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Final dissertation

Exploring Dyadic and Triadic Interactions in Dance Movement Therapy: A Mixed-Methods Study Combining Motion Capture and In-Depth Qualitative Insights

Supervisor: Professor Marco Bertamini

Co-supervisor: Dr. Stergios Makris (Faculty of Arts & Sciences – Psychology Department at Edge Hill University, UK)

Professor Valentina Cazzato (Department of Cognitive, Psychological, Educational and Cultural studies at University of Messina, Italy & Faculty of Health – School of Psychology at Liverpool John Moores University, UK)

Candidate: Buse Ufak
Student ID number: 2071331

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* Candidates must also mention the name of the Department of their supervisors if they don't belong to the Department of General Psychology.

** No more than two people.

Abstract

Introduction: Dance Movement Therapy (DMT) is described as a movement-based framework that relies on the connectedness of mind and body, movement as a currency of one's native language, an assessment tool, an instrument of intervention and widely used one of the effective art therapy modalities. However, the important challenge remains in understanding how DMT actually works. Mirroring is commonly used and important technique of DMT practise and the technique involves the therapist's imitation of a client's movements, emotions, or objectives. Synchronisation is a crucial element in mirroring, enabling the effectiveness of the exercise. *Goals:* In this study we aimed to reveal which axes of movements contribute the most (or least) this synchronisation, exploring synchronisation levels and movement characteristics between participants in dyadic and triadic DMT interactions. *Hypothesis:* We hypothesized that (H1) synchronisation levels will vary across the three spatial dimensions (X, Y, and Z axes), (H2) dyadic mirroring tasks will result in greater synchronisation across all axes compared to triadic mirroring tasks and (H3) movement patterns during mirroring tasks will differ between male and female participants. *Method:* Three brief (15-min) DMT sessions were recorded involving one male and one female participant engaging in dyadic and triadic interactions with a DMT psychotherapist using motion capture technology. Furthermore, semi-structured interviews were performed with the participant to illustrate their experiences. The DMT therapist identified the significant moments of the session where the mirroring exercise occurred. Quantitative analysis included cross-correlation, time lag, and Euclidean distance assessments, examining movement discrepancies through velocity, acceleration, and residual measures. Qualitative analysis involved thematic analysis to gain insight into participants' experiences. *Results:* (1) The results showed that the level of synchrony varied in three dimensions; in fact, the results revealed that vertical movements are more salient and easier to mirror in DMT practice, (2) greater synchronisation is found in dyadic intervention compare to triadic setup, (3) lastly significant discrepancies on movements characteristics of male and female participants were observed. *Conclusion:* This study reveals that during mirroring exercise in DMT session, vertical movements are perfectly synchronized, whereas synchronization is less consistent along other axes. Dyadic interactions show higher synchronization levels than triadic ones, and distinct movement characteristics were observed between male and female participants. These findings contribute to understanding synchronization dynamics in DMT and its impact on therapeutic outcomes.

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‘Dance is the hidden language of the soul’ - Martha Graham

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1. Introduction

1.1. The Rhythm of Humanity: Dance Through Time

Dance is defined as the choreographed or spontaneous movement of one or more bodies, either with or without music (Bläsing et al., 2012). The fundamental idea of dance is conscious human intention. Dance experience originates from the processes of moving and giving meaning to movement (Blacking, 1983). Dance is a type of rhythmic movement, usually accompanied by music, used as a means of expressing emotions or ideas (Boing et al., 2017). It can be performed by one person, two people, or a group and usually involves a purposeful movement pattern that has aesthetic value (Fong Yan et al., 2018). Moreover, dance is an enjoyable and captivating exercise that requires emotional, social, cognitive, physical, and visuospatial interaction (Gomes et al., 2020).

Dancing is a worldwide art form that may have originated as early as 1.8 million years ago in human cultures. Dance has always been an integral part of social and cultural traditions, as well as evolving into a form of art and entertainment (Karpati et al., 2015). "Dance" is not simply a product of human creativity in a particular time and place, but a social fact that arises from species-specific capacities, making it a fundamental force of social existence and part of the constitution (Blacking, 1983). In fact, language, dance and music, according to some anthropologists, are aspects of what "makes us human." If dance is uniquely human, as it is primarily a symbolic activity, then dancing may have played a major role in human evolution. According to military historian William McNeill, there may have been two significant changes in human evolution, both of them for better communication. Initially, the dance and its emotional connections; subsequently, well-articulated speech and its symbolic connections, made possible by fully formed language (Grau, 2016).

According to Darwinian theory, dance should be adaptive when demonstrating particular abilities or capabilities helps the performer (Fink et al., 2021). Indeed, several benefits of dance has been reported by many researchers (Burkhardt & Brennan, 2012; Fong Yan et al., 2018; Gomes et al., 2020; Humphries et al., 2022; Kim et al., 2016).

Across all domains, dance is a physical activity and a form of body language that incorporates motor, cognitive, visuospatial, emotional, and social communication (Gomes et

al., 2020). It is an undeniable fact that dance is one of the oldest forms of healing in human history (Koch et al., 2014). Dance has a long history of being used as a healing tool by indigenous cultures in North and South America, Australia, the Middle East, Asia, and Africa. This strategy involves engaging a person holistically and including the community to overcome feelings of helplessness (Hanna, 1995).

Dance benefits the human being at various levels including psychological, physiological, cognitive, spiritual and social (Hanna, 2010). Dancing also improves the immune system and reduces metabolic factors, cardiovascular health as well as pain, neurodegenerative disorders or mood changes. Moreover, dancing contributes to subjective well-being and affective attitude toward the body (Hanna, 1995; Koch et al., 2014). Given these benefits, it is unsurprising that dance is currently gaining popularity as a therapeutic intervention for a variety of clinical populations. These include people with neurological disorders such as schizophrenia and depression, those with neurodegenerative diseases such as Parkinson's disease, and those managing and preventing dementia (Gomes et al., 2020).

In the following section I will explain the special effects of dance on humans as social beings.

1.1.1. The Social Impact of Dance

The social impact of dance on health is profound. Dancing has a socialisation aspect; when people get together to dance, they form bonds with other dancers; alone exercise lacks this advantage (Alpert, 2011). Different dance styles have different socialisation processes, and a person may experience these socialisation processes well into adulthood and old age in addition to during childhood and adolescence (Malkogeorgos et al., 2011).

The social impact of dance was encapsulated in three overarching themes identified in the study by Atkins et al. (2019): (1) Improving Individual Well-Being, (2) Encouraging Interpersonal Relationships and Connections, and (3) Encouraging Community Connections. In their study, participants ages 2 to 79 enrolled in a dance program aimed at improving physical activity in the community. Over five years, more than 500 people participated in the program by participating in weekly dance sessions. Semi-structured interviews were conducted to explore the social effects and benefits of dance. The first response theme was related to well-

being, and participants claimed that they improved their psychological well-being by participating in social networks and building relationships. Responses in the second theme centred around the social relationships and connections that were made where participants shared how participating built new relationships during the dance class with other program members, doctors, physical therapists and outside of courses. The last theme is “Community and Connections.” Participants noted that conducting such a dance program had the ability to help participants generate bonds with one another (Atkins, et al., 2019).

1.2. Dance Movement Therapy (DMT)

Established in 1940 (Cruz, 2016), DMT is a treatment modality that was pioneered by Marian Chace. The claims on which it is built are physiological and a two-way connection between the body and mind. For example, DMT suggests that someone's emotional states manifest to some degree in their physical movements — hence changes in one's movement patterns can then lead to similar changes in their psychological and social experiences (Martinec, 2018). It is widely described as a movement and body-based framework that relies on the connectedness of mind and body, movement as a currency of one's native language, an assessment tool, an instrument of intervention (ADTA, 2014).

The American Dance Therapy Association (ADTA) defines DMT as “the psychotherapeutic use of movement to promote emotional, social, cognitive, and physical integration of the individual, for the purpose of improving health and well-being” (ADTA, 2014). DMT is a discipline within art therapy that has demonstrated efficacy in several studies. For instance, in one meta-analysis conducted by Ritter (1996) suggests evidence of a modest to moderate effect size of DMT for a variety of various client categories and symptoms, including the reduction of anxiety and depression symptoms (Ritter & Low, 1996).

Compared to cognitive and behavioural therapies, where talking is the primary mode of expression and communication, DMT is very different, focusing more on action, observation and sensation of one’s own body. It highlights that communication and expression are primarily achieved via the human body. While nonverbal communication is essential to DMT, verbal communication is also crucial for modifying tasks and interventions to the verbalisation and developmental abilities of the population being treated (Millman et al., 2021). Depending on

the clients, this kind of treatment can be provided in a variety of locations, such as hospitals, clinics, schools, social agencies, volunteer organisations, jails, and assisted living facilities. Sessions take held once a week at a predetermined location and time, lasting anything from thirty to ninety minutes. Depending on the needs of the client, interventions could last ranging from a few weeks to many months. They can be given as individual, couple, or group therapy (Karkou et al., 2023).

By combining dance's natural therapeutic effects into a systematic framework, DMT expands upon these advantages. Although dance as an art form has many health benefits, DMT focuses on therapeutic outcomes by purposefully using movement to address physical, psychological, and emotional problems. By incorporating psychotherapy approaches the therapeutic use of dance movements in DMT enhances the already established benefits of dance (Levy, 1988).

1.2.1. The Evolution and History of DMT

At the beginning of the 20th century, traditional ballet, which adheres to rigid rules, has dominated formal dance in the west. Among the pioneers of early modern dance were Isadora Duncan, Martha Graham, and Doris Humphrey. They emphasised concepts like bodily awareness, spontaneity, and sincerity of expression (Wahlström, 1979). These early dance educators were the first to recognize that the study of dance somehow went beyond technical, intellectual, and choreographic achievements. Their students were developing into their better selves. Consequently, Marion Chase was influenced by the fact that dance could benefit people in various ways, and she began treating schizophrenia patients using dance therapy (Berger, 2012).

During this period, psychopathology and nonverbal components of psychology attracted the focus of various psychologists, and important advances in psychotherapy were also accomplished. The nature of facial and bodily expression was examined from an evolutionary perspective in Darwin's work "The Expression of the Emotions in Man and Animals" (1872). In an effort to establish precise diagnostic standards for assessing the progression of their patients' illnesses, Eugen Bleuler in Switzerland, Jean-Martin Charcot in

France, and Henry Maudsley in England studied the gestures and movements of psychiatric patients (Stanton-Jones, 1992).

DMT was developed as a result of the enormous popularity of psychoanalytic concepts in the first half of the 20th century. Specifically, the idea that unconscious content might be found through dreams, free association, or verbal blunders inspired dance therapists to propose that dance and movement can also serve as a "royal road" to the unconscious (Penfield, 1992). Therefore, dance therapists also believed that through movement, unconscious processes can be investigated (Millman et al., 2021). An example of psychoanalytic influence is Authentic Movement which is also associated with Jungian psychology. However, DMT's development was influenced also by the humanistic psychology movement of the 1950s and 1960s. For example, one method that is closely associated with humanistic thought is the Marian Chace interactive model (Karkou et al., 2023). In addition to the previously mentioned shared characteristics, more specialised, customised interventions could involve the use of metaphors, expression, synchronization in which patients or a patient and therapist execute the same movements simultaneously 'mirroring' in which a patient imitates and replicates the movements made by the therapist or another patient (Bräuninger, 2014).

From a theoretical perspective, DMT is influenced by various psychological theories. For example, in the UK, Karkou and Sanderson (2000) conducted interviews with dance movement therapists who worked in school (N = 16) and other settings (N = 25). The majority of therapists mentioned the following theoretical influences: Bowlby's theory of attachment, Jungian symbol work, psychoanalytic theory, development theories, object relations theory, play therapy, particular DMT traditions, and client-centered therapy. Less important influences included specific dance traditions, Gestalt therapy, behaviour therapy, integrative approaches, eclectic approaches, Kleinian theory, and group analytic theory.

1.2.2. Different Approaches to DMT

Although there are different types of DMT approaches, most of them focus on the therapeutic relationship between the clients and the therapist, and are generally administered in group sessions (Millman et al., 2021).

(1) *Chacian approach:* (with typically a more circular beginning) and a basic part of warm-up, which can later lead naturally in improvisation work according to themes observed from the movement exploration on the warm up. This warm up concludes by a cool down, which may include some discussion of the movement experience to connect the clients verbal world with their nonverbal experience (Solsvig, 2010).

(2) *Increasing awareness of the body*: To increase our perception of how little movements that happen during the day and exploring the theory that bodily sensations could be the source of our emotions;

(3) *Creativity and expression:* The patient creates their own movement sequence based on an internal feeling, potentially utilizing multiple expressive arts modalities in addition to verbal psychotherapeutic techniques;

(4) *Primitive expression:* Use of play, dance, song and percussion rhythms at a symbolic level to promote self-expression and the appropriate mobilization of drives (Margariti et al., 2012).

(5) *Authentic movement:* When one person is moved as the "mover" and the other as the outside "witness," the assumption is that the mover releases his hidden emotions and becomes a witness of himself. Theories suggest that this can be done by noticing sensations, thoughts, and affects as they find new forms of expression in the movement, and by using a mover-witness relationship. This inner listening and becoming one's own witness is inspired by the belief that "after being seen by another, one begins to see oneself" (Karkou et al., 2023; Millman et al., 2021).

1.2.3. Distinguishing General – Recreational Dance from DMT

It is important to distinguish between DMT and "general/recreational dance" as a type of therapy. The definition of dance is choreographed, disciplined rhythmic movement set to music (Boris, 2001). When dance is done recreationally, it can be done at social events, local studios, clubs, or tango, jazz, waltz, foxtrot, belly dance, hip hop, and other dance forms. Unlike recreational or general dancing, DMT incorporates guided emotional expression, a specialised

therapeutic component, and is conducted by experienced dance movement therapists. It also does not usually require music (Haboush et al., 2006).

When DMT was introduced into the field, it opened up a new view for dance therapy. In contrast to aesthetic movement aligned with the rhythms of music like normal dance or choreography, DMT turns the body into an instrument that can explore and understand a person's emotional and psychological worlds. Instead of concentrating on each person's movement particularity for corrective purposes as is done with traditional dance teachers, here people instead focus upon themselves and what they have to say emotionally or physically. Dance provides an opportunity for practice, rehearsal, and the establishment of order. Dance/movement therapy provides a space and framework for clients to engage in improvisational bodily experiences that resonate with them and effectuate transformation in the real world (Berger, 2012).

1.2.4. Benefits of DMT

This section will investigate the different benefits of DMT and compare them with other types of movement-based interventions. I would also focus on the emotional, psychological, social and cognitive benefits, and improvement in physical health.

1.2.4.1. Emotional and Psychological Benefits

DMT has been studied in different populations, focusing on its effectiveness in improving psychological well-being. First, a reduction in anxiety level attributed to DMT and resulting from DMT-induced relaxation was reported by Ritter and Low (1966). In the study of Jeong et al. (2005), which involved mildly depressed adolescents they found that DMT may be useful in reducing emotional distress and positively regulating serotonin and dopamine concentrations in mildly depressed adolescents. Additionally, a systematic review by Kiepe et al. (2012) explored that patients with breast cancer undergoing DMT sessions for some time had significant increases in quality of life, range of motion and positive body image. Dance therapy also reduced psychological distress in patients suffering from depression (Punkanen et al., 2017). It might be plausible that the nonverbal mode of therapy allows for safe emotional expression, particularly in those who are too intimidated to participate in traditional talk therapy or find it unsatisfactory.

However, a review of the literature on the effects of dance (in general, across various forms) reveals that dance itself produces numerous psychological effects on individuals, many of which are quite similar. For instance, it is found that dance have a positive impact on quality of life and reduce clinical symptoms including anxiety and depression (Karkou et al., 2019). Improvements in affect, body image, positive mood, and subjective well-being have also been noted (Koch et al., 2014). Another example is a study by Humphries and colleagues, who implemented an online dance intervention with healthy adults during COVID-19 crisis and found that online dance courses improved participants' mental health by increasing positive emotions and self-esteem and reducing negative emotions and depression.

Another way to think about the benefits of dance is that dancing is a mind-body activity that improves blood flow to the brain, gives one a way to express emotions, fosters creativity, and has a socialising effect that reduces stress, depression, and loneliness. Just as dance is a miraculous remedy that eliminates stress and tension, it is also seen that stress reduction is achieved by the dancer staying in the moment while performing the routines (Alpert, 2011).

On the other hand, it is reasonable to consider that dancing, like other forms of physical exercise, may have positive effects on mood. Therefore, it would be useful to examine the mood-boosting benefits of dancing as a form of exercise. For example, it is well known that exercise causes a surge of endorphins, which may be why people who exercise report feeling happier; dancing also causes a similar type of mood-boosting response (Alpert, 2011). Apart from this, compared to other physical activities, dance is a multimodal artistic practice that combines elements of the creative, rhythmic, social, emotional, motor, sensory, and cognitive processes. This allows us to view dancing as a more complex kind of exercise (Humphries et al., 2022). Indeed, research indicates that dancing could be more effective than aerobic exercise in promoting brain plasticity and potentially preventing or delaying mood or cognitive impairments in the healthy, elderly, and other clinical populations (Müller et al., 2017).

However, it is important to consider how dance itself differs from other movement-based interventions, such as sports or exercise. Understanding these distinctions is important to understanding how DMT stands apart from other movement-based activities. This may be important because dance, DMT, and various forms of physical activity have shown positive effects on individuals' psychological well-being. Given that these interventions independently produce similar benefits, the question arises as to whether the therapeutic component of DMT

is the primary factor contributing to these results. It is possible that the direction of movement itself is responsible for producing comparable effects, as suggested in the previously mentioned studies. Therefore, separating the authentic therapeutic value of DMT from the general benefits of movement remains a challenge in understanding its true impact.

In this context, there is a clear gap in the literature regarding randomized controlled trials that explore the comparative effectiveness of DMT and other movement-based interventions. This lack of rigorous studies makes it challenging to fully understand whether the therapeutic components of DMT offer distinct advantages over other forms of physical activity in enhancing psychological well-being. In this regard, there is one randomised controlled trial conducted by Ho and colleagues (2018) that explore the beneficial differences between DMT, exercise and a wait-list group for older adults diagnosed with dementia. Both DMT and exercise interventions lasted 24 hours each and were of similar intensity over 12 weeks. Self-report questionnaires on psychosocial well-being, daily functioning, neurocognitive testing, and salivary cortisol levels were completed by each participant at baseline and three times after the study period. The results showed that the DMT group improved in diurnal cortisol slope, daily functioning, and significant reductions in depression, loneliness, and negative mood. However, there were no significant effects on outcomes in the exercise group. The above results seem to point to extra benefits for DMT over exercise in the everyday, psychosocial, and neuroendocrine domains when compared to the null results for exercise intervention. When the two interventions were directly compared, it was clear that DMT produced the desired results in terms of lowered levels of depression, loneliness, and Behavioural and Psychological Symptoms for Dementia (BPSD) as well as enhanced mood, verbal fluency, backward digit span, and ‘Instrumental activities of daily living’ (IADL).

1.2.4.2. Social and Cognitive Benefits

Beyond emotional benefits, DMT also may foster social and cognitive growth, especially when sessions are conducted in a group setting. For instance, in the meta-analysis of Koch et al. (2019), they showed that skills like the therapeutic relationship, group cohesion, and (non-verbal) communication may be especially enhanced by DMT and dance. While social skills are primarily studied in children with Autism Spectrum Disorder (ASD), Down syndrome, or Attention Deficit Hyperactivity Disorder (ADHD), cognitive skills are predominantly studied in the elderly population due to their decreased cognitive abilities. The

meta-analysis by Koch et al. (2019) also found that cognitive skills are improved through DMT interventions.

However, the similarities in the effects of physical exercise, dance, and dance movement therapy raise the question of whether these benefits are primarily associated with DMT or which aspects are uniquely authentic to DMT. Because it is also known that dancing exercises help people heal in a variety of ways. Dancing in a group breaks social and emotional barriers, takes people out of isolation, and produces the positive emotions that come from being with other people (Aktas & Ogce, 2005). This in turn highlights again the fact that there are no randomized controlled trials, particularly no ones that have investigated social and cognitive benefits from DMT.

1.2.4.3. Physical Health Benefits

First, studies focusing on the physical health effects of any dance intervention showed that dance, even at an amateur level, has positive health benefits for people of all ages. For example, dancers have been shown to have better cardiovascular fitness, core strength, dynamic balance, and bone mineral content (BMC) compared with non-dancers. Additionally, dance interventions may help youth reduce their body mass index (BMI) from high risk to normal ranges (Fong Yan et al., 2018).Moreover, dance has the potential to serve as a form of "vaccination" or preventive medicine by teaching people how to manage, recover from, or prevent chronic fatigue, headaches, and other symptoms of stress; similarly, exercise has been linked to the prevention of conditions such as osteoporosis, non-insulin-dependent diabetes, heart disease, obesity, and hypertension (Hanna, 1995). Dancing is a great kind of exercise since it improves flexibility, muscle strength and tone, endurance, balance, and spatial awareness. It also makes you feel good overall. Dance is a continuous motion that can burn 200–500 calories in an hour, depending on the distance (number of steps measured with a pedometer) covered (Alpert, 2011; Keogh et al., 2009).

Considering the specific effects on our physiological body, most dancing steps involve side-to-side movements that support and strengthen the weight-bearing femur, tibia, and fibula. Certain dance styles involve repetitive motions like hip drips, figure eights, circles, and shimmies that can stretch the hip and lower back ligaments and joints to their maximum potential. This improves posture and muscular tone, which helps to prevent lower back issues

(Alpert, 2011). Indeed, since dancing has the potential to enhance muscle tone, flexibility, balance, coordination, and it helps the healing process of some injuries and it may also lessen or even eliminate pain (Hanna, 1995).

However, in DMT, instead of learning steps to music, participants are encouraged to engage in movement that is essentially creative and takes place within an embodied therapeutic interaction. They are also encouraged to engage in movement initiation and cessation, rhythmic diversity, and a range of speeds. Therefore, it is reasonable to anticipate benefits beyond those associated with physical activity or dance classes. It has been suggested that DMT, as a complex and comprehensive intervention, may stimulate various domains such as physical, emotional and cognitive performance (Karkou et al., 2023).

It is a well-known fact that being physically active improves motor skills, coordination, and overall physical fitness, which tend to decline with aging or in cases of dementia (Lam et al., 2018). Therefore, it may be useful to investigate the use of DMT in these populations to assess its physical health benefits. For example, a systematic review revealed that DMT improves gait, balance, and overall disease status in patients with Parkinson's disease (PD) (Wu et al., 2022). Another study evaluated the effect of DMT on individuals with Parkinson's disease and showed improvements in walking speed in the treatment cohort as opposed to the exercised control group (Westbrook & McKibben, 1989).

To summarize, DMT provides multiple benefits in the emotional, social, cognitive and physical aspects. Although research has emphasized its beneficial impact on quality of life, social activities, cognitive function and physical health; challenges remain to differentiate the therapeutic value of DMT over others forms of movement-based interventions. Therefore, there is an obvious need for randomised controlled trials in order to understand more clearly unique effects of DMT on the above-mentioned aspects.

1.2.5. Significant Moments/Moment of Interest (MOI) in Therapy Sessions

Over the last thirty years a great deal of research has been focused on DMT and its effectiveness, scope for change etc., with numerous publications, reviews and meta-analyses outlining evidence (Conceição et al., 2016; Karkou et al., 2019; Koch et al., 2019; Ritter &

Low, 1996; Sharp & Hewitt, 2014). In particular, a great deal of research has been done on the effectiveness of DMT in treating depression (Karkou et al., 2019), with the conclusion being that it is effective.

Yet, the main focus of psychotherapy research within DMT has been whether a particular therapy is beneficial, with an emphasis on confirming the efficacy of treatment approaches. This has been implemented in a realistic setting in randomized controlled trials (Ho et al., 2018). Validations of efficacy are beneficial for a variety of reasons, but they leave therapy as an unexplored mystery with little knowledge of how and why it functions.

The critical mechanisms that contribute to good results are not well understood, but in the tradition of change process research, we must look at processes rather than just comparing outcomes if we wish to understand more about how treatment functions (Elliott, 1985). In light of this, numerous studies have come to the conclusion that brief therapy extracts can provide a more comprehensive insight of the therapeutic process. Therefore, in change process research, meaningful moments are a useful study object because they enhance our comprehension of therapeutic change (Hilzinger et al., 2021).

These brief moments within therapy sessions, where the change process occurs are referred to in the literature by various terms, such as ‘Moment of Interest’ (Fachner et al., 2019), ‘Significant Moments’ (Campbell et al., 2003), ‘Meaningful moments’ and ‘In-session events (Hilzinger et al., 2021). For the coherence in the study, we will use the term of ‘Significant Moments’ to refer to these instances moving forward.

1.2.5.1. Definition, Purpose and History

Those interest points might be indicating some track of future therapy development, an illustration for a case session between therapist and client or a critical change in behaviour due to more important imagery / insight process. In other words, some of the therapy is considered a gauge as to how clients are able to help themselves at different stages of their therapy (Fachner et al., 2019).

The new paradigm largely built upon the extant literature on change processes in psychotherapy by identifying and providing a thorough review of particularly significant events

that occur during therapy (Hilzinger et al., 2021). Nonetheless, interest in their research has increased and gained significance over the years, resulting in a substantial number of theoretical and empirical conceptualisations (Duarte et al., 2019).

The research area of change processes in psychotherapy has developed from different theoretical backgrounds resulting in diverse approaches to specifying, understanding, and analysing relevant events. Such methods include viewing of recorded sessions, transcription, and in-depth interviews with participants (Hilzinger et al., 2021). This pivotal moment paradigm, primarily formulated by Robert Elliott, has been employed to enhance researchers' comprehension of certain events or therapeutic procedures. A wide range of subjects has been explored in interview research, encompassing clients' accounts of misunderstandings, moments of insight, beneficial events, challenging reaction points, and effective interventions by therapists. Extensive research has been undertaken regarding the perspectives of both clients and therapists on significant occurrences (Levitt et al., 2006).

Expanding upon theory related to significant moments as turning points in therapy, the identification of these moments is very important as well. While in this section the theoretical bases and significance of those moments to promote therapeutic change has been addressed, the next section will illustrate how therapists and researchers are able to identify possible significant moments during a session for further examination in order to process them later on.

1.2.5.2. Selection of Significant Moments

Therapists typically use specific segments from one or more sessions to illustrate a story of therapeutic change processes in therapy (Fachner et al., 2019). A case study often presents a singular first-person perspective (from the therapist) regarding the therapeutic process, together with a selection of significant and noteworthy events from a session or a series of sessions (Grocke and Moe, 2015).

However, to examine certain components of the process in greater detail, employing selections and evaluations from other therapists or non-therapists to get a level of content validity for the selected components would be another option. Enquiring solely with the therapist may result in ignoring additional aspects of the therapy (Fachner et al., 2019). For example, in the study conducted by Fachner et al. (2023), three music therapists, including the

therapist who attended the session, served as raters. They watched the recording and selected the three most engaging moments (MOIs), short segments of the session that they deemed important in terms of therapeutic content. They also found three Moments of No Interest/Less Interest (MONI). They concentrated on the intersections of these segments throughout the remainder of the investigation. Similarly, Campbell et al. (2003) identified significant events from family therapy sessions. Several therapists were present, each selecting certain instances for their treatment sessions and discussing them using organised questions, such as, "What factors influenced your choice of this moment as significant?"

On the other hand, there are other studies addressing the client's perspective on their own significant moments. For example, in the study conducted by Hilzinger et al. (2021), they identified and clarified significant events within the framework of systematic psychotherapy, taking into account both the patient's and the therapist's perspectives. Researchers conducted an interview and posed questions such as, 'Was there any moment you considered significant?'. Following qualitative assessment, they discerned significant instances. In addition to that there are also studies that take 3 perspectives. For example, Altimir and colleagues (2010) examined three viewpoints in identifying 'significant moments': clients, therapists, and observers. In addition, consensus was sought on these patterns and therapeutic outcomes. To identify client changes, follow-up interviews were conducted with both therapists and clients, asking questions such as ‘Did you observe any changes during therapy?’ Observers reviewed the video recording of the session, used the outcome questionnaire, and examined the correspondence of the content of the moments of change with the therapeutic outcome.

1.3. The Effectiveness of DMT

The effectiveness of DMT has been studied in a variety of research involving patients with different medical, neurological, and physical conditions. Typically, these studies assess mood or well-being scales, depression scores, or other psychological measures before and after the intervention (Millman et al., 2021). Multiple primary meta-analyses have been conducted to assess the effectiveness of DMT for different conditions. First, I will summarize the findings of these studies in general.

Ritter and Low's, one of the first meta-analyses in the DMT literature, provide compelling evidence for the possible efficacy of dance/DMT as therapies for depression and anxiety. Their study examined the effects of DMT on various demographics and diseases (Cruz, 2016). Although Ritter and Low did not look specifically at depression, they found that DMT greatly increased psychological change, particularly the reduction of anxiety and anger. It was also shown that DMT has positive effects for children, adolescents, adults, and psychiatric patients (Ritter & Low, 1996). Later, Cruz and Sabers (1998) compared the meta-analysis's findings with those of meta-analyses of alternative treatment modalities, such as medical treatment, exercise, cognitive-behavioural therapy, and medical meditation techniques, and discovered that the spectrum of outcomes from DMT treatment is almost identical to other treatment modalities.

Koch et al. (2014) have conducted another meta-analysis, where the main goal was to assess the impact of Dance Movement Therapy and therapeutic use of dance on mental health existing issues. In fact, through the results of their research, they claim that dance and DMT show effectiveness as interventions across a range of clinical contexts. It has empirical evidence showing the improvement in mood, affect, body image, well-being and a decrease in anxiety and depression (clinical outcomes). With respect to health-related-symptom-psychological outcomes, DMT was broadly supported as a moderate evidence-based intervention. This investigation adds further weight to the use of DMT and dance as a beneficial, successful therapeutic intervention in treatment and prevention. In 2019, they conducted another meta-analysis, including 41 trials with a total of 2374 participants, examining the impact of dance and DMT therapies on psychological outcomes connected to health. They replicated most of their previous findings, concluding that DMT and dance are beneficial for a number of health-related outcomes (Koch et al., 2019).

Karkou et al. (2019) conducted another meta-analysis, which included data from eight studies involving 351 participants, aiming to examine the efficacy of DMT in treating people with depression. They came to the conclusion that DMT is a useful intervention in the treatment of adult depression based on research with moderate to high quality.

There are also Cochrane reviews on the effectiveness of DMT for different client groups, however they include very limited number of studies due to strict inclusion criteria

(Meekums et al., 2015). In these systematic reviews, there is an emphasis on RCTs, however due to the limited number of RCT studies in the field of DMT, the issue remains evident.

Conversely, the meta-analysis conducted by Koch et al. (2014) incorporated a greater number of studies outside RCTs. Among the 23-research analysed, ten studies comprising randomised controlled trials and controlled trials incorporated assessments of depression (total scores or subscales). A mild impact of DMT and dancing on depression was observed. Furthermore, in addition to the diverse research methodologies, the populations were also heterogeneous (not limited to depression only) and the therapies encompassed all forms of dance practice (not just DMT) (Karkou et al., 2019).

1.3.1. How Does DMT Really Work?

Although there are a limited number of RCTs and we cannot be certain which specific components of DMT contribute to helping individuals overcome their problems and improve their well-being, there is still a significant body of research demonstrating its effectiveness. However, understanding how DMT actually works remains a significant challenge. Therefore, in this section, I will first explain the different components of DMT from a neuropsychological perspective and discuss possible reasons behind its potential effectiveness. Second, in the following section, I will discuss how neuroscientific studies can help us learn more about the mechanisms that make DMT beneficial.

Starting with the psychological contributions of DMT, the aforementioned Cochrane Reviews identified several potential reasons why DMT is particularly useful, especially for treating depression (Meekums et al., 2015).

The first reason of DMT's effectiveness in treating depression is about its dance and exercise components. The authors examined the possible role of dancing as a fundamental element of DMT to foster vitality and even joy in clients who, due to their depression, exhibited a lack of animation (Karkou et al., 2019). The authors examined the possible role of dancing as a fundamental element of DMT to foster vitality and even joy in clients who, due to their depression, exhibited a lack of animation. Additional arguments can be presented concerning dance participation, attributed to physiological responses linked to exercise, including the

release of endorphins, the augmentation of chemical neurotransmitters (Jola and Calmeiro, 2017), and the active involvement of nearly all brain regions (Bläsing et al., 2019). The beneficial impact of music and music therapy on reducing depression levels has been established (Aalbers et al., 2017). Although music is not a core element of dance practice in a DMT context, its consistent inclusion may serve as an adjunct component to the primary essence of dance for this client population (Karkou et al., 2019).

Another potential advantage of DMT is gained through the therapeutic relationship between therapist and clients, particularly through one of the most important techniques of DMT; mirroring. The therapeutic relationship, along with its psychotherapeutic intent, distinguishes DMT from general dances like tango, salsa or ballroom dancing (Karkou & Sanderson, 2000). In DMT, the therapeutic connection may manifest as an embodied relationship, especially evident in the model established by Chace. The technique of mirroring is commonly employed in this discipline to enhance embodied interactions (Karkou et al., 2019).

Another benefit of DMT is the fact that this intervention may serve as an effective remedy due to its ability to access unconscious, inaccessible, or taboo emotions and thoughts. Imagery, symbolism, and metaphors are essential helps in the DMT experience. Active imagination facilitates the exploration of challenging emotions such as anger. Consequently, imagination may serve as a medium for articulating challenging emotions and, using symbolism and metaphor, facilitate their processing in a secure manner, ultimately leading to resolutions of one's intrinsic challenges (Karkou et al., 2019; Karkou & Sanderson, 2000; Meekums et al., 2015). This argument posits that DMT may exert significant and enduring effects.

In 1985, Schmais contended that the integration of mind and body is a crucial therapeutic element for DMT. Integration can occur by contemplating moving material that may or may not align with one's own thoughts and emotions. Investigating novel and unforeseen relationships among familiar concepts, that is, participating in a creative process (Karkou & Sanderson, 2000) may also possess an integrative nature. Ultimately, capturing one's therapeutic experience through a movement sequence or a symbolic posture or gesture serves as a vital and powerful reference to the therapeutic process. The establishment of connections among the body, thoughts, and emotions is crucial for individuals with depression,

who may encounter a disjunction between their feelings, thoughts, and actions (Karkou et al., 2019).

In summary, there is an extended list of benefits from DMT, especially for individuals encountering emotional, interpersonal or other problems. But without looking at how it affects the body from a psychophysiological perspective, we won't fully understand the underlying mechanisms that underlie these benefits. So, in the next section, I'll look at DMT from a neuroscientific perspective to gain a clearer understanding of its effects on the brain and mental health.

1.3.2. Neuroscientific Insight to Dance and DMT

There has been a great deal of research into the effects of dancing and DMT and the possible reasons for these positive results. However, while numerous studies have looked at the behavioural basis of both, only a small number have examined the neurological basis (Karpati et al., 2015). Therefore, a widely discussed but unresolved question in contemporary research is: What are the precise neural mechanisms by which dance/DMT produce its positive outcomes? Or in another word; what the human brain is really doing when dancing heals people. In the following section, first I will explore potential positive benefits of dance on brain function by focusing on neuroscientific studies that explore its effects on the brain. Then, secondly, I will shift to a more detailed neuroscientific analysis of DMT and neurocognitive mechanisms mentioned in several studies related to DMT practice.

1.3.2.1. The Neuroscience of Dance

First of all, in the literature it is suggested that dancing speeds up and creates new connections in the ageing brain (Burzynska et al., 2017). According to one study, engaging with DMT improves prefrontal and temporal brain activity, which is linked to enhanced memory, enhanced multitasking and planning skills, and imroved attention (Alpert, 2011). That is maybe why on the study by Verghese and colleagues (2003) found that dancing may help older people avoid developing Alzheimer's disease and other types of dementia. According to their 21-year study, 75-year-olds who read, danced, played board games, or picked up an instrument once a week had a 7% decreased chance of acquiring dementia. Participating in these activities at least eleven times a month decreased the risk of dementia in participants by

sixty-three percent. According to Verghese et al. (2003), this is because dancing music keeps the dancer's mind active.

On the other hand, studies conducted with healthy populations are also aligned with these findings. For instance, the effects of 16.5 years of ballroom dancing (1.33 hours per week) on sensorimotor and cognitive abilities were examined by Kattenstroth et al. (2010). A comparison was made between twenty-four amateur dancers, aged 61 to 94, and age-matched non-dancers in terms of lifestyle, motor, tactile, balance, cognition, and reaction time. Almost all tests showed that the dance group performed better than the control group, and individual analysis showed that there were no individuals with poor results in the dance group. In another study by Coubard and colleagues (2011), they demonstrated that, in contrast to motor-skill learning such as fall prevention training or Tai Chi Cuhan, high attentional dance improvisation enhances attention switching in older individuals. With beneficial effects in everyday life, contemporary dance improvisation may be a useful strategy to increase cognitive flexibility, which is known to deteriorate even in highly functioning older persons (Kupis et al., 2021).

Neuroscientific research has further revealed the effects of dance on the brain. Dance activates multiple brain regions, including motor control, sensory processing, and emotional regulation. This may arise from the fact that the senses of vision, hearing, touch, smell, and kinaesthetic are often involved in dance. Therefore, dancing could offer someone an absorbing multidimensional experience. In the complex process of self-expression, the intricate fusion of movement, rhythm, and music uses both the right and left sides of the brain at the same time (Hanna, 1995).

For instance, in the study of Kim et al. (2016) they found that the dancer group showed increased functional connectivity in many brain regions such as the right cingulate gyrus or right medial frontal gyrus, compared with control subjects.

On the other hand, studying the neuroscience of dance offers a unique opportunity to examine brain plasticity and how it interacts with behaviour, which can help us understand brain-behaviour links better (Karpati et al., 2015). In addition to these studies, numerous scholars have examined the function of the putative mirror neuron system (MNS) in dance. Action Observation Network (AON) is a brain circuit in humans that is similarly triggered when someone performs or just watches an action. There is evidence to show that the brain

regions responsible for perceiving and producing movement overlap with the areas involved in understanding movement intention. It is believed that AON activity during emotional movement execution or observation increases limbic system activation, which increases empathy (Gomes et al., 2020), which might have a positive impact on interpersonal relationships.

1.3.2.2. Cognitive Mechanisms of Dance Movement Therapy

There has been numerous research that seems to support DMT for all the outcomes but despite this, there appears to be no connection between its modern scientific theoretical concepts (Millman et al., 2021). Therefore, in this section I will focus on two fields of investigation regarding the effects of dance expertise on embodied cognition and interoception which might broaden our understanding about mechanisms underlying DMT.

1.3.2.2.1. Embodied Cognition

Embodiment can be defined as 'mental representations in bodily forms that significantly influence cognition (Goldman & Vignemont, 2009). Indeed, cognitive neuroscience work suggests that dance expertise affects a variety of cognitive functions, including embodiment (Bläsing et al., 2012). For example, dancers use a method known as ‘marking’ to improve recall of movements in long-term memory. Marking is the repetition of a sequence of movements in a reduced way, for example, using the hands to execute a sequence of movements that is usually performed with the feet. This is an example of bodily cognition in action: choreographers encode gestures through movements, and dancers train their memory and skills by memorizing these movements (Millman et al., 2021).

Another important related term is proprioception, which refers to the awareness of one’s bodily positioning in space, has been demonstrated to be influenced by dance expertise (Jola, Davis & Haggard, 2011). Compared to controls, dancers showed superior ability to align with a target location via their proprioceptive awareness. The authors suggest that dancers have less need for visual information than non-dancers, facilitating the incorporation of proprioceptive information to guide body movements. Dancers show greater interoceptive accuracy, indicating a heightened awareness of the body. Interoceptive accuracy was assessed between professional ballet dancers and a comparable control group of non-dancers through a heartbeat

detection task, indicating that dancers possess enhanced interoceptive accuracy (Garfinkel et al., 2015).

Ultimately, dance training improves performance on mental rotation tasks (Jansen, Kellner & Rieder, 2013). In this study, one group of young people received five weeks of creative dance training while the other group attended physical education classes. Mental rotation performance was assessed before and after training and revealed that children in the creative dance group showed superior development in mental rotation abilities compared to those in the physical education group.

Experience or expertise in dance appears to influence various cognitive-perceptual functions, positioning dancers as specialists in embodied cognition (Warburton et al., 2013). While DMT interventions may not achieve expertise levels comparable to professional dancers, numerous studies indicate that dance training can alter behaviour and brain function within weeks, and occasionally within days of practice (Kirsch & Cross, 2015; Cross et al., 2009). Consequently, it is possible that certain benefits of DMT are facilitated by the mechanisms outlined above and increased bodily awareness (Millman et al., 2021).

1.3.2.2.2. Interoception

A phenomenon that has received significant attention in recent years, and may be essential in comprehending the effects of DMT, is interoception. Interoception means the awareness of one's own body and its internal conditions (Tsakiris & De Preester, 2018). The body-to-brain signalling axis, coming from internal bodily and visceral organs, is closely associated with concepts and methodologies related to embodiment (Hindi, 2012). Herbert and Pollatos (2012) propose interoception as the essential characteristic of human embodiment, asserting that interoceptive states serve as foundational elements that contribute to the essence of the 'self', which has roots in the body.

DMT relies on the assumption that physiological and psychological or emotional alterations mutually affect each other (Koch & Fischman, 2011). Damasio and Carvalho (2013) propose that alterations in the body cause both involuntary physiological reactions and emotions, referred to as 'mental experiences of body states'. Any deviations from homeostasis are identified by the interoceptive system, with sensations subsequently described in relation

to one's internal condition. A fundamental aspect of DMT is the awareness and attentiveness to one's own body, including its physiological and psychological sensations and limitations. Engaging in interoception by noticing and observing physical sensations, focusing on specific body parts, breathing, and muscle tension can increase bodily awareness. Therefore, increasing this interoceptive awareness through interaction with DMT practice may offer another explanation for its benefits.

1.3.2.3. The Neuroscientific Perspective on DMT

As discussed in the previous chapter, DMT has been shown to be effective for various mental health problems, as evidenced by several meta-analyses. However, the key question remains: what is actually happening in our brain when we benefit from dance movement therapy? While it is possible that some underlying mechanisms are similar to those of dance in general, the more important question is identifying the specific mechanisms that are unique to DMT. In the following concepts, I will explore the relationship between DMT and neuroscience in more detail.

1.3.2.3.1 Brain Plasticity

One of the important neuroscience discoveries that underpin DMT include the understanding of the brain's plasticity and the ways in which experiences can alter how it functions (Berger, 2012). Neuroplasticity indicates that brain networks respond to external and inherent changes. Research examining neuroplastic alterations linked to the acquisition and execution of motor tasks has demonstrated that engaging in these activities leads to heightened neural activation in certain specific brain regions (Teixeira-Machado et al., 2019). Since, in the practice of DMT, therapists often encourage clients to discover new ways of moving, this may also lead to the formation of new connections in the brain. Further, DMT is thought to help integrate the left and right hemispheres of the brain and be a tool for accessing and processing body-based memories (Homann, 2010).

1.3.2.3.2. Polyvagal Social Engagement System

Another neuroscience theory that informs DMT is Porges' polyvagal social interaction system (Porges, 2001). This offers an interesting authentic view to earlier established ideas on the sympathetic and parasympathetic systems.

Porges claimed that the body uses a hierarchy to respond to safe of potentially dangerous environment. It explains how the vagus nerve (which is our longest nerve and is in charge of regulating the balance of the autonomic state and linking your brain to all primary internal organs such as the heart and lungs) does its job. This view advances the idea that the nerves two branches serve different functions: one is alerting us to threats by mobilizing our freezing system, (an older more primitive response), and then there is a second section of this nerve that serves in sooth inducing actions as well as for social communication. Perhaps this newly discovered level of social interaction system may occur only when a nervous system perceives its environment as safe (Dunphy et al., 2015).

This theory offers unique considerations for managing body-stored trauma and cultivating a felt sense of safety through DMT and other psychotherapy approaches. For example, Dance Movement Therapist Gray found the Polyvagal Theory extremely inspiring to her work with clients that are extensively dissociated due to severe traumatic history (Gray & Kennedy, 2023). With an emphasis on unlocking the body with breath to reactivate the body so that clients can feel safe. This recovery of somatic agency allows the client to again transit through stillness and go from freeze to quiet, embodied movement back towards social engagement (Dunphy et al., 2015).

1.3.2.3.3 Action Observation Network

The action observation network (AON) indicates a neural network that is active when we observe the movements of other individuals and makes it possible for us to understand and empathize people, their actions and intentions. Given its importance in social bonding, it is of particular relevance to practices such as DMT, which focus on our connections with others. Many explanations of the AON imply that visual information is converted by forward connections, progressing from low-level representations of movement kinematics to high-level representations of the intentions underlying the action (Neal & Kilner, 2010). Derived from the theoretical basis of the AON, kinaesthetic empathy complements this explanatory model by offering an experiential realization of these neural functions in practice. Whereas the AON lays out a neural explanation for how we process other peoples' movements via scientific terminology, kinaesthetic empathy reveals what that means in human terms and everyday physical reactions.

The kinaesthetic empathy and the firing of mirror neurons that are integral to this system demonstrate how observing movement can have a profound emotional and biological impact on us, despite our being in repose. The explanation of the constituent elements in DMT and how they offer insight into movement, emotion and therapeutic processes will be described in the sections that follow.

1.3.2.3.3.1. Kinaesthetic Empathy

Have you ever experienced strong feelings while watching a dance performance? The term “kinaesthetic empathy” has been used in dance research to characterize how some audiences respond to dance. Viewers often report feeling as if they are part of the dance they are watching, experiencing movement and associated emotions and thoughts even when they are sitting still. This type of response has been described as kinaesthetic empathy (Jola et al., 2012). And the associated emotional impact is triggered by this kinaesthetic response. The work of dance critic John Martin, who also coined the term “inner mimicry,” has played a significant role in shaping the idea of kinaesthetic empathy. By engaging in this "inner mimicry," viewers would feel if they were actively taking part in the dance and personally feeling all of the emotions and movements that go along with it (Reason & Reynolds, 2010).

Dance movement therapists have been using techniques like kinaesthetic empathy for decades. The discovery and articulation of mirror neurons as the neurological underpinning for emotional cognition provides a theoretical rationale for these practices (Berger, 2012). Studies conducted on monkeys revealed that when movement was executed, specific brain cell groupings were stimulated (Rizzolatti et al., 1996). This happened both when the animals were moving that specific way on their own and when they saw other monkeys moving in the same manner. It was also recognised that the observation of emotions worked in a similar manner. Therefore, mirroring in DMT is thought to improve comprehension of other people's emotional intentions by optimising the activity of ‘Mirror Neuron Circuitry’ (Dunphy et al., 2015), which is subset of ‘Action Observation Network’.

This raises the second question: How is it possible that simply observing movements can reveal such deep inner feelings? Findings from neuroscientific studies help us understand how this interaction process occurs.

1.3.2.3.3.2. Firing Mirror Neuron

As mentioned earlier, the discovery of mirror neurons has revealed that watching movement triggers extra actions in motor areas, the area of the brain that controls movement (Wildschut, 2008). After analysing this finding, the researchers hypothesised that the mirror neurons form a system that synchronises the observation and performance of motor motions (Di Pellegrino et al., 1992). These innate mirroring abilities help in explaining the nature of the systems behind emotional, kinaesthetic, and social cognition and understanding (Gallese, 2006).

Another question is whether these mirror neurons play a role in establishing the therapeutic relationship between clients and therapists during DMT: When therapists move in sync with their clients or simply watch them move, similar brain neurons (mirror neurons) are activated in both. This creates a bond between them. They understand each other better and build a stronger therapeutic relationship (Berrol, 2006). Therefore, in DMT, the ‘Mirroring’ technique is an important method for improving the understanding of the emotional intentions of others by increasing the use of the AON (Gray & Kennedy, 2023).

The investigation of mirror neurones is very relevant to dance/movement therapists as it offers empirical validation for the mirroring technique employed in their therapeutic practices” (Berrol, 2006). “Mirroring” is a technique commonly utilised in dance therapy, defined as the phenomenon where two individuals execute analogous body motions that are synchronised or subtly repeated in timing (DeSouza & Barnstaple, 2019), which will be explored in the next chapter.

1.4. Mirroring: When We Are Seen by Someone Else

Mirroring is a very effective and widely used method among Dance Movement therapists. Mirroring theory has been used in developmental psychology to emphasize the importance of being "seen" by the mother or primary caregiver to an infant's development. The concept of “being seen” for an infant's development by the mother or primary caretaker. Winnicott emphasises the significance of the mother's look towards her new-born as an act that establishes, delineates, and reinforces the infant's existence (Winnicott, 1971). According to

Meekums (2008), the mother's mirroring provides the new born with an understanding of a largely unfamiliar world, so facilitating their co-creation of the universe they live. The reciprocal gaze between mother and new born is essential for the infant's well-being and significantly influences its subsequent development. The quantity and quality of mirroring experienced in infancy will influence our adult relationships with the external world.

Similarly, founder of DMT, Marian Chace's technique incorporates the mirroring intervention during the initial phase of a DMT session, specifically in the warm-up segment. Through kinaesthetic and visual means, she observed the patients' non-verbal messages, simultaneously conveying in a non-verbal manner, "I understand you, I hear you, and it's acceptable" (Karampoula & Panhofer, 2018). The therapist engages with the client by mirroring certain qualities of their movement, without replicating every detail. The mirrored aspects are frequently intuitively selected, yet may hold specific significance for the individual involved (Meekums, 2008). The mirroring technique in DMT embodies a dynamic dialogue between the therapist and client or among peers in a group, serving as a channel for the uninhibited examination of previously unaddressed material (Karampoula & Panhofer, 2018).

In the following sections, I will examine the mirroring technique in more detail, focus on DMT sessions, their effects and benefits, and finally, touch on neuroscientific insights into the mirroring technique in DMT.

1.4.1. Mirroring in DMT

Mirroring, commonly used as a component of DMT, are perceived by both practitioners and clients to enhance an individual's ability in emotional understanding and empathy towards others. Mirroring involves the therapist's imitation of a client's movements, emotions, or objectives, and is frequently employed to strengthen the therapist's empathy for the client (McGarry & Russo, 2011). Therapists in DMT also use mirroring to increase emotional resonance between themselves and their clients, when used practically and applied as an element of the therapeutic relationship or within patients in a group setting to enhance group cohesion (Mills & Daniluk, 2002).

These practical approaches highlight important themes that correspond to the integration of body-oriented interventions aimed at achieving a therapeutic effect: i) an emphasis on the mind-body connection, ii) improving movement capacity and diversity in movement patterns, iii) normalising physical relationships with oneself and others, iv) incentivize novel relationships by embodying movements (Martinec, 2018). DMT exercise routines such as mirroring, reflection, body symbolization, and exploration of various bodily experiences are used to elicit movements that embody emotions. The therapist helps the client access emotions and memories stored in the subconscious while also helping them verbalize the symbolism or narrative of an action. In such circumstances, one gains self-awareness and comprehension (Martinec, 2018).

With the mirroring there are often problems with initiating movement because they have developed defence mechanisms and the freeze response from trauma. They, however, augment self-awareness by intentionally re-enacting movements and concluding the narrative of a painful experience with favourable results. The therapist mirrors the client's movements for some discovery of physical potential and demonstrates a capacity for self-empowerment and resilience that the therapist herself is aware of. In a social context, mirroring creates opportunities to develop a comfortable connection with others (Mintarsih & Azizah, 2020).

1.4.2. Implementation of Mirroring in Therapy

Mirroring is practised when two people momentarily mirror each other's body positions, movements, or perhaps eye contact during an interaction. The therapist may mirror the exact movements of a patient or copy the qualities of that motion; for example, if a patient has poor posture, he might try to also make this observation through his movement too (McGarry & Russo, 2011). For the therapist, mirroring is a way of encouraging clients to attune themselves to their own bodily movements and expressing an interest which might lead them to further explore the sensation, affect image or memory which has been generated by a movement (Roderick, 2024).

The DMT therapist is skilled in movement analysis, capable of examining a client's movements and replicating specific movement features. At the highest level, the client may be unaware of the imitation, while at the most apparent level, precise movements are replicated or

movement patterns are amplified. The result is a more understanding and embodied therapist. The client may be prompted to practise mirroring to foster empathy towards others. DMT therapists believe that mirroring has a significant impact on enhancing empathy (Berrol, 2006).

1.4.3. The Effectiveness of Mirroring and its Benefits

As we argued before, mirroring is one of the great techniques utilised in DMT. Being in tune with another person's movements may help you access emotions that you never did before and maybe express them and this might eventually lead to better connection between everybody. At the same time, mirroring contributes greatly to developing empathy by allowing people to feel and empathise with what others are experiencing. The next segments will be based on this topic showing how emotional awareness and empathy skills can be enhanced by the power of mirroring.

1.4.3.1. Emotional Awareness: Recognition, Contagion, Connection and Expression

In recent years, the association between emotional processes such as emotional recognition, contagion, connection and expression and therapeutic interventions has gained popularity, within different therapeutic approach including also DMT, especially with the utilization of mirroring technique (Berrol, 2006; McGarry & Russo, 2011; Mills & Daniluk, 2002). Therefore, I will dive more into what benefits mirroring in DMT could have on these emotional processes and therefore its therapeutic potential.

First of all, starting with emotional recognition and understanding, the mirroring technique used in DMT helps individuals become more aware of their own emotions. For example, in the study of Mills and Daniluk (2002) who performed a qualitative research study by interviewing with several women who pursued dance therapy as survivors of child abuse. At the end of the intervention, the women indicated an increased emotional awareness via movement and a sense of emotional connection with others by mirroring their emotional expressions.

Mirroring also enables individuals to express their emotions and create more stronger connections with others. For instance, this has been studied with autistic children in the study of Adler (1970), who often face significant challenges in expressing their emotions and forming

interpersonal bonds with others (Vaisvaser, 2019). Adler, a pioneering dance/movement therapist, is recognised for her innovative contributions to the treatment of autistic children (Haze & Stromstead, 1994). In the film "Looking for Me," Adler (1970) conducted initial treatment sessions by copying the gestures of an autistic youngster to exhibit acceptance and establish a connection. Ultimately, even nonverbal children, who had reportedly never participated in interpersonal connections, commenced expressing themselves emotionally and assertively through movement (Adler, 1970; Haze & Stromstead, 1994). Video recordings of more advanced 5-year-old autistic children during group sessions illustrate one youngster rising within the circle to perform an exuberant "happy dance," with the characteristics of these joyful motions being clearly reflected by the other children in the circle. The progress achieved with these youngsters illustrates the capacity of mirroring to improve emotional communication abilities, even within a disadvantaged demographic. These reports indicate that mirroring functions helps emotional comprehension of others and facilitate emotional bonding (Mintarsih & Azizah, 2020).

In addition, numerous studies have demonstrated mirroring, often termed imitation, as the most efficacious element within DMT and a valuable instrument for improving communication skills beyond DMT (Field et al., 2001; Field, 2017; Heimann et al., 2006; Koch et al., 2015). Additionally, this approach fosters relationships between individuals and therapists and between groups. According to Gro and Weibull (2005), mirroring enhances social understanding, trust, and therapeutic interactions between individuals through nonverbal communication.

However, we remain intrigued by how the mirroring technique in DMT effectively enhances communication skills and ultimately enables individuals to form stronger connections across diverse populations. The details of the mirroring technique provide a comprehensive answer to this question. DMT therapists participate in a mirroring process with their clients, sometimes matching or echoing specific movements, and at other times echoing aspects of motions that reflect their emotional tones. For example, two persons might walk using the same steps, but one may engage in stiffer movements while the other's may be more fluid, representing more nervous or calm emotional states. In a DMT session, the therapist duplicates the quality of a client's motions in order to relate to the client and develop an empathic discourse. The therapist is trained to pay attention to the client' movements on a very sensitive level. Mirroring can also take the form of copying the intentions behind one's motions, as when

a therapist copies a posture or general emotional quality behind a series of movements, rather than exact motor movements themselves. It appears possible 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 strengthening of emotional connections following a DMT session (Berrol, 2006; McGarry & Russo, 2011).

We can therefore conclude that the nuances of the mirroring technique and the concept of being seen by others not only increase individuals' awareness of their own emotions, but also their ability to understand and express the emotions of others, ultimately resulting in stronger bonds between people.

1.4.3.2. Improving Empathy Skills

First, starting with the definition of 'empathy' in this context, it is a deep, intellectual understanding of another person's emotions or motivations. Empathy allows an individual to take another person's perspective in order to see the motivations behind their behaviour more comprehensively; in essence, "experiencing their emotions''. Titchener (1909) first described empathy as employing "the mind's muscle" to project oneself onto another individual to comprehend their emotions. Empathy has been intrinsically linked to motor mimicry from its inception, although science has only lately started to validate this connection (McGarry & Russo, 2011).

Although the precise effects of mirroring on emotional comprehension have been shown in many studies mentioned above, existing research is encouraging and indicates also that mirroring enhances empathy between therapists and clients, as well as among clients in group sessions (Berrol, 2006; Fraenkel, 1983; Mills & Daniluk, 2002). For instance, Fraenkel (1983) assessed the association between empathy and mirroring in both therapist-client interactions and friendships. Videotaped interactions occurred between two friends and between a dance therapist and a client. Two separate evaluators assessed the videotapes based on the extent of mirroring observed during the session. One participant, or the client from the therapist/client dyad, was requested to evaluate the session after viewing the videotape, specifically about the level of empathy exhibited by the other throughout the session. In both therapist-client and friendship dyads, synchronous movement levels were connected with empathy evaluations. Furthermore, movement synchrony in friendship dyads exhibited greater

temporal alignment. This indicates that movement mirroring is associated with empathy in typical social interactions, and that the temporal synchrony of mirroring correlates with the intimacy of relationships as well.

Mirroring a client not only improves the therapist's empathy but also fosters a sense of connectivity in the client towards the therapist (Mills & Daniluk, 2002). By mirroring the client's emotional expressions, a therapist not only enhances their comprehension of the client but also conveys this understanding and acceptance through nonverbal communication (McGarry & Russo, 2011).

McGarry and Russo (2011) proposed a neuropsychological model that incorporates motor simulation and the mirror neuron system to explain the advantages of mirroring in Dance Movement Therapy (DMT) on empathy. Motor simulation between individuals can replicate another's emotional movements in similar motor regions of our own brain. This enables an individual to express their emotions while performing the action. In summary, mirroring may improve empathy and facilitate more robust action observations by enhancing activation in the mirror neurone system (McGarry & Russo, 2011).

Hence, in the section below, I will support this evidence for effects of mirroring especially on empathy with a neuroscientific perspective, focusing on the AON.

1.4.4. Neuroscientific Theories Supporting Mirroring

Mentioned above, the research is growing that brain circuitry called the mirror neuron system (MNS) becomes equally activated when one performs or sees another perform an action (Gallese, 2006). This has caused some researchers to speculate that the movement making and movement perceiving systems are governed by a common set of basic operations. This system seems to be responsive to the intentionality of movement (Rizzolatti et al., 1996), exhibiting similar responses to various movement patterns when the purpose is clearly identical (Mintarsih & Azizah, 2020). Such similar firing patterns for the same neurons provided further evidence that mirror neurons are involved in processing intentions (Umilta et al., 2001).

On the other hand, other studies also revealed that neural substrates of empathy were represented in the activity patterns of human mirror neurons (Carr et al., 2003; Keysers, 2018). For this reason, the MNS is believed to be involved in directly generating actions of our own and understanding the actions of others: their underlying intentions (Rizzolatti & Craighero, 2004; Umilta et al., 2001). Hence, McGarry and Russo (2011) proposed that in DMT, the enhancement of empathy for others appears to be facilitated by an emotional movement feedback loop including mirror neuron circuits. To understand another person's emotional expressions, we activate the brain regions associated with the generation of those expressions, thus affecting the limbic system and enhancing our perception of the emotions associated with those expressions. Therefore, they suggested that mirroring practices could "exercise" mirror neuron system function, thereby increasing the potential for empathy. To the best extent of the word, we can understand more about how and what others feel better through performing those or similar feelings.

Since both the mirroring technique and the DMT practice itself are rooted in non-verbal interaction, in the following chapter I will explore various methods that can be utilized, both qualitatively and quantitatively, to assess non-verbal, movement-based interactions.

1.5. Methods for Measuring Non-Verbal, Movement-Based Interactions

Technology has expanded the capability for studying non-verbal interactions, and a lot of integrated research tools have been used to analyse these interactions even more. For instance, Over recent years a variety of movement libraries have been developed helping to delve in more detail into any movements, how they are perceived and how it helps us communicate but also contribute significantly to our well-being (Christensen et al., 2019, 2023; Orlandi et al., 2020; Smith & Cross, 2023). These libraries vary greatly in the category and complexity of motion they capture, some focusing on gaits and others individual body parts movements (e.g., simple arm movements like pointing, waving or taking/grasping).

The presentation of visual information regarding the body differs with some utilising full video recordings for illustrating movement, while others represent the human form with a reduction of superficial visual details, such as rendering human movement as Point Light Displays (PLDs) (Smith & Cross, 2023). In the following section, I will provide a more detailed

exploration of these movement libraries. As there are yet no libraries that deal specifically with dance movement therapy, I will only look at general dance movement libraries.

1.5.1. Dance Movement Libraries

Over the past ten years, a cognitive science of dance has emerged and developed. Dance has been utilised in investigations that examine the brain underpinnings of movement perception, emotion perception, and as a source of aesthetic pleasure (Bläsing et al., 2012). Stimulus materials have varied significantly based on the distinct study subject and objectives (Christensen & Calvo-Merino, 2013). This impairs the comparability of results across investigations and achieving of unified conclusions. In pursuit of experimental control, researchers have employed movements that significantly deviate from the true essence of dance (Christensen et al., 2014).

Therefore, over the last 10 years, various dance movement libraries containing a substantial number of stimuli have been developed, utilizing standardized coding methods. I will explain the creation of the stimuli for these libraries in the upcoming chapter, starting with The Warburg Dance Movement Library (The WADAMO) and presenting the process in chronological order.

1.5.1.1. The WADAMO Library (2019)

The WADAMO Library created and validated by Christensen and colleagues (2019) is a study that aims to understand the emotional body language of dance movements by removing facial information and recording clips without music. The library focuses on expressivity as the main variable of interest for dance movements, rather than creating different emotional categories. The study aims to provide a contrast between expressive and not expressive movement. The library includes three stages: the stimuli creation process, the validation experiments, and the overall discussion and conclusion.

In the stimuli creation stage, two female and two male professional dancers were asked to bring dance sequences of ballet and contemporary styles and they are filmed one by one while performing dance sequences. They were instructed to portray each dance sequence both technically correct and deprived of any expressivity, as well as with expressivity, in several

repetitions. So, dancers showed similar sequences first with full of emotional expression, and later without any emotional expression. The raters of the WADAMO Library rated the clips consistently for expressive and not expressive movements. Hence at the end, the WADAMO Library contains 234 visual stimuli of dance movement sequences and they are divided into two categories: expressive and not-expressive versions.

The library could be useful for cognitive science and psychology research, as it addresses the question of whether authenticity matters in interpersonal communication. The study provides valuable insights into the expressiveness of dance and dance-related tasks (Christensen et al., 2014).

1.5.1.2. Dance Movement Stimuli by Orlandi and Colleagues (2020)

In their work, they concentrated on the influence of kinematic complexity on the aesthetic appreciation of human movement. They altered kinematic complexity by directing a professional dancer to perform nuanced alterations in movement time for otherwise similar segments of the same choreography. They documented 24 dance video clips, consisting of 12 excerpts. A professional male dancer executed movement patterns. Every sequence was documented twice. In one series of movies, the dancer was directed to execute each move in the proper order while sustaining a consistent speed throughout the entire sequence (uniform kinematics). In the second batch of recordings, he was instructed to execute the identical sequences, but this time to accentuate dynamic variations in movement speed (varied kinematics) to create more pronounced instances of acceleration and pause.

The final stimulus set had 12 pairs of movies depicting the identical movement sequence executed in two distinct manners. In the ensuing editing process, all videos were muted and transformed into greyscale (Orlandi et al., 2020).

1.5.1.3. The McNorm Library (2023)

The Motion Capture Norming (McNorm) library created by Smith and Cross (2023) and it consists of 73 emotionally expressive dance sequences of ballet and contemporary dance movements. These dance sequences have been recorded while a professional dancer performing identical choreography but each time with different emotional intention: non-expressive, happy, sad, angry and fearful.

During the filming stage, she performed 17 different sequences after placing a total of 39 retroreflective markers on her body. This led them to record her body parts while moving and reach more objective data at the end. They also conducted a validation study by asking observers whether the emotional intention of the dancer can be also conveyed to viewers of these sequences (Smith & Cross, 2023).

1.5.1.4. Five-Emotions Stimuli Set from Christensen and Colleagues (2023)

This study is also another study that focuses on emotion recognition in dance movement stimuli. To create the stimuli, a dancer created a sequence of 30 dance movements. Five of the 30 sequences were Western classical ballet, while the rest were Western contemporary dance. The duration was eight beats in dance theory, approximately 8 seconds. The dancer executed each routine five times, switching emotional expressivity with each repetition: joy, fear, rage, sadness, and neutrality. The stimuli excluded facial information, costumes, and music. And in total they created 173 video clips, each 6 seconds in duration, featuring a white silhouette dancer against a black background (Christensen et al., 2023).

In the following section, I will examine how these dance movement stimuli have been applied in a variety of contexts within the dance movement literature, each with different goals.

1.5.2. Exploring Various Studies and Their Focuses on Dance Movement Stimuli

The literature on dance movement stimuli aims to explore various aims to understand the effects of these stimuli. These include likability, aesthetic judgment (Orlandi et al., 2020), emotional expression (Christensen et al., 2019, 2021), emotion recognition (Christensen et al., 2023; Smith and Cross, 2023), as well as trunk velocity and trunk acceleration of these motion stimuli (Punkanen et al., 2017), movement speed, smoothness, entropy (Orlandi et al., 2020), whole-body kinematics (Bigand et al., 2024), postural synchrony, gestural synchrony, gestural sequential connectivity, orientation (Hartmann et al., 2023), and trunk orientation, temporal connectivity, spatial connectivity, vertical head movement (Hartmann et al., 2023). To review these areas in a more standardized manner, I will categorize them under two main sections: one focusing on subjective measurements and the other on objective measurements.

1.5.2.1. Subjective Measures: Emotional Expressivity, Emotional Recognition, Liking, Aesthetic Appreciation, Beauty, Enjoyment

In the upcoming section I will describe different aspects of dance movements and the implications when they are shown to viewers. First, The Emotional Expressivity distinguishes genuine expressive versus non-expressive movements, which is informed by studies in art and dance (Calvo-Merino et al., 2006; Daprati et al., 2009). The Emotional Recognition dimension examines how observers can identify specific emotions when it is communicated through dance, verifying it with dance movement libraries (Smith & Cross 2022; Christensen et al. Liking, Aesthetic Appreciation, Beauty and Enjoyment explore how movements are perceived based on kinematic features or emotional intentions (Orlandi et al., 2020; Christensen et al., 2023). Finally, Similarity and Interaction analyses contrast how the motion of each dancer is an element of their relationship with one another (Hartman et al., 2019; Hartman et al., 2023). These measures combined give insights into the emotional and aesthetic aspects of dance movement.

1.5.2.1.1. Emotional Expressivity

The differentiation between genuinely expressive dance movements and those that are only technically accurate yet lack expressiveness is informed by art theory, art history, dance history, and pedagogy. In these domains, academics differentiate between expressive and formalist art. Expressive art and dance stem from an internal condition, physical sensations, or the artist's and dancer's expressive aim. The beauty of the artwork or dance are merely a by-product and not the primary focus of the artist or dancer. In contrast, formalist art and dance primarily focus on the aesthetics of lines and shapes, exhibiting no concern in emotional expression (Calvo-Merino et al., 2006; Daprati et al., 2009). Therefore, Christensen and colleagues (2019) proposed a movement library that delineates the distinction between expressive movements and non-expressive motions, as its stimulus creation was mentioned above.

In the study of Christensen et al. (2019), they validated The Warburg Dance Movement Library (WADAMO) which includes 234 video clips of dance movements in 2 categories; one version of movements is emotionally expressive and other is not expressive. In validation of expressiveness, results confirmed that non-dancer participant could rate expressive versions as more expressive compared to those without emotional expressive motions. For the stimulus

validation experiment, 160 participants aged 18–34 participated in two online surveys to rate expressiveness. Participants were asked to rate the dance clips on the basis of "how expressive were the dancer's movements to you?" and the final question asked participants how much they liked the dance video clips.

The results confirmed that individuals without dance expertise were sensitive to the expressiveness variable. They rated dance movements designed for expressiveness as more expressive than those not designed for expressiveness. Additionally, participants perceived contemporary dance movements that were expressive as more aesthetically pleasing and showed greater interest in them than in contemporary dance movements that were not expressive. In contrast, participants perceived expressive ballet moves as equally attractive and had the same appreciation for them as for non-expressive ballet movements.

They also later replicated their study and found consistent results with the previous study and also participants enjoyed the expressive full-body movement clips over the non-expressive ones and found the expressive clips were more expressive (Christensen et al., 2021).

Taking steps beyond mere expressiveness, other academics have advanced the field by exploring whether movements can convey specific emotions to the observer, rather than simply being classified as emotionally expressive or not. As a result, they have developed dance movement libraries designed for emotion recognition.

1.5.2.1.2. Emotional Recognition

To begin with, Smith and team as mentioned above generated a dance movement library, called The Motion Capture Norming Library (McNorm) to establish whether observers consistently identified the emotion expressed by the dancer. Every movement sequence required five repetitions, intended to evoke a different emotion in the audience (happy, sad, angry, scared and neutral) with all the same choreography as stated above. Results indicated that on average participants recognized intended emotion from motions within the McNorm library 48.96% of the time (Smith & Cross, 2023).

In another study of Christensen and colleagues (2023), they created a new set of stimuli in highly control environment. A professional dancer performed thirty sets of dance moves five

times each, representing different emotions with each repetition: joy, fear, rage, sadness, or neutrality. The results were consistent with the study of Smith et al. (2023), demonstrating the intended emotion was identified more clearly than chance.

Additionally, in a very new study by Christensen et al. (2024), they created a pilot dataset, consisting of brief dance choreographies, performed multiple times by a dancer who conveyed various emotional intentions at each iteration: anger, contentment, fear, joy, neutrality, and melancholy. The dataset was concurrently filmed professionally and captured via XSENS® motion capture technology (17 sensors, 240 frames per second). The movies were given in four distinct visual formats for emotion recognition: (i) avatars, (ii) full-light displays (FLDs) with obscured faces, (iii) point-light displays (PLDs), and (iv) silhouettes. Participants viewed the stimuli sequentially and assessed the feeling they identified initially. The results showed that a significant main effect of visual presentation was observed; FLD representations best in emotion recognition, succeeded by avatar movies, silhouettes, and PLD. The emotional stimuli of the categories anger, contentment, joy, neutrality, and sadness were recognised above chance level; however, fear was not.

Beyond the recognition of emotions involved in movements, there is also another important field of research targeting the understanding of how much observers like these movements as well as why they appreciate them.

1.5.2.1.3. Liking, Aesthetic Appreciation, Beauty, Enjoyment

What defines a beautiful movement? Research in dance aesthetics is mainly focused on the subjective aspects of moving movements, such as sensory experience and knowledge about the movement being observed, rather than the more formal aspects such as motion speed/acceleration form (Orlandi et al., 2020). In contrast to this view, Orlandi and his colleagues conducted their research study on the aesthetics of dance by looking at whether manipulations in speed and acceleration for an audience affect one's pleasure with regard to specific versions of these movements. A total of 24 dance video clips were videotaped, with 12 segments performed by a professional male dancer. Each segment was taken twice: first at uniform speed (uniform kinematics) and then again at varied velocities (dynamic kinematics). The final stimulus set included twelve pairs of movies showing the same movement sequence performed in two different ways. They found, however, that dance sequences displaying

diverse kinematic profiles were considered more pleasant than were identical sequences showing a more uniform kinematic profile.

There are different factors that influence aesthetic appreciation, enjoyment, and liking beyond only considering the kinematic features of movement, such as speed, as highlighted in the study by Orlandi et al. (2020). For instance, the dance style or expressiveness of the dance figures may also influence how spectators perceive and react to a performance. Differential beauty ratings have, as an example, recently been reported in the WADOMO study by Christensen et al. (1) between contemporary modern dance and ballet characteristics. Ballet movements revealed that both expressive and non-expressive movements were judged as equally attractive. However, in contemporary dance, expressive movements were found to be more beautiful than non-expressive ones (Christensen et al., 2019).

The emotional intention of the performer is yet another important facet that needs to be taken into account when evaluating the beauty of dance movements. The study, for example, by Christensen et al. (2023), investigated aesthetic evaluations of dance movements and reported that whether a movement was intended to convey joy, anger, fear or none related emotions influenced the aesthetics scores judgments: Joy was judged as more beautiful than anger which in turn was considered more attractive than fear and neutral states; sadness was rated more positively than fear but lower compared with joy and neutral states.

The last example--and maybe a key factor in whether we like to watch dance performances is whether the male and female dancer or two-person dance team (a type of dance) is in sync itself. Synchronicity enhances the aesthetic experience by bringing about a sense of harmony among performers, all of which can greatly influence how an audience sees and enjoys what they see. Similarly, to this, Cross et al. (2024) duplicated the influence of synchrony and gaze direction on the perception of togetherness through behavioural assessments. It was anticipated that participants would attribute the greatest significance to aesthetic assessments and evaluations of togetherness when dyads moved in synchrony and faced one another. Results indicated that participants assigned higher ratings of togetherness to video displays featuring dyads who either faced one another or moved in synchrony. Participants rated synchronous dance movements more favourably than asynchronous ones, with no effects of gaze direction on overall enjoyment ratings.

1.5.2.1.4. Similarity and Interaction

Another dynamic area of research in dance is the exploration of similarity and interaction. Similarity can be examined from both qualitative and quantitative perspectives. In this section, I will focus on how these concepts are studied using subjective measures. For example, Hartman et al. (2019) examined in their study similarity and interaction by investigating their specific relationship. This study demonstrated what kinds of dancing movements correlated with the feeling of dyadic interaction and similarity. Dyads were instructed to dance freely to music while their movements were documented by full-body motion capture. Following this, in two distinct trials, viewers were asked to watch silent stick figure animations of these recordings and to judge the interaction and similarity between the dancers. Concurrently, a blended methodology combining qualitative and quantitative analysis identified four distinct movement properties (temporal coupling, spatial coupling, torso orientation, and vertical head synchrony). Their results showed that the way dancers position their torsos, specifically by facing each other more directly, is a strong indicator of perceived interaction between them, even when considering other factors. In contrast, the degree to which dancers move together in time and space—known as temporal and spatial coupling—better reflects how similar they appear to an observer.

Another study by Hartman et al. (2023) focused on interactions between pairs. This time, their study aimed to predict how people judge the connection between dance partners based on their body movements and gestures. By analysing silent stick figure animations of dancing couples, they focused on three key features: how their movements relate to each other in time, how synchronized they are, and how much one person follows the movement pattern of another. These three features were taken from the kinematic data in order to present an explanation of observers' perceptions as to the connection between the dancers. They found that when the dyads mirrored each other movements horizontally, they were scored by observers as being more like each other and having higher interaction.

In conclusion, subjectively characterized dimensions of dance movement research – such as emotional expressiveness and recognition or aesthetic appreciation, beauty, enjoyment or similarity – provide important clues into how various aspects of dance impact on observer perceptions and experiences. Work from Christensen et al. (2019), Christensen et al. (2023), Christensen et al. (2024), Orlandi et al. (2020), and Smith and Cross (2023) illuminates that

intended emotion, expressive dynamism, and synchronized collaboration among dancers heavily influence our evaluations. Results illustrate the relevance of subjective, emotional- and aesthetic-like factors in the assessment of dance movements and their effect on observers.

1.5.2.2. Objective Measures: Synchrony, Speed & Acceleration, Orientation & Complexity

The next steps focus on how movement, especially its kinematic features, associate with emotion and social dynamics in dance. Speed & Acceleration, examines how emotional states relate to the velocity of movements and Synchrony looks at how well dancers are able to move together which has an impact on social bonding among participants as well as audience enjoyment (Chartrand & Lakin 2023). Taken together, these results underline the importance of kinematic parameters and synchrony for communicating emotions and establishing social bonds in dance settings.

1.5.2.2.1. Speed & Acceleration

An important question in the study of movement and emotion is whether emotional states can be inferred from kinematic variables such as the velocity of movement. It has been demonstrated in various studies that arousal level is notably correlated with movement velocity: emotions such as anger, joy, and excitement are associated with rapid movement, whereas sadness and tiredness correspond to slower movement (Amaya et al. 1996; Castellano et al. 2007; Paterson et al. 2000). Additionally, it has been also shown that valence is especially manifested in posture: open and upright postures are associated with good emotional states, whereas forward-leaning and closed postures correspond to melancholy, embarrassment, and boredom (Castellano et al. 2007; Coulson 2004; De Silva and Bianchi-Berthouze 2004).

In order to investigate this phenomenon more objectively, Punkanen and colleagues (2017) conducted a motion capture study aimed at examining the effects of depression on participants' movements, with a particular focus on the speed of these movements. In their study they focused on specific kinematic features such as the velocity and acceleration of the torso, the separation between the hands, the distance between the feet, the cumulative distance travelled by all body parts, as well as the dimensions of the floor space within which each participant. Participants diagnosed with depression exhibited reduced movement, slower velocity, diminished acceleration, and more constricted postures, with only minimal alterations

in their movement patterns when expressing various emotions, in contrast to the control group. These results indicate that depression impairs emotional expression through movement by diminishing movement expressivity. Especially the mean speed of the torso was much lower for sadness and tenderness in comparison to joy and anger.

Studies in this field are still developing. For instance, a pilot dataset is provided by Christensen et al. (2024) including brief dance choreographies, each performed several times by a dancer who conveyed varying emotional intentions during each repetition: anger, contentment, fear, joy, neutrality, and sadness. The dataset was simultaneously filmed professionally and captured via XSENS® motion capture technology (17 sensors, 240 frames per second). For the first time, thirty-two statistics derived from twelve kinematic features were extracted offline into a single dataset: speed, acceleration, angular speed, angular acceleration, limb contraction, distance to the centre of mass, quantity of motion, dimensionless jerk (integral), head angle (relative to the vertical axis and the back), and spatial parameters (convex hull in 2D and 3D).

1.5.2.2.2. Synchrony

Movement synchronisation, or motor synchrony, occurs when two or more persons align their motions in time and space (Chartrand & Lakin, 2023; Bernieri & Rosenthal, 1991). Extant evidence indicates that both spontaneous and induced synchrony can result in heightened prosocial behaviours, improved feelings of connection (Hove & Risen, 2009), affection (Miles & Nind, 2009), rapport (Vacharkulksemsuk & Fredrickson, 2012) and intimacy towards one's synchronised counterpart (Chartrand & Lakin, 2023). In addition to the socially relevant advantages for synchronised individuals, observers of synchronous movements derive enhanced satisfaction as the level of synchrony increases (Vicary et al., 2017; Moffat & Cross 2023). Given the numerous beneficial aspects of synchrony, it may be valuable to explore this phenomenon further, particularly through the use of more objective data.

For instance, Bigand et al. (2023) researched main motivation of the interpersonal synchrony in their study. They stated that the synchronisation of a dyad's dance is influenced by both musical stimuli and interpersonal adjustment. The synchronisation of motions (kinematics) varies when influenced by music as opposed to interpersonal adaptation. The whole-body kinematics of dyads performing with free dance styles at a 'silent disco' were

thereby recorded. They manipulated musical input (whether participants were dancing to identical, synchronous music) and visual contact (whether participants could observe their dance partner). Later, they evaluated which principal movements (PMs) were synchronised in these two scenarios. Their results implied that among all PMs, interpersonal synchronisation comes sooner in the music-driven contexts. Collaborative musical engagement or visual interaction via eye contact increased interpersonal synchronisation among different PMs. On the other hand, the researchers identified a spatial organisation of synchronisation; partner-driven synchrony was lateral, and music-driven and hybrid synchrony were anteroposterior and vertical, respectively.

Another study by Moffat et al. (2024) investigated the relationship between dyadic levels of embodiment, movement synchronization and complexity in a mirror game. It explores how beliefs about physical activity and sensitivity to internal bodily signals are related to movement synchrony and complexity. The study involved dyads playing a mirror game, with each participant leading the game for 2.5 minutes. Both players' arm movements were recorded using GoPro cameras. The study examined the relationship between movement synchrony and complexity during a mirror game and two measures of dyadic embodiment, body competence and body perception. The results confirmed the expected positive association with body competence, but no evidence for the expected negative association with body perception. The study also found no evidence to support the relationship between movement synchrony and complexity over a prolonged mirror game. The study further supports research findings that expert dancers and improvisers, whose work or recreational activities involve controlled but creatively expressed motor activity, are more synchronized in movement than non-professionals.

A final but more relevant study was conducted by Prakash and colleagues (2024) on interpersonal synchrony. This study investigated the effect of group dance therapy (DMT) on interpersonal synchrony (IS) among middle school students. The intervention was 10 weekly 50-min group DMT sessions. Techniques included mirroring, synchronous rhythmic movement, movement biography, group sculpture, and dance choreography. The researchers used an accelerometer that could record objective data on IS development to fit the participants. IS was measured by observing and collecting both rhythmic (RS) and spatial (SS) components of synchrony during group interactions. Additionally, two Certified Movement Analysts used Laban Movement Analysis (LMA) to assess interpersonal synchrony among the participants.

The raters watched the videos independently from different camera angles, unaware of the time points of data collection. They recorded RS and SS at the same rates and re-watched the videos together to reach consensus when disagreements arose. The results of groups 1 and 2 showed a significant increase in RS, while a significant decreasing trend was seen in SS for groups 1 and 3. This can be attributed to the role of music in RS, as music greatly supports RS. In comparison, SS requires not only visual but also verbal signals from the movement leader. Similarly, the comparison of RS-biometric data and observational data yielded parallel results.

In sum, these studies suggest that the synchrony of movement does indeed deepen the bond between interactants and improve their rapport, and it also heightens viewing pleasure for those who watch such performances. Future research using more objective measures will give a deeper understanding of synchrony's actual mechanisms and its effect on both participants and audience.

1.6. Conclusion

The comprehensive literature on DMT and its neuroscientific bases indicates the existence of multiple approaches by which DMT affects health and well-being. The universal art form of dance offers so many social, psychological, physiological and physical benefits. Already, they suggest that beyond the general benefits of dance practice, these things can positively impact on health conditions when integrated into the structured therapeutic framework of DMT. In DMT research, the question is not whether it helps but how does it help for healing different challenges.

Findings from recent neuroscience research are revealing the brain mechanisms that underlie these health-promoting effects of DMT. Some studies look at the activation of many different brain areas in dance, while other put an emphasis on the mirror neuron system, that is so key when it comes to connecting and developing empathy in therapy. Knowing that the reason DMT is such a transformational experience, partly due to these mechanisms has become pivotal to explaining the effects of it.

However, over the past 30 years there have been attempts to identify important moments that happen during therapy sessions—key instances where something significant

occurs for patient benefit—in order that change processes in different therapies can be better understood. In spite of the above-mentioned evidence, and the effectiveness of DMT, there is not much research into the "Significant Moments" within DMT. Thus, it is the purpose of this study to find out more about these moments in order to deepen our understanding how DMT really works by observation and analysis based on real recordings and their significant moments.

The most frequently used method in DMT is that of mirroring. Studies have shown that mirroring can provide a range of benefits, from better emotional understanding to increased empathy. Despite this, there is little in the way of elucidation on how mirroring operates to achieve such outcomes during DMT sessions.

With advancements in technology, particularly motion capture systems, movement analysis has become more objective and precise. These technologies allow us to examine the kinematic features of movement and gain deeper insights into their therapeutic significance. Therefore, this study seeks to investigate DMT by delving into the Significant Moments that often occur during mirroring and analysing their kinematic features to uncover more about their role in the therapeutic process.

Thus, to this end we focused first to characterise the movement kinematic features of key moments within a mirroring exercise session. We started by identifying significant moments so that we could analyse them further. For our kinematic analysis, we aimed to discover movements along the X, Y and Z axis to compare movement components as well as explore synchronisation in these 3 dimensions.

Synchronisation is a crucial element in mirroring, enabling the effectiveness of the exercise. Therefore, in this study we aimed to reveal which axes of movement contribute the most (or least) this synchronisation. For this reason, we investigated the relevant biomechanics and movement studies. Due to various reasons, we do expect different synchronisation levels across the three dimensions. The first is that movements along separate axes rely on different biomechanical and perceptual mechanisms. For example, lateral movements (X-axis) typically necessitate different muscle groups and coordination compared to forward/backward (Y-axis) or upward/downward (Z-axis) movements (Lacquaniti et al., 1997). That would introduce variations in the synchrony, as some directions might be easier to mirror than others for

participants. Secondly, conditions of higher cognitive load such as those imposed by cues to gauging depth and distance may lead participants taking longer time lags in performing movements along the Y-axis (forward/backward) due to a need for more careful evaluation, consequently reducing synchronisation. On the other hand, in the Z axis (vertical), adapting to gravity may sometimes result in a simpler fix and better alignment effect (Jeffery et al., 2013).

Our current study will investigate the characteristics and techniques of movement in three dimensions during mirroring practice. Since no previous studies have been carried out with such an aim, we intend to delve into this area to have a further understanding of what it involves. To achieve this aim, our exploration work for handling this area will take as its starting point the following hypotheses:

H1: *Synchronisation levels will vary across the three spatial dimensions (X, Y, and Z axes), with differences in how movements along each axis align during mirroring tasks.*

Furthermore, we plan to compare the synchronisation levels across significant moments for both dyads and triads. This led us to hypothesise that dyadic interactions might have an overall higher synchronisation than triadic one for a few reasons. First of all, we thought the dyadic interactions of only two participants results in less variables to manage. In contrast, triadic interactions add a third participant, complicating the dynamics of movement and making it more challenging for individuals to focus on mirroring the primary model. This additional complexity likely inhibits synchronisation. Moreover, participants can focus on their partner's motion in dyadic tasks and respond more directly with an intuitive approach. This focused approach is generally considered to be more synchronised than triadic tasks, because attention has to be shared between two parties (Jans et al., 2010).

Alternatively, social influence could be another factor of mirroring that may mediate. An extra person in triadic arrangements could evolve into competitive or distracting stimuli and result in weaker mirroring. As Eagly (1983) suggested, participants might become more interested in their relationship with the group than in genuine reproduction of movements by the primary model. Therefore, we aimed to explore the differences in synchronisation during mirroring practices between dyadic and triadic interactions by testing the following hypotheses:

H2: *Dyadic mirroring tasks will result in greater synchronisation across all axes compared to triadic mirroring tasks.*

In addition to these two hypotheses, we aimed to explore gender differences in their movement patterns during mirroring exercise. We expect that their movement pattern would be different due to several reasons. For a variety of reasons, we hypothesized that they might move differently. The first is that there may be gender-based physiological differences in factors which influence movement patterns, e.g., muscle mass/strength/flexibility (Bente & Suwelack, 1996). These differences could translate into different styles of movement during the mirroring task that are affected by coordination. According to the literature, it is known that females have greater ranges of motion in some articulations such as hips and shoulders (Doriot & Wang, 2006), which can lead them to present exercises differently from males.

A few other sex elements include response times and movement execution. Indeed, evidence from research has shown that men and women can differ in their reaction times and execution of movements (Tanyel, 2007), potentially affecting how they mirror each other in real time. This difference can also affect the timing, smoothness and degree of variability in their movements.

Extended to this, this emotional expressiveness level could exert an effect on the mirror process that divides women and men as well. However, females have been found to be more sensitive than males to the emotional content (Kret & De Gelder, 2012), which could lead to variations in their mirroring style compared to men. This awareness of emotion could give rise to flexible and adaptive movement qualities that can further influence the consistency-variability continuum. As such, the third point of our study is to examine gender discrepancy with this hypothesis:

H3: *Movement patterns during mirroring tasks will differ between male and female participants, with potential variations in the consistency and variability of their movements across 3D space.*

2. Methods

2.1. Ethical Approval and Open Science Statement

All experiments were conducted in compliance with the norms and regulations of Edge Hill University (EHU)'s Code of Practice for the Conduct of Research and its Code of Practice for the Investigation of Research Misconduct. According to these regulations, ethical approval was required before commencement of the research. Therefore, the student's research application was submitted, and the study was approved by the Ethics Committee of EHU, Department of Psychology with the ethical permission number of 2024/BU/09072024, prior to the start of the project.

Participation in the motion capture study and the interviews was completely voluntary and was organized and overseen by the study supervisors (SM & VC). Participants were informed of the essential experimental methods beforehand. Although the overall objective of the motion capture study and the qualitative component were explained to the participants, the research hypotheses were not disclosed prior to data collection. Upon completion of the research, participants were fully informed about the purpose of the study.

The current project, including hypotheses, design, sampling and analysis plan, was preregistered before the research was conducted at the following link: (https://osf.io/registries/drafts/67179bf8a14123698c2d1b01/review?view_only=)

2.2. Motion Capture Study

The motion capture study described below took place at the Department of Sport and Physical Activity of EHU. The motion capture study was designed to collect movements of participants and the therapist in dyadic and triadic interaction.

2.2.1. Participants

One female and one male university student, aged 34yrs and 31yrs respectively, voluntarily participated in the study, acting in the role of the client. The male student had mostly

danced Latin dances, while the female student had danced tango, modern contemporary, gymnastic and rock ‘n’ roll. Only the female student had previously participated in a DMT session as a client a few times. In the role of the therapist, there was a professional, certified DMT practitioner with over 9 years of professional experience.

2.2.2. Apparatus

Participants' movements were recorded utilising a ten-camera optical motion capture system (Oqus 3 +, Qualisys, Gothenburg, Sweden) monitoring the three-dimensional locations of 53 reflective body markers attached to each participant, at a frame rate of 200 Hz. Markers were located as follows (L: left, R: right, F: front, B: back): one marker LF head, one on RF, one on L shoulder, one on R shoulder, one on sternum, one on LB hip, one on LF hip, one on RB hip, one on RF hip, one on L elbow, one on R elbow, one on L humerus, one on R humerus, three on L wrist, three on R wrist, two on R -hand- metacarpal, two on L -hand-metacarpal, four on L femur, four on R femur, two on R knee, two on L knee, four on L fibula, four on R fibula, two on L ankle, two on R ankle, two on L toe, two on R toe. The positions of markers are displayed in Figure 1.

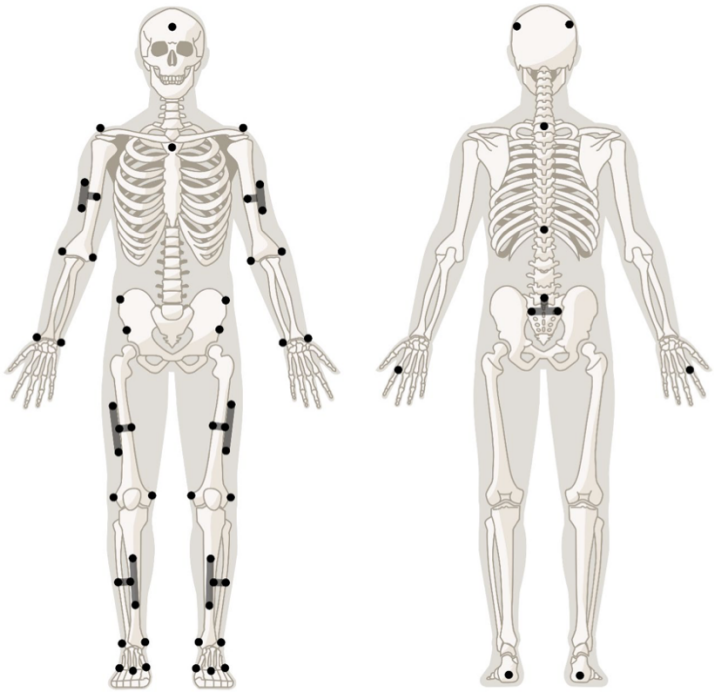

Figure 1: Locations of retroreflective markers (in anterior and posterior view, respectively)

During the recording stage, total of 53 markers were attached on all 3 participants’ body in anatomical regions as described above. The placement had been checked before and after to

each recording to confirm that no markers had become displaced or detached, and adjustments were made as needed.

Movements in all three sessions were also recorded using two video cameras: one facing the participants and the other facing the therapist (shown in Figure 2 & Figure 3).

Figure 2: Dyadic interaction between the therapist and Female Participant

Figure 3: Triadic interaction between the therapist and the female and male participant

2.2.2.1. Motion Capture Technology

Motion capture (MoCap) technology is a modern scientific and technological field that has advanced and expanded significantly in recent years. MoCap is the technique of digitally monitoring and recording the movements of individuals or beings in a spatial context (Menolotto et al., 2020). The technology has a computer recognition system primarily utilised for the identification of data during movement (Thomas et al., 2022).

Motion capture technology was originally utilised in a limited domain, primarily within the realm of animated films. As motion capture technology matures, its applications are expanding significantly, including motion analysis and athletic training (Keller et al., 2022) Additionally, the motion capture system facilitates patient rehabilitation in medicine, sports training, and the analysis of digital human motion postures in academic settings (Gao et al., 2022). A comprehensive motion capture system typically comprises many components, including signal gathering apparatus, data processing units, data transmission mechanisms, and sensors (Keller et al., 2022). Currently, motion capture systems primarily consist of optical, electromagnetic, and mechanical motion capture devices. Contemporary motion capture usually refers to the application of sensors and software to translate the movements of live actors into the motions of digital models in 3D games or animations (Kukla & Maliga, 2022).

Most common motion capture systems can be categorised into four types: mechanical, acoustic, electromagnetic, and optical. Optical motion capture is presently the most popular motion capture method. It does motion capture by monitoring designated light locations on the subject (Hu et al., 2022). Optical motion capture offers the advantage of extensive motion range, absence of cables, and the constraints associated with mechanical devices. This allows performers to move freely and enhances usability. Its elevated sampling rate satisfies the requirements for most high-velocity motion assessments (Park et al., 2022). The drawback is that the system is costly, and while it can capture real-time motion, the post-processing (including marker detection, tracking, and spatial coordinate calculation) is time-consuming. Such systems are susceptible to light and reflections within the performance space. The calibration of the device is also more complex (Yao & Chen, 2022). Particularly when the movement is complex, the markers in various regions might be readily misidentified, and occlusion leads to incorrect outcomes, frequently requiring manual intervention during post processing (Zhao et al., 2022).

2.2.3. Procedure

A female and a male student took on the role of clients in a DMT session and participated in the DMT session with a female DMT therapist. On the day of data recording, they met in the biomechanics laboratory of the Sport Science Department at Edge Hill University, arriving half an hour before the session. The DMT therapist provided an overview of the session, without revealing specific details about DMT techniques to be used. Confidentiality was discussed, and informed consent for participation in the study was obtained. They also discussed whether the two students acting as clients had any prior dance or DMT experience. During the preparation for the session, each of the three participants was fitted with several sensors on different parts of their bodies, in accordance with the study requirements, as shown in Figure 1.

During the sessions, only one technician was present in addition to the session participants to set-up the recording systems. First, the DMT therapist conducted a 15–20-minute session with the female participant, using specific DMT techniques. She then conducted a similar session with the male participant, followed by a triad session involving all three participants. The details of the session contents are shown in Tables 1, 2, and 3. In all three sessions, their movements were recorded using a motion capture system, and each session was video recorded with two cameras. After the sessions, the two participants completed evaluation forms. No musical input was provided during the sessions.

2.2.3.1. Detailed Description of Dyadic Interaction with Female Participant

DMT session was structured with a focus on mirroring. Therapist used embodied empathic communication to listen and mirror participant internal state through movement. The session started out by the participant revealing a bit of movement that reflects their emotional state, with which therapist mirrored so as to create an unspoken bond and connection.

In parallel, through the session the therapist keeps mirroring movements of participants while and adding rocking floatation helping them feel their emotions more somatically; gaining deeper contact with those internal states. She uses techniques such as tapping, stroking and self-touch to link the internal experience of participants with an external action in their own body; grounding her by bringing on physical sensations using techniques that engage the parasympathetic nervous system (PNS), thus promoting relaxation.

Throughout the session, the therapist guided her to investigate their bodily sensations and provide prompts for increased body awareness as time goes on. The therapist then continuously mirrored these actions in order to link and reflect. The session finished with a deliberate completion, where the participant mirrors back their last posture for themselves.

2.2.3.2. Detailed Description of Dyadic Interaction with Male Participant

The dyadic interaction with male participant starts by inviting him to express his internal state through movements. The therapist mimicked his check-in movement to create that knowing and embodied empathic communication. The therapist mirrored these gestures to entirely relay their empathic connection while male participant explored movements of his fingers. Then this translated into an offer for him to rarely play with his fingers. The session continued with tapping gently over the body to relax the nervous system and feeling into the warm touch.

The therapist suggested him to check this out in movement by copying how he taps his finger using his body as a way of helping him to connect deeper within himself. He was then prompted to discover what the feeling he recognized might be wishing for and asked how it would manifest if that sensation were released. The therapist empathically communicated with the previously soothing mirroring and continued to do so, while helping him to explore different ways of responding emotionally. Lastly, opened and closed body exercises for the release the sensation that he mentioned is used and allow emotional releases.

2.2.3.3. Detailed Description of Triadic Interaction with Male and Female Participant

During this DMT group session, the therapist began by asking both male and female participant to express their emotional states through movement. Through this process, empathic embodied communication has been fostered among participants, promoting understanding at the group level. The therapist then introduced rhythm in their feet to create group cohesiveness and called the participants for any contributions, which lead to more individuality and playfulness.

The group was then encouraged to explore free-flowing movements. Their movements were free, but based on a group rhythm or speed and structured to facilitate social bonding.

They were also encouraged to try on a new rhythm, change their speed or move in reverse order; this allowed for an exploration of play within different kinds and common nature.

The therapist then called the participants back to union with one another by leading them in a shared rhythm before taking an ending pose together as both individuals and class beings. The subjects were then requested to decide symbolically (in an imaginary way) what they would bring with them and what they are going to leave behind. Within this, the therapist would mirror their gestures to increase consciousness and reflect back what might be felt on the inside.

The timing and details of the three short sessions are outlined in Tables 1, 2, and 3 below.

Time	**Therapist responses:**	**Reasons of these responses:**
02:15	Invited her to use a movement to share how she is today	To externalise internal state through non-verbal communication.
02:20	Mirrored her 'check-in' movement	Understand in my body what she is communicating Demonstrate my understanding to her (Embodied empathic communication)
03:06	Body scan Mirroring her swaying motion in legs	Understand in my body what she is communicating Demonstrate my understanding to her (Embodied empathic communication)
05:13	Mirroring rocking and hands on abdomen	Understand in my body what she is communicating Demonstrate my understanding to her (Embodied empathic communication)
05:44	Invited her to rub the area she identified as a place of sensation connected to emotion	To connect with external surfaces of the body and encourage a connection between internal and external sensation.
06:07	Invited her to stroke over whole body starting at feet	To connect with external surfaces of the body and encourage a connection between internal and external sensation.
07:28	Tapping with fingertips around the body	Gentle stimulation of external surfaces, calming nervous system
07:57	Tapping around the body	Stimulation of external surfaces, bringing blood to surface to warm body up and still making connection between external and internal.
08:14	Stroking body from head to toes, connecting to breath	Completing self-touch, grounding, connecting breath to movement - parasympathetic nervous system (PNS) stimulation.
08:36	Invited her to come back to body area she identified as an emotion sensation and to move this in a way she found useful.	Bring awareness to sensation/emotion, find new ways to connect to this and to open up new awareness.
09:09	Mirroring changes to me mirroring her	Understand in my body what she is exploring, demonstrate my understanding to her (Embodied empathic communication) and offer her a mirror to deepen her awareness of her internal state and the external reflection of this.
09:25	Invite her to share any words to describe her experience of the sensation	To externalise unconscious / non-verbal awareness into conscious / verbal understanding.
09:50	Invite her to hold her verbally identified sensation into her hands	To externalise the sensation / feeling state and use metaphor to be curious about it.
09:59	Invite her to take the sensation on a journey.	To encourage the possibility of new ways of engaging with the sensation / feeling state.
10:00	Mirroring her movement (sensation journey)	Understand in my body her sensation journey, demonstrate my understanding to her (Embodied empathic communication), be on the journey with her, and offer her a mirror to deepen her awareness of her internal state and the external reflection of this.
11:22	Ask her where her body might want to go now, where the sensation is	Encourage exploration and understanding of current feeling state.
11:42	Moved my body position slightly away from her and dropped into a neutral stance.	For the purposes of the experiment, I actively stopped mirroring her. This was not a therapeutic intervention or choice.
12:23	Changed my stance to be more attentive to her and mirror her body position.	To return to therapeutic active listening stance.

12:41	Invited her to bring hands to the area of sensation and move her breath to this area.	Using metaphor to bring awareness to the area and stimulate PNS
13:50	Verbally discussing the metaphor she used to describe the sensation (A closed door) and asking her what it needs.	Using metaphor to explore something she might need.
14:20	Invited her to use open and closed positions of the body	To explore the feeling of opening and closing as in her metaphor.
15:42	Invited her to find an intentional ending position	To bring the session towards a close and give her autonomy to decide where she needed to finish.
16:12	Mirrored her ending position	Understand in my body what she is communicating Demonstrate my understanding to her (Embodied empathic communication)

Table 1: The content of the session conducted with the female participant is presented in detail, along with the rationale behind it

Time	***Therapist responses:***	***Reasons of these responses:***
01:54	Invited him to use a movement to share how he is today	To externalise internal state through non-verbal communication.
02:02	Mirrored his 'check-in' movement	Understand in my body what he is communicating Demonstrate my understanding to him (Embodied empathic communication)
02:37	Body scan	Bringing E's attention to the body
05:34	Mirroring his fingers moving gently	Understand in my body what he is communicating Demonstrate my understanding to him (Embodied empathic communication)
05:46	Invited him to play with the finger movement as the area he identified as a place of sensation connected to emotion	To be curious about the internal feeling state in the body.
05:58	Invited him to tap with fingertips over whole body starting at head	Gentle stimulation of external surfaces, calming nervous system
07:14	Rubbing over body	To connect with external surfaces of the body and encourage a connection between internal and external sensation.
07:57	Tapping around the body	Stimulation of external surfaces, bringing blood to surface to warm body up and still making connection between external and internal.
07:50	Invited him to follow the movement and see what journey it might want to go on.	To encourage the possibility of new ways of engaging with the sensation / feeling state.
07:53	Mirroring his finger tapping movements	Understand in my body what he is exploring, demonstrate my understanding to him (Embodied empathic communication) and offer him a mirror to deepen his awareness of his internal state and the external reflection of this.
08:08	Invited him again to move this sensation more freely	Opening up opportunities for exploration.
08:22	Moved my body position slightly away from him and dropped into a neutral stance.	For the purposes of the experiment, I actively stopped mirroring him. This was not a therapeutic intervention or choice.

08:42	Changed my stance to be more attentive to him and mirror his movements.	To return to therapeutic active listening and mirroring. metaphor to be curious about it.
09:50	Asked him what does the sensation need	Encourage exploration and understanding of current feeling state.
10:45	Asked him what would the "release" he identified look like	Encourage exploration and understanding of current feeling state, and exploring possibilities of new ways of being.
10:50	Mirroring his response	Understand in my body what he is exploring, demonstrate my understanding to him (Embodied empathic communication) and offer him a mirror to deepen his awareness of his internal state and the external reflection of this.
11:48	Invited him to use open and closed positions of the body	To explore the feeling of opening and closing to explore the large space he stated he needed for release.

Table 2: The content of the session conducted with the male participant is presented in detail, along with the rationale behind it.

Time	**Therapist responses:**	**Reasons of these responses:**
02:06	Invited both to use a movement to share how we are now	To externalise internal state through non-verbal communication.
02:10	Mirrored his 'check-in' movement	Understand in my body what he is communicating Demonstrate my understanding to E (Embodied empathic communication) Encourage group to engage with each other's movement for social interaction
02:27	Mirrored her 'check-in' movement	Understand in my body what she is communicating Demonstrate my understanding to her (Embodied empathic communication) Encourage group to engage with each other's movement for social interaction
02:50	Introduced rhythm in feet	Encourage group cohesion
03:02	Invited group to add in own beats to existing rhythm	Encourage group members to bring their own selves as individuals to the group. Encourage playfulness.
03:42	Invited group to move in space by following their right hand (and later both hands)	Encourage group members to be curious about space around them and use their body in a state of flow.
04:38	Asked group stay with their individual movement but to find a cohesive rhythm or speed quality as a group	To encourage social connection.
04:49	Invited group members to change the rhythm / speed quality and group must follow.	Encourage playfulness and group mirroring of individual choices.
05:20	Invited group to be asynchronous in rhythm / speed quality.	Playfully explore difference and the feeling of mismatched intentions.
06:30	Invite group to return to similar rhythm / speed quality.	Bring the group back to cohesiveness.
07:09	Invited group to find a ending position in a group tableaux	To bring the movement to a close and invite group to use autonomy to find where they want to finish both individually and as a group.

07:43	Invited group to take turns to leave behind anything they would like to leave and take away anything they would like to.	To finish the session by acknowledging things (feeling states / thoughts / movements) they no longer need and what they might find useful to take with them.
08:47	Mirrored her movements in response to what she needs.	Understand in my body what she is exploring, demonstrate my understanding to her (Embodied empathic communication) and offer her a mirror to deepen her awareness of her internal state and the external reflection of this.
09:05	Mirrored his movements in response to what he needs to leave behind and take away.	Understand in my body what he is exploring, demonstrate my understanding to him (Embodied empathic communication) and offer him a mirror to deepen his awareness of his internal state and the external reflection of this.

Table 3: The content of the session conducted with the male and female participant is presented in detail, along with the rationale behind it.

2.2.3. Kinematic Feature Extraction

Marker trajectories were reconstructed, labelled, and gaps of up to 10 frames were calculated using a polynomial fill in Qualisys Track Manager (Version 2.18.1, Qualisys, Gothenburg, Sweden). Processed trials were exported to Visual 3D (version 2021.09.1, C-Motion, Germantown, MD, USA). The joint angles and body orientation were computed via an XYZ Cardan rotation sequence (Langley et al., 2023).

2.2.3.1. Marker Selection for Analysis

The selection of markers for analysis was determined by the exercises performed during the DMT sessions. Since the therapist employed different types of exercises for each participant (in the dyadic sessions with the female and male participant, as well as in the triadic session), markers were selected accordingly. Since we collected about 8,000 data points per marker, it was key to be selective and focus on the markers that at least showed good consistent performance throughout the sessions. During movements some of the markers failed to record properly and there were always parts where data was missing. Accordingly, we went for with minimal gaps to ensure consistency.

All body parts were examined, and markers were selected as detailed below, according to the exercises and movements involved. This is consistent with other studies, which have likewise impressed the importance of focusing on body parts that are relevant for a given task (Wu et al., 2022; Khan et al., 2020).

Since the mirroring exercise was the primary focus of our study, we analysed data from the body parts most relevant to that task. The DMT therapist created a reference sheet noting when mirroring exercises took place so that we could synchronise the data between video recordings and kinematic data. We filtered down the segments of a session that included mirroring. Despite an inconsistency in the duration of mirroring practice between Participants B, E and in triadic interaction this variation does not affect the analysis, as we are comparing kinematic data across conditions.

Markers Selected for Analysis:

Dyadic interaction with the female participant: Since her movements primarily involved extending her arms and moving them up and down, we selected markers from her hands (left and right) and shoulders (left and right), focusing on upper body movement.
Dyadic interaction with the male participant: Similar to the female participant, we focused on the markers from the left and right arms and shoulders.
Triadic session: For the group session, we selected markers from the thorax, and left and right hips.

2.2.3. Statistical Analysis

A cross-correlation analysis was applied to 3D coordinates of marker positions (x, y and z) acquired from the motion capture system to evaluate synchronisation between participants during mirroring tasks. The cross-correlation function quantifies how similar the movements are of both participants at different points in time. In other words, higher cross-correlation values, indicating stronger synchronisation, suggest better alignment in the participants' movements.

A Time Lag analysis was conducted in the mirroring task, besides cross-correlation. This lag quantification between the movements of therapist and participants provides a purely objective measure for when one participant was to follow or mirror another. In another word, this analysis gives information about delays in the mirroring task.

To estimate the spatial alignment of participants during the task, we computed a Euclidean Distance analysis between positions in 3D space for each two persons at every time point. This measure allows us to calculate exactly how far apart their movements actually were — so we can figure out just how well they mirrored each other in physical space.

An additional analysis on disparity in the mirroring was also carried out which implemented the differences of velocity, acceleration and residuals from movement data by the participants. These analyses helped us to detect differences of movement dynamics and the accuracy in mirroring over time, which provided a new layer of granularity in assessing motor coordination between participants.

2.3. Qualitative Aspect of the Study

In addition to motion capture data, qualitative insights were incorporated into the study to enhance our understanding of significant moments from both the therapists' and participants' perspectives. For this study semi-structured interview, as mentioned below in details, was planned and completed by participants at the end of the session. By conducting these interviews, we aimed to capture their immediate experiences about the DMT sessions.

2.3.1. Post-session Interview

Following the completion of the three short DMT sessions, participants E and B were asked to complete a brief evaluation form to provide qualitative insights into the study. The form contained three key questions: (1) "What were the most helpful aspects of the session and why?", (2) "What were the least helpful aspects of the session and why?", and (3) "Do you have any additional comments?"

The participants' responses to these questions are presented in Table 4 for further reference.

	FEMALE PARTICIPANT	MALE PARTICIPANT
QUESTION 1	*The most helpful point during the whole process was discovering some sensations on my body & offering then to move around just to see that is possible for them to be somewhere else.*	*It was very helpful to relax and release energy. Also, to get in touch with your sensations and your own body. This was helpful because this is not anything that I normally do and it's important for good physical and mental health.*
QUESTION 2	*I would prefer dyad work instead of 3 people. Maybe this is because of me but I feel more comfortable & able to focus on practice & myself when we were just 2 of us.*	*I didn't find any. I would say that probably I got too relaxed and I would find it hard to focus on a challenging activity hour.*
QUESTION 3	*I'd like to thank you for even its practice & research purpose & very short, it was still effective, at least for me to see that I can reach out my body & invite myself to change something which is not so necessary to exist in my body.*	*I really enjoyed the activity and the experience.*

Table 4: Participants' responses to the three evaluation questions regarding the sessions.

2.3.2. Statistical Analysis

Apart from the quantitative analyses, a brief thematic analysis was carried out in order to interpret participants' experiences during DMT sessions. After the session, participants were asked to complete an evaluation form that included open questions as described. Based on their evaluation, we identified thematic content within those answers using a method called "thematic analysis", which provided qualitative understanding of the experiences described by these participants.

Thematic analysis is a method used to identify, analyse and organize these patterns or themes in qualitative data allowing the researcher to systematically explore participant perspectives. This method categorizes the data into themes that help capture what participants talk about in terms of their experiences, feelings and understanding of how they were affected by the intervention (Kiger & Varpio, 2020).

3. Results

3.1. Results for Motion Capture Study

3.1.1. Therapist with Female Participant in Dyadic Interaction

A cross-correlation analysis reveals that the therapist and female participant were not synchronizing their movement along any of these three axes (X, Y and Z) during their dyadic mirroring session. The results for female participants' session are shown as bellow:

Movements along the X-axis indicated a negative relationship, with the highest cross-correlation occurring at a negative lag of -8573 frames ($r$max = -282408.70), suggesting that there is very large absence of synchronization. The Y-axis movements revealed a positive cross-correlation throughout the mirroring exercises, with the highest value being at a lag of 93 frames ($r$max = 1.13×10^9), showing a delay of 0.47 seconds. This result reveals that the therapist mirrored the female participants' movements with a great delay in the vertical plane. For vertical movements, there was almost perfect synchronization, with the highest cross-correlation occurring at a lag of 0 frames ($r$max = 1.31×10^10), showing that therapist and female participants' vertical movements were tightly coordinated and happened simultaneously without lag.

The time lag analysis confirmed the cross-correlation results, evidencing no lag along the Z-axis yet a notable 0.47 second delay in the Y dimension, and a substantial -8573-frame lag in the X-axis. These delays strongly reinforce the interpretation of misalignment in the X-axis and delay in the Y-axis, with perfect synchronization along the Z-axis.

The Euclidean distance between the therapist and the female participant' positions was calculated as well, indicating an average distance of 1207.40 units (SD = 208.69). The minimum distance was 727.84 units, and the maximum distance was 1895.47 units, showing variability in spatial alignment. Periods of closer mimicry are seen when the distances were smaller, whereas larger distances point to divergence in their motions at that moment.

3.1.2. Therapist with Male Participant in Dyadic Interaction

A cross-correlation analysis for the dyadic interaction between male participant and the therapist's movements is as follows:

Movements along the X-axis indicated a substantial positive lag of 9932 frames ($r$max = -316745.27), showing a significant lack of synchronization. This result suggests that the male participant's and the therapist's movements along the X-axis were not well-timed or potentially out of phase. Y-axis movements demonstrated a moderate level of synchronization, with a peak cross-correlation at a lag of 47 frames ($r$max = 4.04×10^9), corresponding to a delay of approximately 0.235 seconds. This indicates that the therapist mirrored the male participant's lateral movements with a slight delay. For Z-axis movements, there was strong synchronization with no lag observed, indicated by a cross-correlation peak at 0 frames ($r$max = 2.08×10^10). This suggests that vertically they moved at exactly the same time.

The time lag analysis revealed similar results to the cross-correlation analysis, evidencing a 47-frame (0.235 seconds) delay in the Y-axis, no lag in the Z-axis, and a large positive lag of 9932 frames in the X-axis. These lags indicate very weak synchronization in horizontal movements and moderate delay in lateral movements, but almost perfect synchronization along the vertical axis.

On average, the Euclidean distance between our male participant and his therapist across their mirror session was 1683.98 (SD = 285.29) units, with a minimum of 1076.59 units and maximum 2302.97 units. These fluctuations indicate varying degrees of spatial alignment, with closer mirroring at times and divergence in others.

3.1.3. Triadic Interaction

The cross-correlation analysis was conducted to investigate how well the therapist mirrored the male and female participants' movements during the task, with time lags indicating the delay or misalignment in their movements.

Regarding the male participant's movements, while a large negative lag of -15196 frames was observed, suggesting a significant misalignment or possible inverse-phase relationship in the therapist's horizontal (X-axis) movements relative to the male participant, a

lag of 1316 frames (approximately 6.58 seconds) indicated a noticeable delay in the therapist's attempts to mirror the male participant' movements along the Y-axis. For Z-Axis, a lag of 33 frames (approximately 0.165 seconds) showed a smaller delay in their vertical (Z-axis) movements, indicating closer synchronization in this axis.

With respect to female participant's movements, while the therapist also performed poorly in synchronization along the X-axis, with a large negative lag of -14832 frames, showing desynchronization and potential anti-phase movement, a substantial lag of 14003 frames (approximately 70 seconds) was revealed, suggesting a big delay in therapist's Y-axis mirroring. This result exhibits significant difficulty in synchronizing movements along the lateral dimension. However, the therapist perfectly synchronised along the Z-axis, with a time lag of 0 frames.

Euclidean Distance Analysis showed that both participants maintained similar spatial proximity to the therapist during the triadic session. The male participant's mean Euclidean distance was 1732.51 units (SD = 424.55), while the female participant's mean distance was 1685.32 units (SD = 312.86). These results indicate that both participants maintained a relatively close alignment with the therapist, although the male participant exhibited more spatial variability.

3.1.4. Analysis of Discrepancies in Mirroring: Velocity, Acceleration, Residuals

To better understand the observed differences in movement dynamics across participants, velocity, acceleration, and residual movement characteristics from both dyadic and triadic interactions were compared. First, I will describe in detail the differences between dyadic sessions, including kinematic characteristics for velocity, acceleration, and residuals for each participant; then I will describe the changes in these kinematic measures in triadic participation.

3.1.4.1. Discrepancies in Dyadic sessions

The acceleration recordings for both participants unveiled notable contrasts in how their bodies reacted to the therapist's motions during the mirroring activity. In the male participant's acceleration graph (shown in Figure 4), the blue line represents the male participant and the

green line represents the therapist. The smaller fluctuations in the male's acceleration indicate smoother speed transitions, suggesting a more controlled and fluid adaptation. In contrast, the female participant's acceleration data (shown in Figure 5), where the green line represents the female and the blue line represents the therapist, show larger, more erratic spikes, pointing to abrupt adjustments.

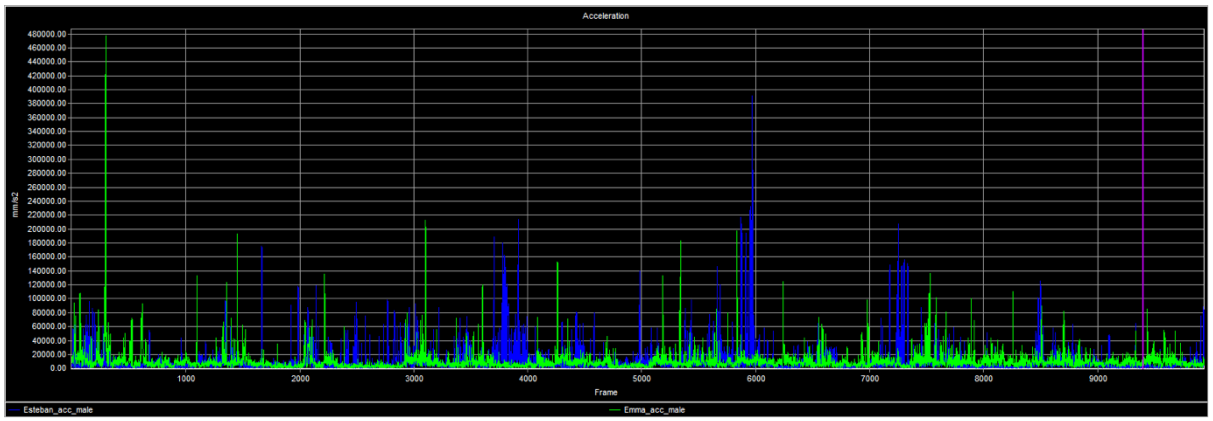

Figure 4: Acceleration Data for Male Participant and Therapist

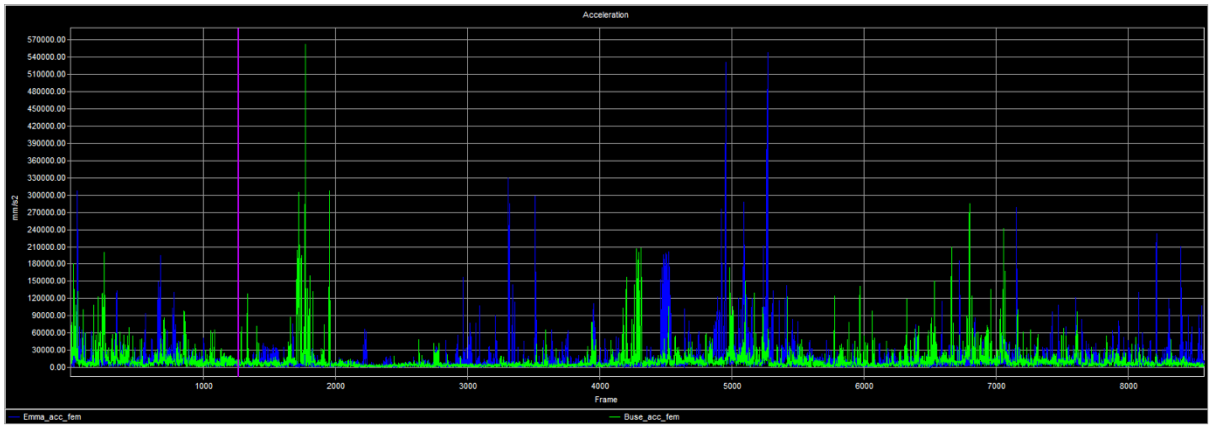

Figure 5: Acceleration Data for Female Participant and Therapist

The velocity graph for the male participant shows a consistent pattern, suggesting a smoother adaptation to the therapist's movements, as seen in Figure 6. Figure 6 displays the velocity data for the dyadic interaction between the male participant (blue line) and the therapist (green line). The scale of the y-axis is velocity in millimetres per second, and the x axis represents frame number with respect to time. By contrast, in the velocity graph of the female participant (green line) and therapist (blue line), there are large changes taking place at 800; ~1800 frame marks as well as around 5000 frames that can be seen from Figure 7. These variations indicate inconsistent speed on her part.

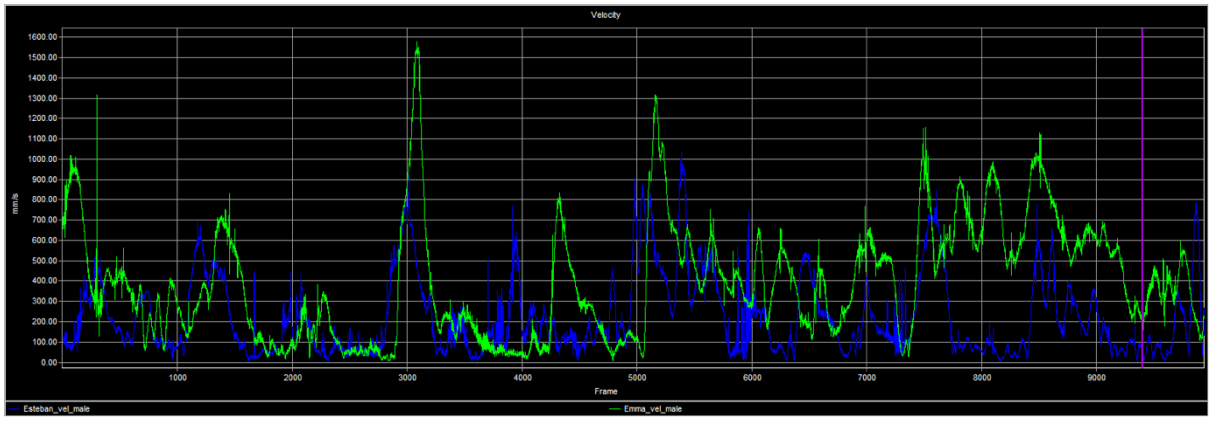

Figure 6: Velocity Data for Male Participant and Therapist

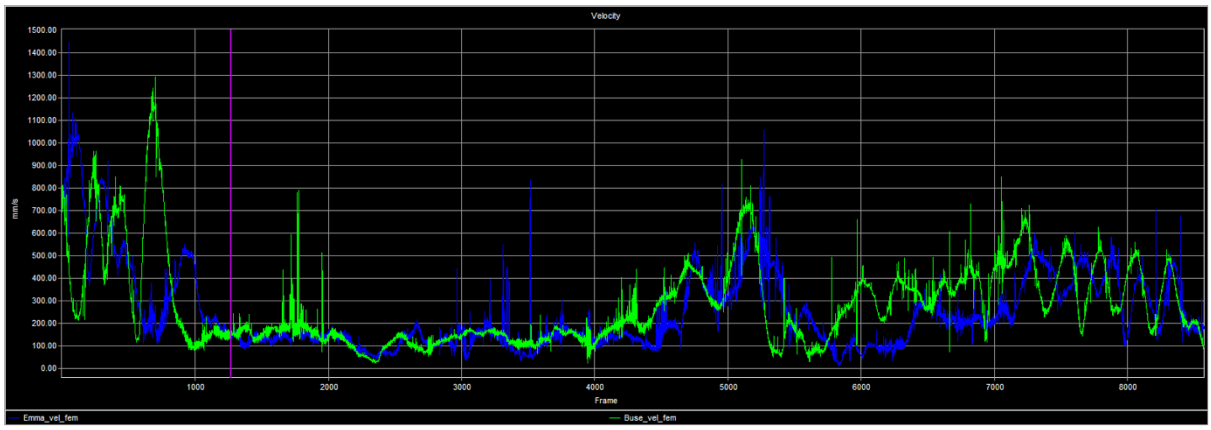

Figure 7: Velocity Data for Female Participant and Therapist

The residual data for both female and male participants reveal distinct patterns in their synchronisation with the therapist's movements. The residual data for the male participant, illustrated in Figure 8 (blue line), indicates moderate discrepancies and a relatively stable alignment. Conversely, the data for the female participant, illustrated in Figure 9 (green line), demonstrate more substantial discrepancies, signifying greater inconsistencies with the therapist's movements.

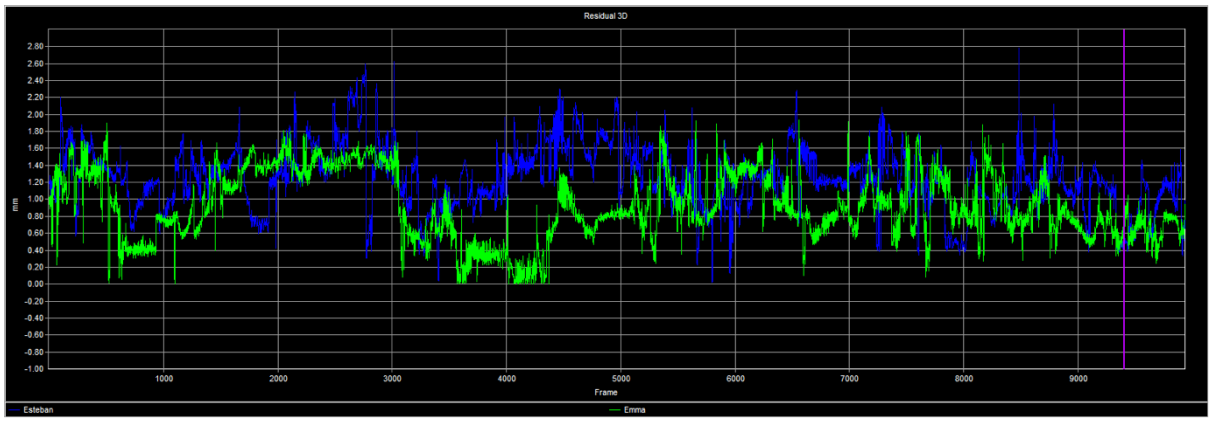

Figure 8: Residual 3D Data for Male Participant and Therapist

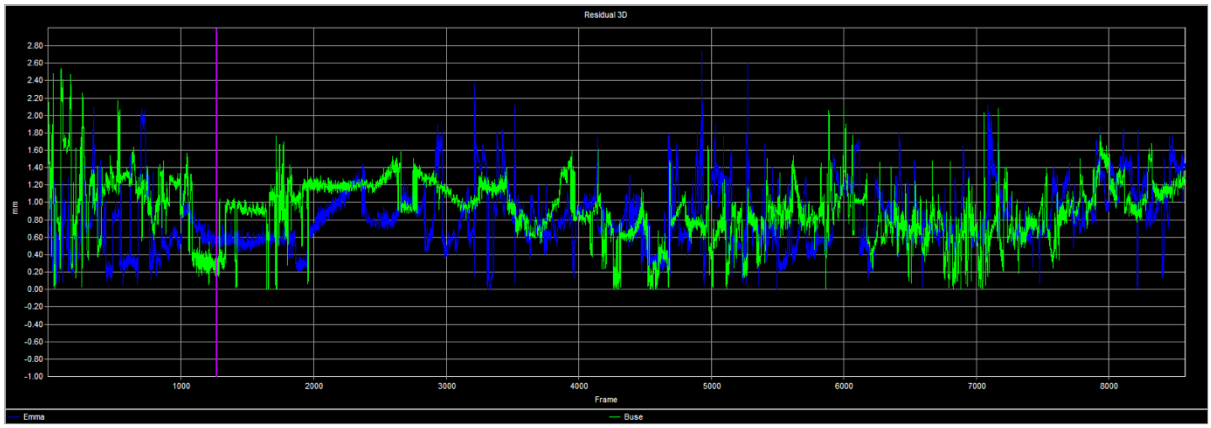

Figure 9: Residual 3D Data for Female Participant and Therapist

3.1.4.2. Discrepancies in Triadic Sessions

The acceleration data of the male participant (shown as the green line) and the female participant (shown as the purple line in Figure 10) revealed contrasting patterns in their movements during the triadic interaction. The male participant's data show smaller, more controlled changes in velocity, indicating smoother transitions. In contrast, the female participant's acceleration data show more erratic and abrupt changes.

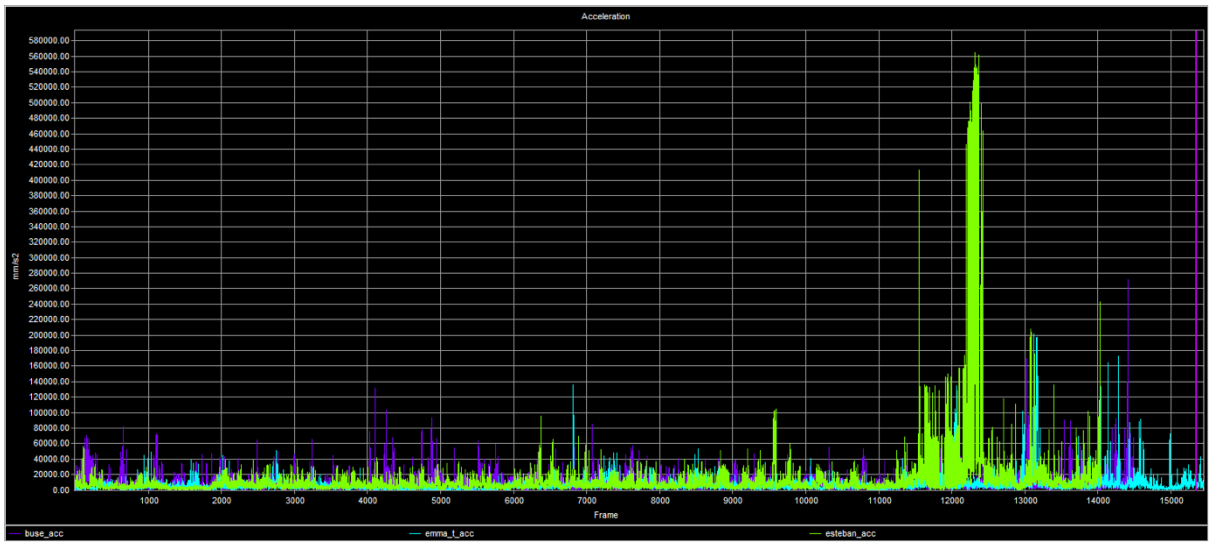

Figure 10: Acceleration Data for Female Participant, Male Participant and Therapist

The velocity data for the male and female participants, as shown in Graph 11, highlight distinct differences in their movement control during the mirroring task. The male participant’s velocity profile (represented by the green line) indicates a more stable and consistent speed. In contrast, the female participant’s velocity data (represented by the purple line) revealed more erratic speed changes.

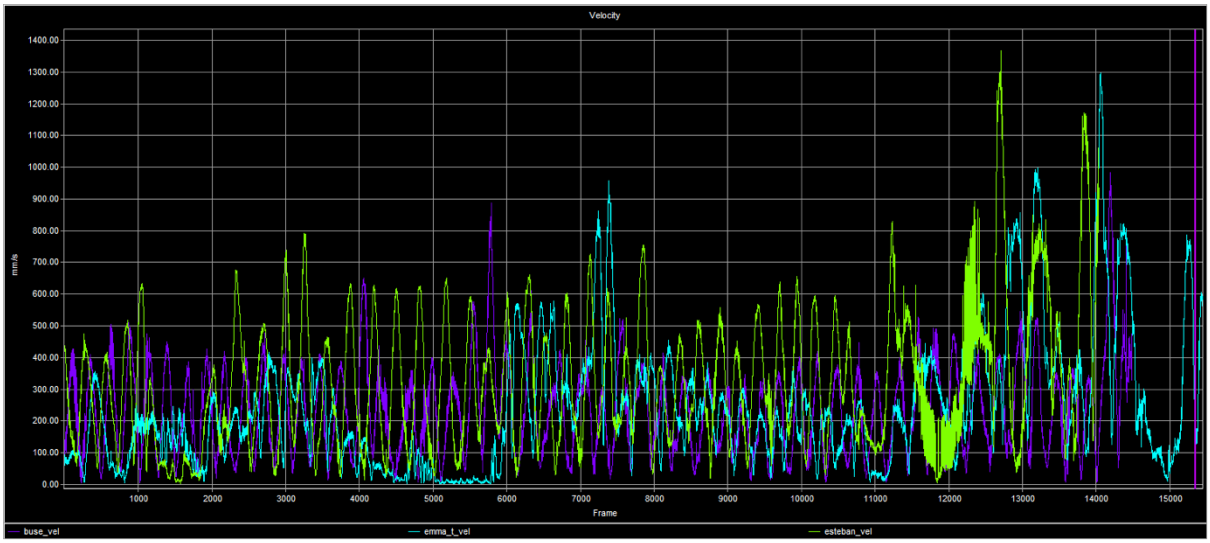

Figure 11: Velocity Data for Female Participant, Male Participant and Therapist

Differences between male and female participants emerged from the residual data in relation to their interaction during mirroring practice. The residuals of the male participants are mild and rather constant. The residuals of the female participant, on the other hand are huge. This is shown in Graph 12, where the purple line represents the female participant and green for male.

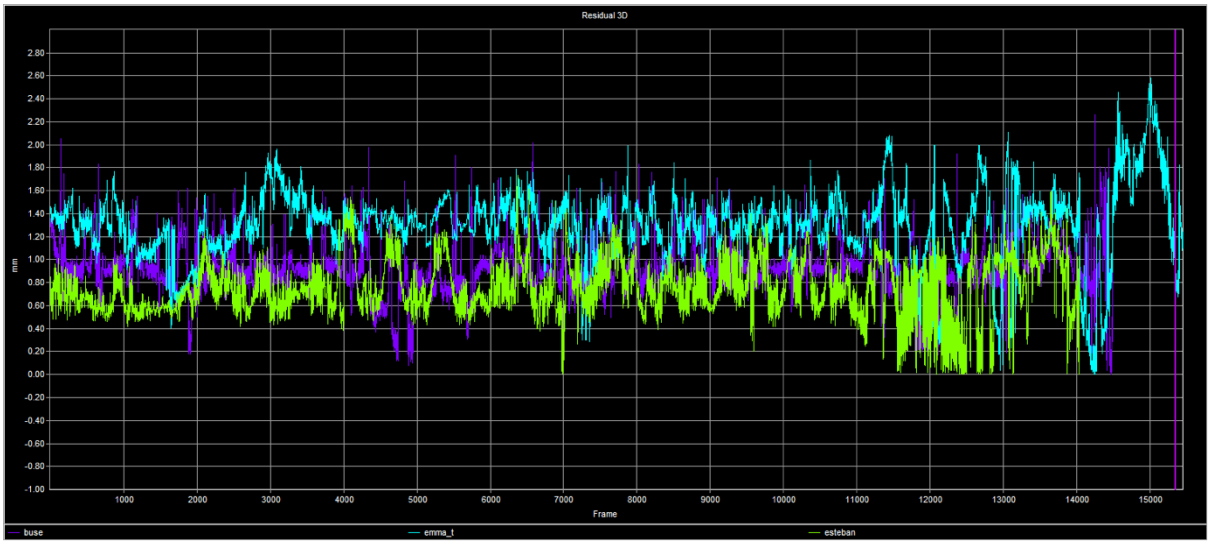

Figure 12: Residuals 3D Data for Female Participant, Male Participant and Therapist

3.2. Thematic Analysis for Evaluation Form

In the analysis of the interview, four key themes emerged, highlighting the participant's experiences and reflections: *Sensations, Preference for Dyad/Triad, Positive Experiences of the Work, and Relaxing/Releasing*.

The theme of Sensations was prominent throughout the interview, with the participant describing how they became more attuned to the physical sensations in their body during the session. They reported "discovering sensations" in their bodies and described the ability to consciously "move around these sensations." This increased awareness aided their ability to "connect with sensations in the body," and they demonstrated an increasing sensitivity to internal physical changes as the session progressed. Overall, the participant's connection to bodily sensations was central to the DMT session.

Another important theme that emerged was a 'preference for dyad/triadic interactions'. The male participant clearly stated that he preferred working in as being only participant rather than with another one because it allowed him to focus more on his own experiences. Participants reported feeling "more comfortable in a dyadic interaction" because it gave them the opportunity to think and reflect, whereas in a trio there were too many distractions, making it difficult to concentrate. This preference appeared to stem from the participant's desire for a simpler, more focused environment to facilitate their personal processes.

The participants also noted the many benefits of the practice, particularly its impact on their body. Although the session was short and research-focused, they still reported that it was beneficial. The participant stated that they were able to "make changes in their body" as a result of the exercises, reflecting on the transformative potential of the work. They also expressed their appreciation for the novelty of the experience, and spoke of the benefits of "doing something different" with their bodies.

Finally, Relaxation/Release emerged as another important aspect of the experience. They described the session as being distributed and felt that it facilitated the release of energy, which they perceived as beneficial. However, they also noted that at times they "perhaps got too relaxed" and that this caused a shift in focus and enhanced their drive with the exercise. Despite this general feeling of relaxation and release of energy, the occasional loss was seen as a positive outcome along the way.

4. Discussion

This study investigated the characteristics and techniques of movement in three dimensions in order to investigate more about synchronisation between participants involved in a DMT session and compare levels of synchronization between dyadic and triadic interactions. Lastly, we aimed to explore more about gender discrepancies especially on three kinematic measures; velocity, acceleration and residuals. The findings reveal several distinct patterns, particularly differences in synchronization on the X, Y and Z axis. These results provide insight into the role of the mirroring in therapeutic context and contribute to our understanding of DMT.

Regarding our first hypothesis, which posits that synchronisation levels will vary across the three spatial dimensions (X, Y, and Z axes), with differences in how movements along each axis align during mirroring tasks, the results reveal significant variations in synchronization levels across the three spatial dimensions during dyadic interactions. The therapist exhibited a significant lack of synchronisation along the X-axis, with both male and female participants. Especially in the practice with female participants, a negative lag suggests that their movements were not only misaligned but may have been in opposite directions or occurred at entirely different times. This result can suggest that the movement was anti-phase, and one of a single participant may be in reverse direction from others on the X axis. This unusually clean pattern is indicative of how hard it may be to synchronize in horizontal movement, likely due to the complexities involved in lateral motion (Maki et al., 2000). Hence, this could indicate that the therapist was not closely following both participants' side-to-side movements, or they were moving in opposing directions.

In contrast, synchronization along the Z-axis was nearly perfect for both participants, with zero lag observed in both dyadic interactions. They were likely matching their raising or lowering movements (such as lifting arms or bending knees) precisely in time without any discernible delay. This highlights the ease of coordination in vertical movements, which may be more instinctive and less influenced by external factors (Jeffrey et al., 2013). Taken together, the synchronization in the Z-axis with very high precision of mirroring and alignment in vertical movements.

The Y-axis showed moderate synchronization for male participants (47 frames delay) and a significant lag for females (93 frames), indicating a similar but slightly more effective

mirroring in lateral movements compared to horizontal ones. The lag of 93 frames, corresponding to approximately 0.465 seconds (at 200 Hz) suggesting that the therapist mirrored the female participant's movements along the Y-axis with a considerable delay. A delay of nearly half a second indicates a noticeable gap in time between the female participant initiating a movement and the therapist reacting to it. This could be expected in such a situation where the therapist observed her actions, processed the movement, and then mirrored it (Karampoula & Panhofer, 2018) with a response delay that is within the expected range for more conscious or intentional mimicking tasks (Hale & Hamilton, 2016). In the case of the male participant, the delay was corresponding to 0.235 seconds, indicating the therapist was mirroring his movements along the Y-axis with huge delay. This kind of lag could be expected in natural settings where one participant attempts to follow the other's movement but needs a fraction of a second to observe, process, and respond to the movement. A lag in the range of 0.2-0.3 seconds is typical in human movement tasks where one person mimics another.

When we compare the therapist's interaction with the male and the female participant, the patterns of lags were different. Both with male and female participant, the therapist showed the perfect synchronization in the Z-axis and in both cases, there were delays in the Y-axis (with male: 0.235 seconds, with the female: 0.465 seconds), however with the female participant, the therapist showed longer delay. For the female participant, the X-axis showed anti-phase motion (large negative lag), while the male participant had large positive lag, indicating that different types of mismatches occurred for the therapist in their horizontal movements. These differences suggest that the therapist engaged in the mirroring task differently with each participant and had different levels of success in achieving synchrony across the axes.

According to the Euclidean distance analysis, the results of the pairwise interactions for the female and male participant showed the variability in spatial alignment. These results highlight the complexity of synchrony in therapeutic settings and the need for therapists to adapt to the unique patterns exhibited by their participants.

During triadic interaction, the cross-correlation results showed a significant negative lag along the X-axis for mirroring the female and the male participant's movements by the therapist, suggesting challenges in synchronization with both participants. The male participant's X-axis movements showed a negative lag of -15196 frames, indicating a large misalignment or out-of-phase movement with the therapist. With the female participant's X-

axis also showed a negative lag of -14832 frames, indicating similar issues with synchronization. For the Y-axis, with the male participant, the therapist exhibited a moderate delay of 6.58 seconds (1316 frames), while with the female participant showed a much larger delay of 70 seconds (14003 frames), highlighting significant difficulty in mirroring forward/backward movements in the triadic condition. Vertical movements (Z-axis) remained the most synchronized, with the female participant achieving perfect synchronization (0 frames), and with the male participant showing a minor delay of 0.165 seconds (33 frames).

These findings provide strong evidence supporting Hypothesis 1. Synchronisation level varied across three dimensions for both dyadic and triadic sessions as well as with both female and male participants. Indeed, the results revealed that vertical (Z-axis) movements were more synchronized, as evidenced by zero frame delay and perfect cross-correlation. In contrast, horizontal (X-axis) movements were not synchronized, as evidenced by the large negative delay, whereas lateral (Y-axis) movements showed some synchronization. The results are consistent with the expectation that the level of synchrony would vary with different movements in three dimensions; in fact, the results show that vertical movements are more salient and easier to mirror in DMT practice.

Considering hypothesis 2, we expected that dyadic mirroring tasks would lead to higher synchronization across all axes compared to triadic tasks, and the results support this claim. In triadic interactions, the therapist showed significant synchronization difficulties with both male and female participants on all axes. For example, with male participants, the therapist had a delay of 1316 frames (6.58 seconds) on the Y-axis and a surprisingly latency of 14003 frames (70 seconds) with female participants. These significant delays suggest that the addition of a third participant complicated the mirroring process, likely due to increased cognitive load and distraction (Skuballa & Jarodzka, 2019).

When we consider the mirroring along the horizontal axis, the notable negative lags were observed during triadic interactions with both genders which further reinforces the conclusion. The anti-phase movement shows a lack of effective communication and coordination, which becomes increasingly difficult when there is more than one participant. The consistent challenges in horizontal and lateral movements across both dyadic and triadic setups point to the necessity of focused therapeutic strategies that facilitate better alignment, particularly in situations involving multiple participants. However, in both cases dyadic and triadic interactions in Z-axis movements were perfectly synchronised between the

therapists and participants, which again supports the ease of mirroring along the vertical movements. However, a future comparison including more than one group with triadic tasks is necessary to fully test this hypothesis.

Considering hypothesis 3, we aimed to explore movement features of participants during both dyadic and triadic setup, focusing on the velocity, acceleration and residuals of their movement. In the both dyadic and triadic mirroring task, the male participant maintained a steadier and more consistent velocity compared to the female participant, who exhibited larger fluctuations on her speed. This would be one reason for the therapist's struggle with the female participants' movements for mirroring her. Since she had more inconsistencies in her movement's speed, the therapist might have difficulty to follow and reflect her movement, especially on X and Y-axis.

Similarly, to velocity, the male participant's acceleration was smoother and more controlled, allowing the therapist synchronization with him perfectly, especially on vertical movements. However, the female participant's acceleration data shows larger, more abrupt changes, giving difficulties to therapist for mirroring her movements.

During the triadic mirroring task, these differences were further accentuated. The male participant maintained closer positional alignment and smoother velocity and acceleration profiles, reinforcing his ability to adapt in real-time to the combined dynamics of the session. In contrast, the female participant's movements showed increased variability and larger discrepancies, particularly in the Y-axis, suggesting that she made the mirroring of the therapist even harder task in a triadic setting. This pattern underscores the complexities that arise when multiple participants engage in mirroring tasks, particularly for those who may already have difficulties in individual contexts.

With regards to residuals, the male participant movement's residuals were more moderate compared to the female participant who has larger residuals indicate greater discrepancies during both dyadic and triadic interactions.

When we considered the therapist's movements, overall, the results suggest that the therapist continued to mirror the male participant with better accuracy, maintaining a stable position, smoother velocity, and controlled acceleration, while with a female participant the therapist faces more pronounced challenges in keeping up with her movement, with greater deviations in position and larger, more erratic changes in velocity and acceleration. Her

difficulties in the Y-axis remained significant, leading to larger residuals and less consistent synchronization.

Overall, this study with the motion capture part only, emphasise the importance of understanding individual differences in movement patterns across genders, providing information that can introduce therapeutic practices aiming to improve synchrony and coordination in their practices. Future work should investigate these dynamics, determine the mechanisms underlying the observed differences and explore effective manipulations of their interventions to enhance movement synchrony in therapeutic settings.

Considering both the qualitative post-session interview data and the quantitative kinematic data, an integrated interpretation of participants' preference for dyadic interactions, along with motion capture data showing improved synchronization in dyadic sessions, reveals a meaningful connection between perceived comfort and movement alignment. Participants' reported preference for dyadic interactions likely created a more relaxed and focused environment, facilitating better synchrony. In a one-on-one setting, both therapist and participant could pay full attention to each other's movements without the complications of a third person. The motion capture data support this, as synchrony was consistently stronger in dyads, suggesting that comfort directly influences the quality of mirroring and alignment. This suggests that emotional comfort in dyadic interactions may be a driving factor behind the improved coordination that allows for more sensitive and mindful engagement

Another possible reason could be that triadic interactions introduce additional difficulties on social and cognitive complexity, as participants are also supposed to follow others' movements and respond to them as well. This likely increases cognitive load, which may disrupt the natural rhythm and fluidity of reflection. In post-session interviews, participants reported feeling more comfortable in dyads, possibly because when they are alone with the therapist, this likely reduced social pressure, allowing them to focus only on themselves. This is consistent with data showing better synchrony in dyads, suggesting that minimizing social complexity may increase physical alignment and movement flow.

When considering the therapeutic alliance, dyadic sessions appear to foster a stronger bond by providing a deeper, more personalized connection between therapist and participant. This is consistent with the synchrony results where therapist-participant coordination is higher

in dyadic settings, suggesting that the therapeutic relationship itself may play a critical role in fostering mirroring.

The convergence of qualitative and quantitative findings suggests that, for participants who struggle with coordination, comfort, or social anxiety, dyadic formats may provide a more effective therapeutic environment. This has implications for dance movement therapy and other modalities, as structuring sessions to allow for personalized, one-on-one interaction could yield stronger therapeutic benefits, especially for participants who benefit from focused, direct engagement with the therapist.

4.1. Clinical Implications for DMT

The findings highlight several important implications for the use of mirroring in DMT sessions. First, the therapist showed better synchronisation with the male participant, who demonstrated more consistent and less variable movements throughout the mirroring practice. In contrast, with the female participant—whose movement features, such as speed and acceleration, were less consistent—the therapist struggled to mirror her synchronously in terms of kinematic data. This could suggest that due to different patterns of movements, the therapist might be better to mirror more closely the clients especially who have huge discrepancies on their movement, which might lead to better synchronisation and high level of mirroring with its increased benefits in therapeutic context as well.

Since in each case, both in dyadic and triadic interactions across male and female participants, synchronization level in the Z-axis (vertical movements) were notably perfect, while it is very problematic in the X and Y axis, this could reflect the problem of less spatial awareness about movements on these dimensions (Jeffrey et al., 2013), which could be an area of focus for more adequate therapeutic DMT intervention.

In the triadic session, the therapist continued to perform well with the male participant while she had challenges with female participant. This would suggest that the group dynamics may give additional emotional pressure or complexity for the therapist, making the mirroring harder to both participants effectively. These findings can guide the therapist in tailoring future sessions according to each client's movements' pattern, with a focus on improving real-time responsiveness and exploring more complex mirroring tasks. This highlights the potential

influence of group dynamics in DMT, which may introduce additional challenges for the therapist.

4.2. Limitations and Recommendations for Further Studies

Considering our study, there are some limitations. First, even though there were over 50 markers in motion capture study which records participants movements, we had to select few of them due to huge amount of data collected. The way we extract the body parts which were most relevant was based on observation of the movement engaged, which is quite subjective. For example, since we observed that the arms were actively involved in the movement, we decided to include markers placed on specific points along the arms. This selection has been done in a subjective way for most relevant body parts. This can be problematic because subjective selection of body parts may lead to an incomplete or biased representation of participants' whole-body movement patterns. By focusing on only certain markers, subtle movements in other parts of the body (potentially important for understanding synchrony) may have been missed. In addition, this approach introduces an element of observer bias (Burghardt et al., 2015). Because the decision about which markers to include is based on the researcher's judgment rather than an objective standard. This subjectivity could affect the consistency and replicability of the study, as other researchers might choose different markers, leading to variability in results and potentially limiting the study's generalizability and accuracy in capturing a comprehensive picture of movement synchronization. Implement a more standardized or automated method for marker selection to reduce observer bias in identifying relevant body parts. For example, machine learning algorithms could help objectively detect and track the body parts most frequently used across participants, leading to more consistent data selection and a more complete representation of movement synchrony.

Another inherent limitation of our study is that the movements of the mirroring exercises were different during each dyadic and triadic interaction, as each participant had the freedom to initiate and move according to their own movement characteristics (Mintarsih & Azizah, 2020). This would be a problem if mirroring was not well performed, not only because of the therapist's compliance, but also because of the movement characteristics. For example, if a participant engaged in extremely flexible or very rapid movements, these could inherently limit the therapist's ability to mirror accurately, regardless of their intent or skill. This variability may confound our results, as some synchronization difficulties may be attributable

to physical or stylistic movement characteristics rather than interactional adaptation. In future studies, some standardization of movement tasks or analysis of the effects of different movement types on mirroring effectiveness may help clarify these effects and better isolate the role of the therapist in maintaining synchrony.

Sample size and generalizability can be seen as another weak point of our study as well. Since our study had a limited number of participants, only one woman and one man, it may be difficult to generalize the findings to a larger population. In this study, we observed perfect synchrony along the Z-axis and poorer synchrony in the other dimensions. However, this does not mean that this model will be universally applicable. Future studies should include a larger number of participants to allow these findings to be generalized. Additionally, synchrony levels for the same participants may vary between days, possibly due to changes in mood (Smykovskyi et al., 2024) or other temporal factors. We recommend future studies to repeat the DMT sessions in longer period of times with same participants in order to have deeper insight about mirroring characteristics.

Considering to our comparison of synchronization between dyadic and triadic interactions, triadic interactions are inherently more complex than dyadic ones, and this increased complexity may lead to more variability in results that aren't solely due to mirroring ability. Interpersonal dynamics or external factors, such as group cohesion or individual comfort levels, could influence the findings, making it harder to isolate the effect of the mirroring task itself.

Another limitation may arise from the motion capture technology. While motion capture data enable us to have a quantitative view of synchrony, it may still not capture small elements of the therapeutic interaction, such as micro expressions, which are also important during mirroring. Additionally, technical limitations in capturing very subtle movements or the accuracy of frame-by-frame synchronization may lead to small inaccuracies in the data. For this reason, we might recommend for future studies to include also other technologies such as micro analysis of sessions.

While our study aims to explore potential gender-based differences in mirroring patterns, gender alone might not capture the full range of individual differences in movement synchronization, even if future studies would have with appropriate number for each gender as

participants. Because cultural background, previous experience with dance/movement, or personality traits could also impact mirroring behaviour and might not be fully controlled in the analysis. Therefore, we would need to be careful while interpreting of these results also for future studies.

Lastly, since this study is conducted in a controlled experimental setting, the findings might not fully translate to real-world therapeutic sessions. The structured nature of the tasks could differ from the spontaneous interactions typically seen in therapy, which may limit the applicability of the findings to naturalistic therapeutic contexts. In this study, we aimed to create a session-like environment with the therapist's assistance. However, external factors, such as the body markers, the presence of another person in the room, and the surrounding cameras, may still have influenced the outcomes.

Even though there are several limitations in our study, this research represents a pioneering attempt to explore synchronization during mirroring exercises in DMT sessions. Thanks to motion capture technology, we could collect data in a more objective way and this enhanced the reliability of our study. Our design prioritized ecological validity; we created an environment closely resembling typical therapeutic DMT sessions, encouraging participants to engage mindfully and connect with their bodies. Furthermore, by analysing significant moments identified through structured interviews and considering both the therapist's and participants' perspectives, we could also improve the ecological validity of our results.

In conclusion, this study examined the synchronization level of two participants and one therapist during DMT session, focusing on mirroring practice. Movements in three dimensions have been captured with motion capture technology and analysed to reveal the patterns of synchronisation for each participant during dyadic and triadic interaction. Differences between genders and dyadic - triadic interaction have been investigated. Our findings revealed that there is a perfect synchronisation in Z-axis movements regardless of the participants' gender and interaction style (dyadic or triadic), which shows that it might be easier for people to follow and mirror back up and down movements. However, our results also showed that synchronization level is very weak in X and Y axis, which might be focus for further studies and therapeutic context in order to develop the benefits of mirroring by increasing the synchronization levels in these axes as well. We also discovered gender differences in their movement characteristics and the therapist mirrored the male participant

with higher synchronisation level, whose movements are more stable and consistent. This could be another focus of attention for therapeutic intervention. Additionally, we also observed the difference on synchronisation between dyadic and triadic interaction, suggesting that dyadic interactions enhance comfort and improve synchronisation, highlighting the need to carefully consider group dynamics in therapeutic settings. Future research could extend these findings by including larger sample sizes and examining how mood or emotional states affect synchrony across sessions.

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