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Mapping Movement: A Systematic Review on the Role of Mental Representation in Dance.

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Author Note

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Abstract

Mental representations are essential for understanding the creation and teaching of dance. Recent research from cognitive and dance sciences have described the interaction between imaginary abilities, dance movement and creative performance. This systematic review explores the role of mental representations in dance, focusing on their influence on motor performance and creativity. We aim to: (1) Identify the key themes and concepts that the current body of literature has endeavored to investigate within the field of mental representations and dance. (2) Evaluate the extent to which this literature aligns with the Revised Applied Model of Deliberate Imagery Use. (3) Describe and showcase the benefits and purposes of mental imagery in dance.

We systematically reviewed guided by Preferred Reporting Items for Systematic Review and MetaAnalysis Protocols (PRISMA-P) and the Cochrane Collaboration Handbook. Thirty-five articles meeting the inclusion criteria were selected. To report our findings, we employed the ¨Revised Applied Model of Deliberate Imagery Use¨ to identify and describe ¨the 5 Ws and the How¨ of imagery use within the scientific literature published: Where, When, Why, What, Who and How. The benefits of incorporating imaginary training into dance teaching were frequently reported, but few studies specifically addressed the interaction between imagery and dance creation. Our review shows that the literature addressing the use of mental representations and imagery in dance creation is limited, and future studies are needed to explore the interactions between cognitive performance during movement production, especially within the creative practice. This is essential to understanding the interplay between cognition, artistic expression and creativity within the performing arts.

Keywords: mental representation, imagery, cognitive performance, dance teaching, dance creation, choreography.

Introduction

Dance provides a unique and unparalleled opportunity to investigate the role of mental representations in motor performance and creative skills. It provides a distinctive window for scientific inquiry, enabling researchers to explore the intricate interplay between cognitive representation processes, motor performance, and creative abilities. Here, we focus on the field of dance, recognizing it as an optimal domain for exploration because of its distinctive combination of physical and cognitive demands (Bläsing et al., 2012). Dancers frequently use mental representations to transform verbal and visual cues into movement, engaging in a unique interaction of physical and cognitive challenges.

The interest and use of dance cognitive tools, understood as the strategies that individuals employ to process, interpret, and organize information in relation to movement, applied to dance learning, dance performance, dance observation, dance memorization and creation processes has recently increased. Evidence suggest an important relationship between the type of cognitive tool employed and the kind of action performance achieved by the individual (Mao et al., 2022; May et al., 2020; Orlandi et al., 2020). In addition, dance is an art form that synthesizes the body and mind through both fundamental perception-action coupling and advanced cognitive processes (Yang et al., 2023). For example, differences in brain activity among individuals with varying levels of dance expertise during the observation of dance suggest that dance experience significantly influences both perceptual processing and internal motor simulation (Calvo-Merino et al., 2010). This enhanced neural response to observe dance movements, is complemented with heightened perceptual sensitivity, which stems from extensive visual and motor experience (Calvo-Merino et al., 2005). The investigation of the perceptual, emotional, and cognitive processes involved in movement observation, along with their neural correlates, has been also proposed as a foundation for understanding the aesthetic experience elicited by the observation of dance (Christensen & Calvo-Merino, 2013). Finally, dancers enhance both physical and cognitive abilities through embodied cognition, motor control, cognitive representations of action and intention, attentional focus, visuomotor imagery, emotional comprehension, among other factors (Christensen et al., 2017; Sevdalis & Keller, 2011).

The exploration of motor action representation and simulation has deep roots in psychological and movement science research. William James (1890) posited that "every representation of a movement awakens, to some degree, the actual movement" (James, 1890). Around the turn of the 21st century, cognitive approaches to human action gained prominence. These approaches, which emphasize the cognitive processes underlying goal-directed behavior, have become influential in various experimental frameworks, including ideomotor action, common coding, anticipatory behavioral control, and event coding theory. These theories underscore the cognitive nature of motor behavior, with motor cognition as a key concept (Jeannerod, 2006a), offering a robust alternative to traditional non-cognitive perspectives on human movement. In the scientific literature on motor control, it is widely recognized that actions are mentally represented in a functional way, combining both the executed action and the intended or observed outcomes (Jeannerod, 2006b). The connection between movements and perceptual effects is bidirectional and is believed to be organized hierarchically in long-term memory (Schack et al., 2014). Differences in an individual's motor skill level give rise to distinct structures of mental representations of practiced movements, which evolve into more structured forms through sustained training (Bettina Bläsing et al., 2009; Frank et al., 2014).

The concept of imagery is core to dance practice. One definition of the term "imagery" is the deliberate mental representation of motor abilities, whether with or without actual movement (Short et al., 2001). However, it is important to note that the term imagery extends beyond the representation of motor skills. Imagery has been characterized as "the formation or re-formation of an experience derived from memory, involving quasi-sensory, quasi-perceptual, and quasi-affective features, which is subject to the volitional control of the individual, and can take place in the absence of the actual stimulus that typically accompanies the real experience (Morris et al., 2005). Different types of imagery inspires dancers and choreographers' creativity enhancing the learning of technical abilities (Hanrahan & Vergeer, 2000; Nordin-Bates & Cumming, 2006; Vaccaro, 1997) and is commonly used in dance science literature.

The term mental representation has a broader scope than imagery, encompassing various types of internal cognitive structures such as semantic knowledge, concepts, beliefs, attitudes, propositions, rules, situations, analogies, images, and so on (Thagard, 2014). In contrast, imagery is more specific, referring to the process of generating sensory-like experiences (e.g., seeing, hearing, feeling) without external stimuli, and there is evidence suggesting that mental images are indeed 'perception-like' in nature (Albers et al., 2013). Another approach to the relationship between both terms was presented by Maryam Fourtassi, who asserted that visual mental imagery is a cognitive experience characterized by the activation of the mental representation of an object or scene in the absence of the corresponding stimulus (Fourtassi et al., 2017). Given that imagery is conceptualized as a form of cognitive representation, both terms have been incorporated into the search.

Here, we explore the use of cognitive strategies, with a particular emphasis on mental representations, in dance training and creativity settings. These serve as a principal component in the development of both technical skills and creative expression (Gose, 2007). We discuss the contribution to of cognitive representations and related strategies to enhancing performance, choreography, and overall artistic development in dance. We apply the Revised Applied Model elaborated by Munroe and colleagues (Munroe et al., 2000) as a framework to report the findings. This model and its updated version ¨Revised Applied Model of Deliberate Imagery Use¨ (Hall et al., 2009) have been already successfully applied to dance research in the past (Pavlik & Nordin-Bates, 2016). The main goal when choosing this model as a framework is to identify and describe ¨the 5 Ws and the How¨ of imagery use within the scientific literature published so far: Where, When, Why, What, Who and How (Hall et al., 2009). Here a description (see Table 1 for a summary):

1. **Where**: This refers to the *location* or *environment* in which the mental representation or imagery takes place. In the context of dance, this could refer to various settings such as a rehearsal studio, the stage during a performance, or even a specific space like a dance studio or private space where mental rehearsal happens. Understanding "where" helps us contextualize how the environment influences the use of imagery in dance practice.
2. **When**: This aspect describes the *timing* or *moment* in which mental imagery is used. This could be after a performance routine when the dancer reflects on their movements, before a performance to prepare mentally, or even during a practice session to enhance technique. The timing of imagery might play a crucial role in its effectiveness, depending on the dancer's needs at that particular time.
3. **Why**: The *function* or *purpose* of imagery is highlighted here. This explains why an individual engages in imagery, outlining its specific goal or benefit. In the context of dance, the function of imagery could range from improving technique, such as enhancing balance or movement precision, to aiding in creative expression, fostering emotional connection, or even as a tool for mental recovery. This helps understand the motivational or functional aspect of why dancers engage in mental imagery.
4. **What**: This refers to the *type* of imagery being used. It could distinguish between different kinds of imagery, such as **metaphorical imagery** (e.g., imagining oneself as a flowing river to enhance fluidity in movement) versus **descriptive imagery** (e.g., visualizing specific movements or steps in great detail). Different types of imagery might be used for various purposes, such as refining technical skills or enhancing emotional expression.
5. **Who**: This focuses on the *individual* or *group* who is using the imagery. It could vary based on the dancer's experience level, such as a professional dancer versus an amateur or novice. It also touches upon factors like age, training background, and personal goals, all of which may influence how the dancer employs mental imagery.

6. **How**: describes the way by which imagery is accomplished, the manner used to engage with the imagery, such as while walking, dancing, or even without any movement.

Overall, we aim to provide a valuable review for synthesizing existing research, identifying knowledge gaps, and shaping the direction of future inquiry in this interdisciplinary field. We expect to promote a deeper understanding of the cognitive processes underlying motor performance and facilitate the development of evidence-based practices to support dancers' training, creativity, and artistic expression. We have identified three main objectives: (1) Identify the key themes and concepts that the current body of literature has endeavored to investigate within the field of mental representations and dance. (2) Evaluate the extent to which this literature aligns with the Revised Applied Model of Deliberate Imagery Use. (3) Describe and showcase the benefits and purposes of mental imagery in dance.

Method

We systematically reviewed guided by Preferred Reporting Items for Systematic Review and MetaAnalysis Protocols (PRIMA-P) and the Cochrane Collaboration Handbook. The electronic search was completed through the following databases, Web of Science (core collection), MEDLINE ProQuest, Scopus, Pubmed and PsycINFO. Databases, terms, and search syntax are presented in Table 1. A visual representation of the frequencies by decades is presented in Figure 2.

We included published articles written in English or in Spanish as a criterion to take a national and an international publication level into consideration. Studies included in this systematic review focused exclusively on healthy populations, and therefore, studies involving dance therapy or movement therapy, including those with only control groups, were excluded. This criterion was applied to ensure the consistency of the population under investigation. We excluded studies developed with humanoids or robots but not human movement, we also excluded reviews or any other scientific contribution not published. The experimental studies designed to analyse the mental representation-dance movement interaction were selected if they included both dance and imagery or mental representation as a subject of study. Inclusion and exclusion criteria are presented in Table 1.

A first search brought 46 articles. Two articles written in Russian were manually dismissed, given our language exclusion criteria (Dikaya et al., 2015; Naumova et al., 2016). Another 2 articles were manually removed being their core topic a sports discipline, like tennis (Schack et al., 2014) and Karate (Strenge et al., 2020). Another 7 additional articles were excluded due to their core topic belonging to a different field of study, such as the use of visual input for artistic purposes (Hugel et al., 1999), the abstraction processes (Aviv, 2017), the principles governing the perception of rhythmic structure in dance and music (Charnavel, 2022), the flow experience during group collaborations (Łucznik & May, 2021) and one final study that appeared in the search, although some of its materials included dance images, is not related to this field of knowledge (Kimmel et al., 2024).

Another article was excluded due to a wording mismatch, this article evaluate Franklin Method visual images (pictures) affecting the height of dancers' jumps (Heiland & Rovetti, 2013), the databases search engine mixed up the terms imagery and images and we manually removed this article. One last article was removed due to its not pertinency to our topic (Laberge-Cote, 2020) .

The final search was conducted in 2024, and upon evaluation, it yielded a total of 35 eligible articles. The articles were thoroughly reviewed, confirming their relevance as their content aligned with the study's objectives. The Revised Applied Model of Imagery Use was applied to assess, analyse, and group the publications into six broad categories. When, Where, Why, Who, What and How. This categorization was previously applied, and we deemed it to be a beneficial method for organizing the information (Cumming & Williams, 2013; Hausenblas & Downs, 2002; Pavlik & Nordin-Bates, 2016). Table 1 summarizes and exemplifies the components that the ¨Revised applied model of deliberate imaginary use¨ (Cumming & Williams, 2013) proposes. PRISMA 2020 flow diagram presented in Figure 1.

The methods employed within each study were then used to categorize the articles into three research categories, following the framework proposed by Nemecek and Chatfield (Nemecek & Chatfield, 2007) classification: analytical (A), descriptive (D) and experimental (E). Note that "analytical" research refers to studies that compile quantitative and qualitative data and expert viewpoints but does not imply that data were subjected to statistical analysis by the researchers. Articles reviewed are presented in Table 2.

Results and Discussion

Thirty-five articles satisfied the inclusion criteria. The articles were published between 1980 and 2023 and included a total of 1311 participants. Only two of the studies had children in the sample (Muir et al., 2018; Pietsch et al., 2019) . We present the results attending to ¨the 5 Ws and the How¨ of imagery use in dance field and starting with the components ¨Where and When¨.

Before proceeding, an important consideration is the predominance of Western-specific literature, particularly focusing on ballet. It is essential for future research to embrace greater cultural diversity in order to enhance the generalizability of findings. The impact of mental imagery in Western ballet may not necessarily extend to other dance styles, thereby underscoring the need for further investigation across a broader range of cultural and dance contexts.

Where (location) and When (situation)

A minority of studies attend the moment of time in which the imagery is used or the space and environment in which the mental representation arose. From the database we only find two articles addressing the contexts in which dancers use volitional mental representations. Muir et al (2018) provided a classification of potential locations into three categories: (a) dance settings, (b) homes, and (c) educational settings. Within dance setting, the authors established different sites, the studio, contests, recitals, conventions, backstage, and the changing room. All age groups of dancers reported employing imagery in the studio and during competitions. With the sample consisting entirely of adolescents, only the older age cohorts (ages 11–12 and 13–14) reported using dance imagery at home (Muir et al., 2018). From another perspective, patterns of recalling a movement turn out to be influenced by the context and the environment where those happen (Carmona, 2021). This study highlights the dynamic interaction between the body's direct perception and mirroring, asserting that both are essential for the formation of movement patterns in dance. Direct perception refers to the way individuals experience and respond immediately and unmediated to environmental stimuli, such as the movement of others, music, or interaction with space. Movement patterns are influenced not only by direct perception but also by mirror perception, where individuals automatically replicate movements, sometimes without being fully conscious of it. This study concludes that both forms contribute to the learning, adjustment, and refinement of movement patterns in real-time, often without the need for detailed conscious processing.

The component ¨when¨ finds less research published than others. However, research shows that dancers make use of mental imagery throughout their preparation, training, creative processes and performance, not only in rehearsals or during a live performance but also before and after (Hanrahan & Vergeer, 2000; Nordin-Bates & Cumming, 2006).

In a deeper investigation of the timing of the imagery applied by the dancers, Muir et al., (2018) proposed eight different categories: (a) prior to going on stage, (b) while on stage, (c) during practice, (d) after competing/performing, (e) after making mistakes/experiencing difficulties, (f) days prior to a competition/performance, (g) before going to bed, and (h) during free time. Dancers of all ages mentioned creating mental images shortly before taking the stage to prepare themselves for the performance (Muir et al., 2018). Employing a slightly different approach May et al., (2020) evaluated the impact of a series of workshops aimed at developing metacognitive abilities in the use of mental imagery. They developed five versions of a Flexible Thinking Test (FTT) designed to facilitate repeated assessments of creativity, following the guidelines of Barbot (2019) (Barbot, 2019). The FTT was constructed using three tests from the Comprehensive Ability Battery (Hakstian & Woolsey, 1985) : Ideational Fluency, Spontaneous Fluency, and Originality. Their results show that students attending this workshop demonstrated an improvement in flexible thinking in comparison to another student group who did not attend the workshops (May et al., 2020).

Who (individual/experience)

Factors that could influence the impact of imagery and mental representations and its outcomes include gender, competitive level, age, experience, and the person's disposition or personality (Cumming & Williams, 2013). However, most of the articles found on this subject focused on examining the differences in the use of mental representation in individuals with different experience, namely expert dancers vs non-dancers. Few studies explore teaching methodologies across various dance techniques, the usage of imaginary tools by dancers of different modalities, or the differences in how instructors incorporate visualization techniques in their training, comparing practices between dance and sports.

Dancers vs Non-dancers

From the scientific literature to date, the most productive line of research regarding the interaction between mental representations and dance focuses into the differences between dancers and non-dancers; it represents a rich and fruitful area of inquiry that continues to yield important contributions to our understanding of the cognitive underpinnings of dance expertise. Most significant differences between expert dancers and non-dancers are presented in Table 3.

In recent years, the imagery style, the integration of proprioceptive signals and the brain activity associated with creative thinking, among other aspects have been explored and significant differences between dancers and non-dancers have been highlighted. Overall, these works strengthen the benefits that the use of mental representations brings to the population of dance practitioners.

The use of different movement imagery style has been explored in individuals with dance experience and without this expertise. Golomer et al., (2008) classified ballet dancers and untrained participants in relation to their movement imagery style. Results showed that dancers tended to use kinesthetic and mixed imagery styles, with 'mixed styles' referring to both kinesthetic and visual imagery, whereas untrained participants mainly used a mixed approach. This suggests that dance training improves the representation of kinesthetic sensation and affects the choice of spatial orientation, enhancing the connection between the body and space (Golomer et al., 2008). Further research has focused on describing how different imagery styles can support achieving different outcomes, with special emphasis on how trunk strategies and leg stability interacts with different imagery styles (Golomer et al., 2009).

The structure of imagery representations in long term memory between professional dancers, as opposed to beginners or advanced amateurs, has been also investigated (Blassing et al., 2009). Dancers demonstrated differences in their imaginary representation structures stored in long-term memory; these differences were associated with the functional stages of movement, with dancers' representations being more structured. In comparison with beginners and advanced amateurs, the more experienced participants exhibited mental representations that were not only more organized but also systematically aligned with the functional stages of movement, resulting in more effective representations (B. Bläsing et al., 2009). Same authors also explored how professional dancer create experience-based embodied representations of the body and movement (Bläsing et al., 2012). The authors analyzed the representation of spatial movement parameters in dance. The study involved participants with varying levels of dance expertise, including professional dancers, dance amateurs, and non-dancers. The results suggest that only those individuals with expertise in dance possess distinctive embodied representations of complex movements, hence, incorporating information regarding body-centered spatial parameters. (Bläsing et al., 2012). These studies provide evidence that motor expertise, such as that acquired through dance training, significantly influences sensorimotor processing. enhancing the brain's ability to perceive and understand complex movements.

The influence of expertise level on the motor and visual imagery ability has also been explored (Mao et al,. 2022). The authors confronted amateur dancers and non-dancers to an original dance movement reproduction task, and they applied the vividness of visual imagery questionnaire (VVIQ) and the vividness of motor imagery questionnaire (VMIQ). Amateur dancers showed greater kinesthetic and motor imagery abilities, but similar visual imagery abilities to non-dancers (Mao et al., 2022).

The use of mental representations in dance *has also been explored at the brain level*, by comparing neural differences between groups using EEG. Fink et al (2009) compared the neural activity novice dancers with no comprehensive knowledge and of expert dancers, during two imaginary tasks which demanded different creative skills. Results described higher right-hemispheric alpha synchronization in expert dancers than the non-expert group during the task that demanded more creative skills (Fink et al., 2009). This result contributes to the broaden research exploring on the link between creative thinking and

EEG alpha activity described in other domains (Bazanova & Aftanas, 2007, 2008; Jausovec & Jausovec, 2000; Martindale & Hines, 1975; Tarasova et al., 2006).

Levels of desynchronization or power reduction in the alpha and beta frequences are further explored by Di Nota et al., (2017). The authors compared EEG activity during and action observation and kinesthetic mental imagery of ballet-movement sequences and a non-dance movements sequences in a group of ballet dancers, dancers from different genres, and non-dancers. Results show how ballet dancers who were very familiar with the ballet vocabulary observed showed higher individual alpha peak frequency (iAPF), higher alpha desynchronization, and more task-related beta power during action observation. A faster iAPF was also observed during kinesthetic motor imagery of non-dance movements (Di Nota et al., 2017). These data strengthen the idea of an experience-dependent activity represented in the alpha and beta frequencies during executing, observing and imagining movements.

The modulation of the neural correlates associated to the time required to produce movement imagery based on the individual's dance expertise has been explored by Orlandi et al., (2020). Their study recorded EEG activity in professional dancers and non-dancers associated while measuring the timing needed to generate complex movement mental imagery. Their findings showed different neural networks engaged during imagery in the two groups. Prefrontal regions showed stronger response in non-dancers, compared with dancers, in the motor imagery task. Interestingly, dancers showed stronger activations in occipitotemporal and bilateral sensorimotor areas during the same motor imagery tasks. These results suggest that dance training may enhance the use of action representation skills during imagery (Orlandi et al., 2020). In a similar way, the effect of expertise over mental representation skills was also described by Bläsing and Schack (2012), whose analysis of dance movement representations showed that information on body-centered spatial attributes is exclusive to dance experts (Bläsing & Schack, 2012).

The sensory information that comes from different sensory modalities is integrated to compose the body experience as a whole entity, and proprioception is a fundamental element to generate a mental representation (Graziano & Botvinick, 2002). Research examining proprioceptive signal integration in individuals with and without dance experience revealed that dancers showed a greater local proprioceptive signal integration to form a whole-body representation than non-dancers (Jola et al., 2011). On the other hand, Coker et al (2015) compared two types of motor imagery task (visual and kinesthetic) while measuring the kinematic parameters of the movement itself on a group of elite dancers. The study didn’t find any differences of expertise or type of imagery task in the kinetic or temporal parameters of movement execution (Coker et al., 2015).

Other studies comparing experts

Other studies have further explored the differences that may be found in dance teaching based on the style practiced, or by comparing teaching strategies in dance with the ones applied in sports disciplines. Regarding the type of expertise, Paris-Alemany et al., (2019) compared the used of visual and motor imagery in dancers experts on different dance modalities (ballet, contemporary and flamenco). The results evidenced significant differences in the kinematics and timing between the groups when analyzing a mental jump movement generation (Paris-Alemany et al., 2019).

Teaching practice styles have also been compared in a study conducted by Klockare et al (2011). Here the authors examined teaching practices in relation to imagery training from different kind of dance techniques. They conducted their study with professional jazz, ballet and contemporary teachers. The findings suggested that all teachers attempted to achieve the following outcomes through mental training: group cohesion, self-confidence, and anxiety management. All the teachers additionally placed a significant amount of attention on performance planning, assessment, and feedback (Klockare et al., 2011).

Finally, Overby et al., (1998) compared the mental imagery used by soccer coaches, figure skating coaches, and dance instructors. The findings showed that the groups were very different in the way they apply imaginary techniques within their training sessions, especially in the use of kinesthetic imagery and metaphorical imagery (Overby et al., 1998).

Why (function) and How (experience)

We found a large amount of research investigating the function of the mental imagery use. We classified the results in three groups, the studies focusing on injury prevention, the ones with emphasis on technical achievements and others.

Injury prevention: Among the studies reviewed, two investigated the effects of mental imagery interventions designed to prevent injuries in dancers. Noh et al., (2007) evidenced that interventions based on coping skills, autogenic training, imagery and self-talk reduce injury through training (Noh et al., 2007). Years later Girón et al. (2012) proposed a study that analyzed the effects of two different imagery modalities on pelvis and hip kinematics. They differentiated in between visual and kinesthetic mental representation comparing its effects through two different tasks during dance technical practice. Dancers performed two different technical ballet movements. They concluded that combining imagery modality with technical practice helps to avoid injury (Girón et al., 2012).

Technical achievements: Taking a different perspective in relation with the function of the imagery, Golomer et al. (2008) analyzed the kinematic of technical movements, specifically hip and shoulder rotation during pirouettes, regarding to imagery motor actions. They demonstrated that dance practice increases the imagery of kinesthetic sensation and benefits the interaction between the body and the space (Golomer et al., 2008). Similar approach was followed by Carey et al. (2019) analyzing how the experience of the dancer influences the motor imagery and the attentional effort. Their participants were 18 female dancers, aged 23 on average, categorized into three experience levels: novice, intermediate, and expert performers. Regarding the control group, the study did not include a separate group of non-dancers. Curiously their findings revealed non-significant effect of the dancer´s experience on the motor imagery measurements. On the contrary, they found significant results in the interaction between expertise and attentional effort (Carey et al., 2019). The lack of significant findings regarding the expertise effect on motor imagery may be attributed to the absence of a non-dancer control group, which contrasts with other studies that incorporated such a group to better isolate the influence of dance expertise.

Other studies have explored the benefits of imaginary training interventions to enhance the execution of ballet technique of specific movements. Abraham et al. (2016) focused on the execution of the “elevé¨. The elevé is a basic technical movement in ballet. During this study, imagery practice was proposed to enhance its performance. Their results suggest that the motor imaginary practice would be a great addition to the training of the ¨elevé¨, helping achieving a greater execution. The motor imagery practice viability was determined with full compliance, and participants reported favorable opinions (Abraham et al., 2016). On another study, Couillandre et al., (2008) analyzed the use of kinesiological strategies and mental representation tools during the training of a ¨demi plie¨, a basic technical exercise of classical ballet. Electromyographic and biomechanical measurements showed that kinesiological and imaginary strategies may increase a dancer's dynamic alignment without compromising their technical ability (Couillandre et al., 2008).

The Dynamic Neuro-Cognitive Method (DNI) is a practice-based package of tools for movement and postural training that enhances proprioceptive and kinesthetic mental representations (Franklin, 2003; Lotze, 2013). Abraham et al. (2019) explored the benefits of this method on the kinematics of the ¨developé¨ performance (a basic ballet technical movement) additionally to dance imagery skills. Their results showed an increased hip range of motion enhancing the ¨developé¨ performance after three days of DNI training. Improvements in self-reported measures and imagery skills were additionally observed by the intervention (Abraham et al., 2019).

Other studies:_From a very different perspective Klockare and colleagues (2011) published findings showing that dance teachers attempted to achieve cohesion, self-confidence, and anxiety management in their classes by applying imagery strategies (Klockare et al., 2011). The study was conducted with six female professional instructors in jazz, ballet, and contemporary dance.

From a neural perspective, Sacco et al. (2006) examined the effects of tango training in the activation of the motor neural networks using fMRI. Their findings suggest that a motor imagery intervention after each tango session provokes a larger activation of bilateral motor areas (Sacco et al., 2006). These primary motor regions are involved when the individual generates voluntary movements as well as when mental sensorimotor representations are recruited using motor imagery (Hanakawa et al., 2003). In another fMRI study Tipper et al. (2015) explored the neural networks that take part in the understanding of the movement meaning. For the movement meaning task, participants watched videos of performers engaged in modern dance and pantomime, which conveyed specific themes such as hope, agony, lust, and exhaustion. They suggested that the meaning-sensitive temporal-orbitofrontal regions activity supports the established idea of a hierarchical action observation network (AON), which is essential to developing meaning from expressive movement (Tipper et al., 2015). This proposal builds on the idea of a predictive coding model for action understanding. It is crucial to highlight at this point that there exists a notable distinction in meaning-making in dance between Western and non-Western traditions. All forms of dance, whether from Western or non-Western contexts, reflect the cultural frameworks in which they evolve (Kealiinohomoku, 1983). As Shilpa Darivemula and colleagues (2021) describe, dances such as Bharatanatyam, an Indian classical dance, inherently involve the specific use of movement for communication and meaning-making in dance ("Rehumanizing Clinical Language Through Classical Indian Dance," 2021).

A recent approach presents evidence supporting the value of dance-based exercise digital games. Participation in digital somatosensory dance games for 6 month not only facilitated structural and functional alterations in various brain regions associated with somatosensory, motor, visual, and attentional functions but also improved physical and mental health.(Tung et al., 2024).

How

Regarding the component ¨How¨ the differences between open- and closed-skill sport events in terms of imagery ability was explored by Di Corrado et a. (2014). The purpose of their study was to determine if the vividness and controllability of the imaginary is affected differently depending on whether the task was open or closed. Open skills activities are those in which the movement decision making takes place in an environment that shifts constantly, and demands from the individual quick anticipation, decision-making, reaction, and precise and regulated physical movements (Singer, 2000). Classical ballet is an artistic dance genres that demands closed skills and its movement is frequently self-paced (Spittle & Morris, 2007). Di Corrado et al. (2014) compared the imaginary ability of karate practitioners and ballet dancers. The findings of this study indicate that regardless of the sport they participated in, the groups did not differ in their imaginary ability (Di Corrado et al., 2014).

Olshansky et al. (2015) used functional magnetic resonance imaging to investigate brain activity underlying motor imagery training. They revealed that when the individual performances a motor imagery of a dance over a familiar music the primary auditory cortex reduces its activity and the supplementary motor area the reverse, increases its activity, compared with what happens when the imaginary is performed over an unfamiliar music (Olshansky et al., 2015). Batson and Sentler (2017) published another study aiming to contribute to the conversion of kinesthetic versus visual imagery effects within the field of movement research. Their study relates with the component ¨How¨ emphasizing the benefits of mental imagery in choreography and performance creation processes. Two dance educators present the results of a pilot study that explored the use of two contrasting imagery tasks in teaching improvisation. One task employed tactile-kinesthetic imagery through verbal prompts, while the other emphasized visual prompts. Each task led to distinct movement patterns and reflections on embodiment, raising important considerations for future research. (G. Batson & S. Sentler, 2017).

The idea of creativity has also been included. For example, May et al (2020) were interested on the training on mental imagery and its interaction with creativity development. In particular they asked how metacognitive skills training could benefit creativity. In a longitudinal study, 240 undergraduate dance students were recruited to evaluate the effectiveness of a series of workshops aimed at developing metacognitive skills in the use of mental imagery to enhance choreographic creativity. The authors provided evidence that imagery training can benefit creativity, mainly when it is based on an empirical understanding of the role that imagery plays in creativity (May et al., 2020). In another study, Palmiero et al. (2019) framed their results in line with the domain-specific hypothesis of creativity. The promotion of creativity using motor imagery training has been far demonstrated (Couillandre et al., 2008; Purcell, 1990; Sacha & Russ, 2006). Palmiero and colleagues broach this question focusing specifically on divergent thinking measurements within the dance field. They evidenced that dancers identified the body segments quicker and more precisely than non-dancers. They found that the topological map of the body interacts with motor divergent thinking (Palmiero et al., 2019). Their studies were carried out with children highlighting the benefits of practicing dance from childhood.

From the creation point of view May et al. (2011) broached the study of mental representation and decision making. Their study was framed within a program of choreographic strategies research, following choreographer Wayne McGregor's approach to movement creation, and its participants were professional dancers. Their fMRI results demonstrated shared activations in the orbitofrontal cortex, middle temporal areas, and occipital brain across the spatial-praxis and emotional imagery tasks. They also carried out an experience sampling methodology study examining the factors that affected the dancers' mental processes as they produced movement in response to the choreographer McGregor's instructions. The results show that dancers were not often influenced by things going on around them when they are generating new movement vocabulary. The highest rating for the items addressing dancers' mental focus while producing movement was given to spatial-praxis (May et al., 2011).

Finally, the influence of perspective and point of view have also been investigated in relation to mental imagery and dance, it has been shown that generating a motor imagery has an impact on memory performance of a dance movement. The perspective adopted during imagining influences memory performance, as the person imagined (self vs. other) significantly affects memory for self-performed tasks. Specifically, when individuals imagine from a first-person perspective, memory performance is enhanced (Foley et al., 1991).

What (Type)

The type of content that characterizes different mental representations and their interaction with motor performance in dance has been approached from various angles. The predominant content concerning the type of task faced by the dancer or the specific technical requirements of the practiced dance or style, the examination of spatial skills according to the content of mental representations in various sports and dance, and the significance of the structural content of mental representations in guiding the motor plan in dance, will be some of the key points addressed in the following discussion.

An interesting finding in this regard is that Spanish professional dancers primarily relied on visual imagery modalities rather than kinaesthetic ones to produce motor imagery regardless of the dance style (Paris-Alemany et al., 2019). Coker et al. (2015) provided evidence of different effects comparing third-person visual imagery and kinaesthetic imagery in ballet dancers while they were executing certain kind of technical requirements. They measured the kinematics of hip and pelvis during technical execution of a plie and a sauté (ballet technical movements). The kinematics measurements were the change in external hip rotation and the sagittal pelvic tilt excursion. They analysed temporal variability graded according to the start and end times of movements. The imaginary training did not revealed differences in the temporal measurements of the movement´s kinematics but they presented interesting tendencies (Coker et al., 2015).

One of the most thoroughly researched spatial skills is mental rotation, which is described as the mental representation and rotation of objects (Shepard & Metzler, 1971). Object-based and egocentric transformations in front and back view are two examples of distinct types of mental rotation tasks (Linn & Petersen, 1985). Pietzch et al. (2019) compared adolescent soccer players and dancers analyzing their reaction time and object- based versus egocentric transformations differences. The "dancing group" consists of 28 girls, with a mean age of 15.54 (SD = 1.13). They have practiced dance for an average of 9.00 years (SD = 2.73) and engage in an average of 4.43 hours of practice per week (SD = 2.85). There were no differences in the mean age between the two groups, nor in the weekly hours dedicated to training or in years of experience. They evidenced that dancers had slower front view than back view reaction time while soccer players exhibited no difference in reaction time scores between front and back view stimuli. Additionally, for front view stimuli, soccer players revealed a faster reaction time than dancers and dancers showed a higher precision for tasks involving object-based transformations in the back view (Pietsch et al., 2019).

Charnavell (2021) researched the mental representation guiding the motor planning in dance. She hypothesized that the dancer unconsciously generates a mental imagery regulated by predominant structural basis. She followed the approach of musical grouping fundamentals of Lerdahl and Jackendoff's work (Lerdahl & Jackendoff, 1996). This study aimed to make a first step toward creating a universal syntax of dance evidencing that grouping principles regulate how viewers mentally represent dance movements (Charnavel, 2019).

Based on studies on the enactive imagination, Carmona proposed in 2021 that contentless memory forms function alongside content-involving memory forms during remembering tasks of a dance movement. By "contentless memory forms," the author referred to those that do not necessarily involve meaningful representations of the world or provided information about it in terms of satisfying some form of correctness conditions. (Carmona, 2021).

Aiming to explore the nature of dance expertise and its associated cognitive mechanisms, Bläsing et al (2009) proposed an study investigating mental representations stored in long term memory of dancers with different level of dance training. They proposed two groups: an expert group consisting of professional dancers trained in classical ballet or both classical and modern dance, who were active members of professional classical or modern dance companies at the time of the study; and an amateur group, who had received ballet training ranging from 3 months to 20 years, with most also having trained in modern dance and/or jazz dance. However, their training was not at a professional level. With this objective they analysed the mental representations of Pas assemblé and the Pirouette en dehors, two technical complex movements of classical ballet. The movement's functional structure was stronger in more experienced dancers´ mental representations of the proposed complex movements (B. Bläsing et al., 2009).

Recent findings were presented in support of the notion that experience in activities utilizing mental imagery (MI) influences implicit MI, while formal training may have a stronger impact on explicit MI. Significant effects were found for individual and team sports and music, but not dance (Bek et al., 2025).

Conclusions

Based on the studies reviewed, it is important to note that these conclusions are primarily based on dancers trained in Western classical ballet. The results may vary depending on the type of dance, as factors such as the style and focus of training could influence the outcomes.

Only two of the thirty four studies analysed broach the component ¨where¨, providing a classification of potential locations where imaginary strategies are used by the dancers and highlighting the importance of the environment where the metal training happens (Carmona, 2021; Muir et al., 2018). Exploring into the component ¨when¨ we found that dancers of all ages revealed to used mental images shortly before taking the stage to prepare themselves for the performance (Muir et al., 2018).

With great difference the component ¨who¨ is one of the more researched components, fourteen articles from the databases were found, and notably, except four of the articles the rest were all based in studying differences in relation with the dance expertise of the individuals. The four exceptions approaching this component were comparing the teaching practices in relation with imagery training from different kind of dance techniques and the varying use of imagery strategies from different dance genders professionals (Di Nota et al., 2017; Klockare et al., 2011; Overby et al., 1998; Paris-Alemany et al., 2019). While Overby et al. (1998) provided a comparative analysis of imagery practices across different coaching disciplines, including dance, identifying various forms of imagery utilized such as visual and kinesthetic, Paris-Alemany et al. (2019) investigated the prevalence and characteristics of visual motor imagery among Spanish dancers concentrated solely on professional dancers, offering a more in-depth understanding of imagery use within the dance profession.

We can tell that dancers in comparison with non-dancers tended to use more a kinesthetic imagery style, showed higher right-hemispheric alpha synchronization during imaginary tasks, reveal greater local proprioceptive signal integration to form a whole body representation, included body-centered spatial information in their embodied representations of movement, showed greater kinesthetic and motor imagery abilities, demonstrated greater integration of local proprioceptive signals and showed enhanced engagement occipitotemporal and bilateral sensorimotor areas relative to non-dancers (Bläsing & Schack, 2012; Fink et al., 2009; Golomer et al., 2008; Golomer et al., 2009; Jola et al., 2011; Jola et al., 2014; Mao et al., 2022)

In contrast, no differences were found in between groups divided by the dancer´s expertise, in the kinematics of the execution of technical ballet movements measured through different imaginary tasks. This study examined the impact of two motor imagery modalities, third-person visual imagery and kinesthetic imagery, on hip and pelvis kinematics during two technical dance movements: plié and sauté. (Coker et al., 2015).

The component ¨Why¨ was also extensively explored, twenty-three studies were found. Only two of those based their research in the benefits of imaginary training to prevent injury in dancers (Girón et al., 2012; Noh et al., 2007). Most of the published articles addressing this component were investigating the kinematics of dance technical movements regarding to imagery motor actions. They demonstrated that dance practice increases the imagery of kinesthetic sensation and benefits the interaction between the body and the space, that the motor imaginary practice would be a great addition to the training of the several technical ballet movements like the ¨elevé¨ ¨demi plie¨ or ¨develope¨, to achieve a greater execution and that also benefits creativity (Abraham et al., 2016; Abraham et al., 2019; Couillandre et al., 2008; Golomer et al., 2008; May et al., 2020).

We found five studies regarding the component ¨How¨, one of them emphases the benefits of mental imagery in choreography and performance creation processes (Glenna Batson & Susan Sentler, 2017) . The differences between open-skill and closed-skill sport events in terms of imagery ability were also explored (Di Corrado et al., 2014) and other three articles investigated the brain activity underlying motor imagery training. FMRI findings suggest that a motor imagery intervention after each tango session provokes a larger activation of bilateral motor areas (Sacco et al., 2006), demonstrated that the meaning-sensitive temporal-orbitofrontal regions activity is essential to developing meaning from expressive movement (Tipper et al., 2015) and revealed that when the individual performances a motor imagery of a dance over a familiar music the primary auditory cortex reduces and the supplementary motor area increases its activity (Olshansky et al., 2015).

In relation with the type of imagery involved in the studies and the component ¨what¨ there are six articles published. Among other findings we can tell that dancers unconsciously generates a mental imagery regulated by predominant structural basis (Charnavel, 2019) and that contentless memory forms function alongside content-involving memory forms during remembering tasks of a dance movement (Carmona, 2021). Curiously, professional Spanish dancers generated motor imagery mostly through visual rather than kinaesthetic modality (Paris-Alemany et al., 2019).

What it is clear now is that low attention was given to the interaction of mental representations and creative processes from any of the component's analyzed. We can only count with one study found that from the creation point of view was broaching the study of mental representation and decision making (May et al., 2020). Future research would be enriched by studies aiming to explore the effects of imaginary tasks in the creation of new dance movement vocabulary.

It is challenging to draw direct comparisons and conclusions due to issues like the use of homogeneous measurements in between studies or the absence of dance specific measurements. Also, larger participant rates, and comparable methodology across studies are future research issues to be solved.

As an overall view we found that the relationship between imagery and dance as an artform received little attention, despite numerous research studying the advantages of including imagery training into dance instruction. We believe that this is a crucial gap to fill since dance is an artistic discipline. Future research on this topic might focus on the intricate interplay between imagery and the creative process in dance production. This line of inquiry holds promise for enriching our understanding of the cognitive mechanisms underlying artistic creation in the realm of dance, ultimately contributing to the advancement of both theoretical knowledge and practical applications within the field.

This review holds significant relevance to the dance community, as it offers valuable insights that can be directly applied to both dance training and teaching practices. Understanding the cognitive and physical aspects of dance, as explored in this study, can help dancers in training optimize their practice methods and refine their technical skills. Dance teachers can use these findings to better tailor their instruction, potentially enhancing the learning experience by incorporating strategies that align with cognitive processes. Furthermore, through this review we would like to emphasize the need for stronger collaboration between researchers and the dance community, ensuring that future research continues to inform and benefit applied practice in dance. By bridging the gap between theory and practice, dancers and educators can use this knowledge to enhance both performance and pedagogy.

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Table 1. Inclusion and exclusion criteria. Databases. Terms and search syntaxis. Revised applied model of deliberate imagery use components and examples.

Inclusion criteria

- Articles written in English (international language) or Spanish (national language) to which it has been possible to access the full text.
- Studies that report any type of interaction between the terms: Mental representation or Imagery and Dance
- Healthy population.

Exclusion Criteria

- Systematic, narrative or author reviews.
- Essays, contributions to conferences or unpublished articles.
- Chapters of the book.
- Studies on movement of humanoids or robots instead of on human movement.
- Studies in which the results are influenced by other simultaneous experimental conditions (for example, food), which do not allow to extract clear relationships between cognition, movement and action activity.
- Other languages.

Databases	**Search Terms and Sintaxis**
Scopus	((¨Mental Representation¨ OR ¨Mental Imagery¨ AND ¨Dance¨))
WOS	Mental Representation OR Mental Imagery (Topic) AND Dance (topic)
Pubmed	((mental representation) OR (mental imagery)) AND (dance)
Medline	(mental representation OR mental imagery) AND dance
PsyInfo	(mental representation OR mental imagery) AND dance
Cochrane	(mental representation OR mental imagery) AND dance

Revised applied model components and examples

Component	**Description**	**Example**
Where	Location	On Stage
When	Situation	After a performance routine
Who	Individual	An amateur/A professional
Why	Function	Improve balancing
What	Type/Content	Metaphorical imagery/Descriptive imagery
How	Characteristics	Dancing/walking

Table 2: List of studies included in the systematic review organized by publication date. E:Experimental D: Descriptive, , PD: Professional Dancers, NPD: Non-Professional Dances

Study	Type	Style & Level	Sample	Who	What	Why	Where	How	Ability	When
Foley et al., (1991)	E	Non-Specific	27 (PD, NPD)	x	x	✓	x	x	✓	x
Hanrahan & Vergeer (2000)	E	Non-Specific	65 (P)	x	✓	x	x	x	✓	x
Overby et al., (1998)	D	Non-Specific	49 (P)	✓	✓	x	x	x	x	x
Sacco et al., (2006)	E	Tango	8 (NP)	x	x	✓	x	x	✓	x
Noh et al., (2007)	E	Ballet	35 (P)	x	x	✓	x	x	x	X
Couillandre et al., (2008)	E	Ballet	7 (P)	x	x	✓	x	x	✓	x
Golomer et al., (2008)	E	Ballet	15 (PD, NPD)	✓	x	✓	x	x	✓	x
Golomer et al.,(2009)	E	Ballet	15 (PD, NPD)	✓	x	x	x	x	✓	x
Bläsing et al., (2009)	E	Ballet	66 (PD, NPD)	✓	x	✓	x	x	✓	x
Fink et al.,(2009)	E	Non-Specific	32 (PD, NPD)	✓	x	x	x	x	x	x
Jola et al., (2011)	E	Non-Specific	24 (PD, NPD)	✓	x	✓	x	x	x	x
May et al., (2011)	E	Contemporary	9 (PD)	x	x	✓	x	x	x	✓
Klockare et al., (2011)	D	Jazz, Ballet, Contemporary	6 (Teachers)	✓	✓	✓	x	x	x	x
Girón et al., (2012)	E	Ballet	3 (NPD)	x	✓	✓	x	x	✓	x
Bläsing & Schack, (2012)	E	Ballet	69 (PD)	✓	x	x	x	x	x	x
Di Corrado et al., (2014)	E	Ballet/Karate	90 (PD)	x	✓	x	x	✓	x	x
Coker et al., (2015)	E	Non-Specific	24 (PD)	✓	✓	x	x	x	✓	x
Tipper et al., (2015)	E	Modern	46 (NPD)	x	✓	✓	x	x	x	x
Olshansky et al., (2015)	E	Break Dance	1 (PD)	x	x	✓	x	x	✓	x
Abraham et al., (2016)	E	Different Styles	5 (PD)	x	✓	✓	x	x	✓	x

Table 2 (continuation) :

Study	Type	Style & Level	Sample	Who	What	Why	Where	How	Ability	When
Batson & Sentler, (2017)	D	Comtemporary	4 (NPD)	x	✓	✓	x	✓	x	x
Di Nota et al., (2017)	E	Ballet	92 (PD)	✓	✓	✓	x	x	x	x
Muir et al., (2018)	D	Differen Styles	23 (NPD)	x	✓	✓	✓	x	x	✓
Abraham et al., (2019)	E	Differen Styles	34 (NPD)	x	✓	✓	x	x	✓	x
Carey et al., (2019)	E	Non Specific	18 (PD, NPD)	x	x	✓	x	x	✓	x
Paris-Alemany et al., (2019)	E	Ballet, Conte, Flaming	45 (PD)	✓	✓	x	x	x	x	x
Paris-Alemany, et al., (2019)	E	Spanish dance	74 (PD)	✓	✓	✓	x	x	x	x
Pietsch et al., (2019)	E	Ballet	60 (NPD)	x	✓	x	x	✓	x	x
Charnavel, (2019)	E	Non Specific	30 (NPD)	x	✓	x	x	x	x	x
Palmiero et al., (2019)	E	Non Specific	58 (NPD)	X	x	✓	x	x	✓	x
Orlandi et al., (2020)	E	Ballet	32 (NPD)	✓	✓	✓	x	x	x	x
May et al., (2020)	E	Impro	240 (NPD)	x	x	✓	x	x	✓	x
Carmona, (2021)	D	Contemporary	15 (NPD)	x	x	x	✓	x	x	x
Mao et al., (2022)	E	Break Dance	40 (NPD)	✓	x	✓	x	x	x	x
Tung et al. (2024)	E	no Specific	60 (NPD)	x	x	✓	x	x	x	x

Table 3: Selection of studies focusing on the differences in between expert dancers and non-dancers.

Author	Research focus	Dancers	Non-Dancers
Golomer et al. (2009)	Imagery style	Kinesthetic and mixed Imagery styles	Mixed imagery styles
Fink et al. (2009)	EEG activity and creative thinking.	Higher right-hemispheric Alpha synchronization during Creative thinking	Lower right-hemispheric alpha synchronization during creative thinking
Di Nota et al. (2017)	EEG activity and kinesthetic mental imagery	Higher individual alpha peak frequency (iAPF)	Lower individual alpha peak frequency (iAPF)
		Higher alpha desynchronization	Lower alpha desynchronization
		Faster iAPF during kinesthetic motor imagery	Slower iAPF during kinesthetic motor imagery
Jola et al., (2011)	Proprioceptive signal integration	Greater integration of local proprioceptive signals	Lower integration of local proprioceptive signals
Blasing & Schack (2012)	Representation of spatial movement parameters	Include body-centered Spatial information in their Embodied representations of Movement	The don't include body-centered spatial information in their embodied representations of movement
Jola et al., (2014)	Neural activity (using EEG)	Higher individual alpha peak frequency (iAPF)	EEG activity Lower individual alpha peak frequency (iAPF)

Note: EEG = electroencephalography; iAPF = individual alpha peak frequency

Figure 1. PRISMA diagram flow and identification of studies via databases or registers.

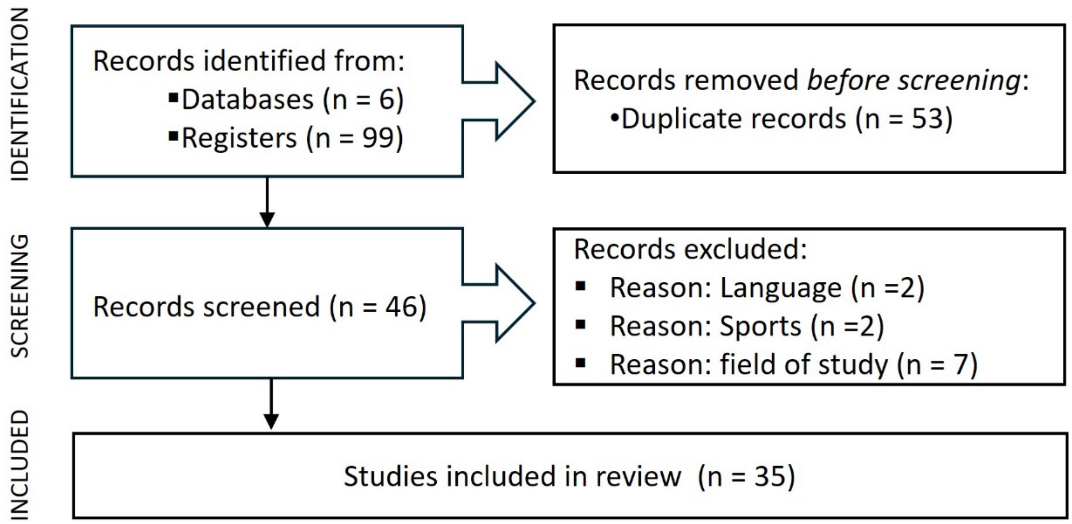

Figure 2: Distribution of articles included in this systematic review across the last four decades.