding if they trust one another (Van Baaren, Janssen, Chartrand, & Dijksterhuis, 2009). It is thus likely that a client will make greater progress engaging in mirroring practice with a trusted DMT therapist. Additionally, we suggest that the exaggerated, more purposeful, and extended mirroring that takes place during DMT is more multi-faceted and thus allows for enhanced activation of mirror neuron areas compared to simple mimicry of movement in a social setting. Research suggests that when an emotional posture is

exaggerated, embodiment of that posture leads to greater recognition and experience of the associated emotion (Atkinson, Dittrich, Gemmel, & Young, 2004). Some forms of dance, such as modern or contemporary dance, are made up of exaggerated emotional movements (Boone & Cunningham, 1998; Dittrich, Troscianko, Lea, & Morgan, 1996), making these movements prime material for a mirroring session.

Another important distinction between dance movement and mimicry in regular social interaction is the common presence of music in dance. Dancing to music can involve coordination with an external rhythm, which is known to facilitate coordinated movement, for example in Parkinson's patients (McIntosh, Brown, Rice, & Thaut, 1997). Areas of the brain involved in beat perception are known to overlap with movement production brain areas, such as the basal ganglia and supplementary motor area (Grahn & Brett, 2007), and people have a propensity to move in coordinated time with an external rhythm (Bartlett & Bartlett, 1959). Movement to rhythmic music is thus likely to facilitate temporal coordination during mirroring. This should increase the temporal synchrony of mimicked movements or reflected movement qualities with the person being mirrored, and ultimately enhance the emotional resonance to be gained from mirroring.

Since music has been shown to reliably elicit strong emotions (Roy, Mailhot, Gosselin, Paquette, & Peretz, 2008; Witvliet & Vrana, 2007), it can be viewed as a tool for induction of emotion in a training session. The presence of music in dance adds to the authenticity of emotionality which may be difficult to induce in a traditional therapeutic session, especially with patients who have emotion-related deficits. It has been shown that dance steps mirror the emotions of the music they are choreographed to (Krumhansl & Schenk, 1997), making music not only a reliable but relevant emotion induction tool during DMT. In addition, music adds another sensory modality to visual mimicry, possibly facilitating emotional learning through the use of multimodal presentation (Moreno & Mayer, 2007).

A training program for empathy based on dance could consist of a series of mirroring sessions within the context of a traditional DMT relationship, beginning with mirroring highly exaggerated emotional movements supported by congruent mood-inducing music. Initially, the therapist would engage in more exaggerated types of mirroring, and would encourage the client to do the same. As individuals deficient in empathy become able to easily identify the emotions conveyed by exaggerated movements, the level of exaggeration could be reduced, and the music phased out. Eventually, sessions could consist of mirroring and interpreting the emotional qualities that are more typical of regular social facial expression and gesture. This method of successive approximation to a target by scaling down from an exaggerated example is practiced with favorable results in the rehabilitation of patients with post-stroke aphasia using melodic intonation therapy (Schlaug, Marchina, & Norton, 2008).

Depending on the client's disorder, and his or her susceptibility to verbal instruction, patients could also be trained in movement analysis and verbally taught about what different subtleties of movement represent, in combination with the procedures outlined above. However, available research suggests that this is not necessary. Simply viewing someone else mirroring oneself has been shown to enhance prosocial behaviors in autistic children, and to increase one's own propensity to mirror (Adler, 1970). On a neural level, even when autistic children play video games designed to reward them for suppression of the mu rhythm, an 8–13 Hz brain oscillation whose suppression is thought to represent mirror neuron activity, prosocial behaviors are again enhanced (Pineda et al., 2008). These findings imply that, at least in the case of autism, simply engaging in mirroring of a client, and encouraging the client to mirror successively less exaggerated emotional movements should be effective in enhancing the client's ability to empathize through enhanced MNS activity.

In order to determine whether this therapy is effective, research protocols should be in place throughout therapy to see whether the client is improving. Empathy questionnaires can be periodically administered to clients. Additionally, family members can be regularly interviewed in order to determine whether prosocial behaviors are increasing. Experimental data should be compared to a control group who receive no therapy, or an alternate type of therapy, in order to ensure that the differences observed are a result of mirroring therapy specifically.

Review of the literature

Mirroring and dance therapy as treatment

Most research on dance therapy has focused on changes in affect that can come from the practice as a whole, rather than from mirroring specifically (see Ritter and Low (1996) for a review; see also Berrol, 2000; Brooks & Stark, 1989; Erwin-Grabner, Goodill, Hill, & Von Neida, 1999; Koshland, Wilson & Wittaker, 2004; Kuettel, 1982; Siegel, 1995). Ritter and Low (1996) report that empirical research on the topic is lacking, perhaps because many practitioners of arts therapies believe that this type of therapy cannot be measured quantitatively. However, these authors point out that it is important to explore empirically the aspects of dance therapy that are effective, in order to define consistent and effective ways of administering therapy across therapists, and establish dance therapy as legitimate in the medical/scientific community (Ritter & Low, 1996). Berrol (2000) offers a discussion of viable research options for DMT.

While the specific effects of mirroring on emotional understanding are limited, research that has been conducted is promising, and suggests that mirroring strengthens empathy between therapist and client, and between clients (Berrol, 2006; Fraenkel, 1983; Hartshorn et al., 2001; Mills & Daniluk, 2002).

Fraenkel (1983) measured the correlation between empathy and mirroring in therapist/client interactions as well as in friendship interactions. Interactions between two friends, or between a dance therapist and client, were videotaped. These videotapes were rated for the amount of mirroring that took place during the session by two independent raters. One friend, or the client from the therapist/client dyad, was asked to rate the session after watching the videotape for the degree of empathy they felt the other had demonstrated during the session. In both therapist–client and friendship dyads, it was found that the level of synchronous movement was correlated with empathy ratings. Additionally, movement synchrony in friendship dyads was more temporally aligned. This suggests that mirroring in movement is correlated with empathy in regular social interactions, and that the temporal synchrony of mirroring is related to relationship closeness.

Vulcan (2009) reviews the literature on a phenomenon referred to in Dance/Movement Therapy as somatic countertransference, emphasizing the importance of mirroring for the therapist in a DMT setting. Somatic countertransference is defined as "the therapist's awareness of their own body, of sensations, images, impulses, feelings and fantasies that offer a link to the client's process and the intersubjective field" (Orbach & Carroll, 2006). Whereas traditional psychotherapies actively avoid countertransference, emphasizing a detached manner in order to provide professional service to a patient, the Dance/Movement Therapist actively engages in mirroring to enhance somatic countertransference, using it to increase empathic understanding of the client in order to make a more individualized diagnosis and treatment plan (Vulcan, 2009).

Mills and Daniluk (2002) conducted a qualitative research study, interviewing women who sought out dance therapy as victims of child abuse. The women reported having enhanced emotional awareness through movement, and a sense of emotional connection with others through mirroring their emotional movements. The following quotation illustrates the effect dance therapy seems to have had on empathy and emotional unity with others in their study:

> The women also spoke about factors like music and synchronized movement that contributed to a feeling of unity in the group. The participants believed that this connection and intimacy added greatly to their growth and healing through dance therapy, because they felt supported by others and accepted both physically and emotionally within the group. Mills and Daniluk (2002, p.10)

Adler, an early dance/movement therapist, is known for her groundbreaking work with autistic children (Haze & Stromstead, 1994). Documented in a film called "Looking for me", Adler (1970) would conduct early therapy sessions by mirroring the movements of an autistic child in order to demonstrate her acceptance of the child and form a connection with him or her. Eventually, even children with no speech, who had reportedly never engaged in personal relationships, began to express themselves emotionally and confidently through movement (Adler, 1970; Haze & Stromstead, 1994). Footage of more advanced 5-year old autistic children in her group sessions depict one child getting up in the circle to do a vibrant "happy dance", and qualities of the happy movements are visibly mirrored by the other children in the circle. The advancements made with these children exemplify the potential of mirroring to enhance emotion communication skills, even in such a challenged population. These reports suggest that mirroring functions to increase emotional understanding of others, and enhance emotional bonding in the process, making it an important exercise to explore further through research. It is also interesting to note that treatment began with the therapist mirroring the client, and eventually the clients were engaging in mirroring of their own. It appears, then, that an important element of a mirroring training module includes mirroring of the client before the client begins to mirror others, especially in more serious cases.

Hartshorn et al. (2001) examined the effects of an interactive movement session on children with autism. Their movement paradigm consisted of 30-min sessions twice per week for two months, each consisting of a series of movement activities that involved interaction between a trained dance movement therapist and a group of autistic children. Activities involved moving together to a tambourine and stopping when the tambourine stopped, and following the therapist through an obstacle course. By the end of the sessions, participants were spending significantly less time wandering, less time responding negatively to touch, less time resisting the teacher, and more time showing on-task passive behavior. While this study did not directly measure the effects of mirroring therapy on prosocial behaviors or empathy in autistic children, the movement paradigm did consist of movements that involved interaction with or imitation of the therapist, suggesting that a mirroring protocol may elicit similar results.

Imitation therapy in naturalistic environments has also been used successfully in improving prosocial behaviors in autistic children (Ingersol & Schreibman, 2006). In a study by Ingersol and Schreibman (2006), autistic children were trained in imitation skills using familiar and then novel actions involving familiar and novel toys. Imitation training led to enhanced imitation skills that were subsequently applied to novel environments. Increases in other prosocial behaviors such as language, pretend play, and joint attention were also observed following imitation training (Ingersol & Schreibman, 2006). While this study involved imitation of naturalistic action, the ability to generalize trained actions to novel environments is promising in terms of our proposed DMT mirroring training, in which we hope that the benefits of mirroring exaggerated emotional movements can eventually be scaled down and generalized to various naturalistic social settings.

Dance and mirror neurons

Several studies have been conducted that demonstrate increased use of mirror neuron circuitry following dance training (Calvo-Merino, Glaser, Grezes, Passingham & Haggard, 2005; Cross, Hamilton & Grafton, 2006; Orgs, Dombrowski, Heil, & Osmann, 2008). Similar to mirroring in DMT, when a dancer learns a dance from a choreographer, he or she engages in purposeful and extended mimicry of the other's movements. With training, it becomes easier to mimic a series of movements, even if some of the movements are novel. Initial research provides support for the theory that the effects of mirroring in DMT on empathy occur through enhanced use of mirror neuron circuitry. Orgs et al. (2008) measured event-related desynchronization (ERD) in alpha and beta frequency bands in dancers and non-dancers. Reduced power in these rhythmic waveforms is thought to reflect increased processing in the MNS. They found reduced power in these waveforms when dancers, as opposed to non-dancers, watched dance movements, whereas there was no difference between groups while watching regular movements. Calvo-Merino et al. (2005) conducted an fMRI study on dancers, capoeira artists, and inexpert controls who watched videos of ballet or capoeira actions. Each expert group had greater activation in the premotor cortex and superior temporal sulcus toward his/her own movement style as compared to the other two groups.

Cross et al. (2006) demonstrated that this increase seen in mirror neuron activation in expert groups can be manipulated through dance training. Trained dancers learned a set of choreography over a period of weeks, while fMRI scans were taken weekly. Each week in the scanner, participants watched a video of someone else performing the dance that they were in the process of learning. Participants were asked to imagine that they were dancing along with the person in the video. Mirror neuron activation increased as a function of participants' rated abilities to perform the dance outside the scanner, suggesting that the extent of mirror neuron activation while observing dance is related to the extent of dance training.

While the majority of these studies have demonstrated increased mirror neuron activation toward learned dance steps, an important next step will be to include measurement of mirror neuron activation to new dance movements with similar emotional associations following training in dance. This would demonstrate that mirror neuron activation associated with different movements with the same emotional goal can be generalized, as has been shown in movement intention research (Umilta et al., 2001).

Conclusions and suggestions for future research

When we see a person move emotionally, how do we know what they are feeling? It seems unnecessary that we would have a unique brain area, separate from that involved in movement generation, to inform us of others' movement intentions. Instead, the MNS appears to be involved in the production of our own actions, as well as the perception of other's actions and the intentions behind those actions (Rizzolatti & Craighero, 2004; Umilta et al., 2001). In DMT, it seems likely that the process of mirroring, which enhances empathy for others, is mediated by an emotional movement feedback system that involves mirror neuron circuitry. In order to understand another's emotional movements, we activate the neural areas associated with creation of these movements,

which in turn affects the limbic system, enhancing our sensations of the emotions associated with these movements. As a result, we come to better understand other people's intentions by feeling these intentions, or emotions, ourselves.

DMT-based mirroring therapy could be applied to help various patient groups with mimicry or MNS deficits, such as patients with autism (Adler, 1970; Hartshorn et al., 2001; Williams et al., 2001), as well as post-stroke or brain-damaged patients with damage to the MNS. As a promising option that is unlikely to have side effects, mirroring seems like a valuable form of treatment to explore in controlled research studies utilizing behavioral and physiological indices.

Future work should consider the link between mirroring in DMT and empathy, as well as between DMT training and MNS functioning. Our prediction is that mirroring in DMT will enhance empathic understanding and that it will be most effective with music. Finally, long-term studies should determine whether the effectiveness of mirroring in DMT can be generalized over time to enhance empathy in regular social interaction.

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