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BAHCESEHIR UNIVERSITY
GRADUATE SCHOOL
PSYCHOLOGY HEAD OF THE DEPARTMENT

EFFECTS OF DANCE EXPERIENCE ON WORKING MEMORY: VISUOSPATIAL SKILLS

MASTER'S THESIS

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ISTANBUL, 2023

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ABSTRACT

EFFECTS OF DANCE EXPERIENCE ON WORKING MEMORY: VISUOSPATIAL SKILLS

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The present study aimed to investigate the relationship between dance experience and visuospatial working memory in young adults. The study included 74 participants (*M* = 23.3, *SD* = 1.72) divided into four groups based on their level of expertise in dance training. Among these groups, 54 participants were selected from dance classes who were dancing for at least 3 months, while the remaining 20 participants had no prior engagement in dance activities. The Montreal Cognitive Assessment (MoCA) was employed as a measure of participants' cognitive abilities to ensure their suitability for the study. The Corsi Block Tapping Test was utilized to assess their visuospatial working memory capacity. All participants completed the demographic questions, Positive Affect Negative Affect Schedule, MOCA, and a computerized version of the Corsi Block Tapping Test. The first hypothesis suggesting that individuals in the dancing groups would exhibit enhanced visuospatial working memory abilities compared to those who did not engage in any dance practice was partially supported due to only expert dancers' enhanced performance on the Corsi Block Tapping Test. The second hypothesis suggesting that participants with three or more years of dance experience would display the highest visuospatial skills compared to those with either three months or no dance experience at all was fully supported because expert dancers demonstrated the highest performance in the visuospatial working memory task compared to all other participants. Given the limited research on the impact of dance experience on executive functions, this study offered a focused examination of visuospatial skills among young adults.

Keywords: Dance Experience, Working Memory, Visuospatial Skills

ÖZ

DANS DENEYİMİNİN ÇALIŞMA BELLEĞİ ÜZERİNDEKİ ETKİLERİ:
GÖRSEL-MEKANSAL BECERİLER

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Bu araştırma, genç yetişkinlerde dans deneyimi ile görsel-uzamsal çalışma belleği arasındaki ilişkiyi incelemeyi amaçlamaktadır. Araştırma dans eğitimindeki uzmanlık düzeylerine göre dört gruba ayrılan 74 katılımcıyı içermektedir (M = 23.3, SD = 1.72). Bu gruplar arasında, en az 3 ay boyunca dans eden 54 katılımcı bulunurken, geriye kalan 20 katılımcı daha önce hiç dans etmemiştir. Montreal Bilişsel Değerlendirme (MoCA), katılımcıların bilişsel yeteneklerini genel olarak değerlendirmek amacıyla kullanılmıştır. Görsel-uzamsal çalışma bellek kapasitelerini değerlendirmek için Corsi Bloklara Dokunma Testi kullanılmıştır. Tüm katılımcılar demografik soruları, Pozitif Duygu Negatif Duygu Ölçeği (PANAS), MoCA ve bilgisayar destekli Corsi Bloklara Dokunma Testi'ni tamamlamışlardır. Dans eden gruplardaki bireylerin, hiç dans pratiği yapmayanlara göre gelişmiş görsel-uzamsal çalışma belleği yetenekleri sergileyeceğini öne süren ilk hipotez yalnızca uzman dansçıların verilen görevde gelişmiş performans göstermesi nedeniyle kısmen desteklenmiştir. Üç yıldan fazla dans deneyimine sahip katılımcıların, ya üç ay ya da hiç dans deneyimi olmayanlara göre en yüksek görsel-uzamsal becerilere sahip olacağını öne süren ikinci hipotez uzman dansçıların, diğer tüm katılımcılara kıyasla görsel-uzamsal çalışma belleği görevinde en yüksek performansı sergilemesi nedeniyle tam olarak desteklenmiştir. Dans deneyiminin yürütücü işlevler üzerindeki etkisi üzerine sınırlı araştırmalar göz önüne alındığında, bu araştırma genç yetişkinler odağı ile görsel-uzamsal becerilerin incelemesini sunmuştur.

Anahtar Kelimeler: Dans Deneyimi, Çalışma Belleği, Görsel Mekansal Beceriler

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Chapter 1

Introduction

1.1 Physical Activity

Physical activity is known for its favorable impact on both physical and mental well-being (Penedo & Dahn, 2005; Siddiqui et al., 2010). The significance of physical activity and its association with cognitive skills in our daily lives has been widely acknowledged (Fox, 1999; Palmiero et al., 2019). Koščak-Tivadar (2017) states that most of daily activities rely on cognitive abilities (e.g., preparing a meal, using a telephone, handling finances, etc.), while others depend on physical capabilities (e.g., walking, climbing stairs, etc.). Consequently, the level of daily activity depends on how well we function in situations that necessitate the use of both physical and cognitive abilities.

Physical activity consists of two primary forms: aerobic and anaerobic exercise. Aerobic exercise involves sustained energy production utilizing oxygen over an extended duration (e.g., running, swimming, dancing, etc.) while anaerobic exercise entails rapid and intense energy production without reliance on oxygen (e.g., heavy weightlifting, jumping, etc.) during physical exertion (Siddiqui et al., 2010). Specifically, engaging in low-intensity aerobic exercise yields a favorable outcome for visual-spatial perception and attention, whereas moderate physical activity produces beneficial effects on overall cognitive ability, working memory, and attention, as well as verbal memory (Koščak-Tivadar, 2017). Aerobic physical activity has been shown to enhance executive functions in older adults, possibly due to improvements in hippocampal and prefrontal cortex regions through neuroplasticity (Blumen et al., 2020). Specifically, previous literature has illustrated that engaging in aerobic sports is linked to enhanced performance in a spatial memory task (Sánchez-Horcajo, 2015).

1.2 Dance and Cognition

Among various forms of aerobic exercise, dance practice stands as one of the most prevalent aerobic physical activities, having served as a therapeutic approach for centuries and demonstrating proven benefits for mental health through clinical research (Muro & Artero, 2017). Besides being an aerobic form of exercise with multifaceted advantages, dance involves attention, spatial perception, memory, and executive functions (Noguera et al., 2020). Dancers with more experience indicated notably higher self-perceived advantages in terms of physical, social, and cognitive aspects compared to those with less experience (Lakes et al., 2016). Dance, as a multifaceted art form, involves complex bodily expressions and coordinated movements that connect the mind and body, extending beyond the boundaries of the traditional mind-body dichotomy (Ro, 2014; Yang et al., 2023). Researchers have begun to recognize dance as a rich context for investigating various aspects of cognitive functions, including perception, memory, and emotional expression. For instance, Calvo-Merino et al. (2005) demonstrated that observing and performing dance movements activate mirror neuron systems in the brain, suggesting a strong connection between physical movement and cognitive processes. Additionally, the immersive nature of dance may promote enhanced sensory processing and integration, contributing to heightened spatial awareness and attentional focus. Merom et al. (2016) argued that dance practices provide greater benefits compared to regular physical activities as dance significantly engages the brain and its plasticity mechanisms. Combining physical activity with musical elements, dance requires recalling sequences of steps and motions to construct choreographic compositions (Noguera et al., 2020). Dance provides a chance to enhance not just motor abilities, but also various cognitive functions which leads us to embodied cognition theories, and overall well-being as demonstrated by the fact that even individuals without professional dance experience showed enhanced emotional well-being after short sessions of dance improvisation lasting 5 minutes (Palmiero et al., 2019). As dance engages sensory, motor, and emotional dimensions, it provides a unique platform for studying embodied cognition, shedding light on how bodily experiences intertwine with cognitive functions.

1.2.1 Dance and embodied cognition theories. According to the embodiment approach in cognitive science, cognitive functions are fundamentally grounded in the body's engagement with the environment, with sensory and motor faculties being employed for cognitive endeavors (Voyer & Jansen, 2017). This approach suggests that our thoughts, perceptions, and even abstract concepts are shaped by our bodily experiences and interactions with the world around us, in other words, the body and mind are interconnected, and cognition emerges from the dynamic interaction between them (Barsalou, 2008). The study conducted by Foglia and Wilson (2013) explained the realm of embodied cognition theories, exploring the complex connections between the body, cognition, and perception. They indicated that bodily experiences shape and influence cognitive processes, challenging the traditional view that cognition is solely a product of the mind. Dance, as a form of expressive movement, engages both the body and mind in a coordinated manner, leading to a profound interaction between sensory perceptions, motor actions, and cognitive functions. Calvo-Merino et al. (2005) demonstrated that observing and performing dance movements activate mirror neuron systems in the brain, suggesting a strong connection between physical movement and cognitive processes. This finding not only supported the embodied nature of cognition but also underscored the role of dance as a unique avenue for investigating the interplay between the body, movement, and cognitive functioning. Furthermore, supported by theories of embodied cognition, dancing is linked to various positive psychological outcomes, shaping cognition through the interplay of bodily movements with the external world (Muro & Artero, 2017). According to Shen et al. (2020), dance has the potential to enhance attention, cognition, and physical fitness while also influencing psychology and physiology. The effects of systematic dance training on cognition, as well as brain structure and function, remain inadequately comprehended despite the fact that dance has been engaged for millennia as a ritualistic practice and leisure pursuit (Burzynska et al., 2017). In relation to dance practice, numerous studies have investigated its relationship with cognitive abilities (Blumen et al., 2020; Douka et al., 2019; Noguera et al., 2020; Pavlidou et al., 2018; Shen et al., 2020). Furthermore, Shen et al. (2020) contended that dance practice, through its rhythmic and dynamic characteristics, enhances coordination, organization, attention, physical fitness, and cognition—several of which are subcomponents of executive functions.

1.2.2 Executive functions. Executive functions are actively employed in our daily lives for tasks such as attention, problem-solving, concentration, organization, inhibition, control, shifting, reasoning, and planning (Diamond, 2013). Diamond (2013) identifies three core executive functions: inhibition, entailing the filtration of irrelevant information to focus on relevant tasks (Diamond, 2013); working memory, responsible for temporarily storing and processing information in cognitive activities (Baddeley, 2012); and cognitive flexibility, enabling task shifting and adaptive thinking in response to changing demands (Miyake et al., 2000).

In a dance class where individuals try to learn a new choreography, executive functions are actively involved in all processes. These functions facilitate attention management, inhibition of distractions, and switching between dance moves. Blumen et al. (2020) demonstrated that social dancing improves executive functions in older adults. Dancers who practice dance regularly for at least 6 months showed improved planning abilities as one of the executive function skills (Noguera et al., 2020). Douka et al. (2019) found improvements in executive functions as a result of 6-months dance training intervention among the elderly. Yet, the benefits of physical activity, especially dance practice, extend beyond the aging population to other age groups, including children. For instance, in preschool children, dance was found to improve communication abilities and motor development (Pavlidou et al., 2018). Shen et al. (2020) stated when children try to learn dance, they need to attend, observe, remember the movements, and listen to the instructions carefully besides listening to music and memorizing the melody, rhythm, and emotion. These processes help to train children's cognitive abilities in terms of attention, memory, movement, hearing, and vision and they found that after 8-week of street-dance (hip-hop) training, executive function had improved among preschool children (Shen et al., 2020). Moreover, the synchronization of movement to music in dance requires precise timing, which may enhance temporal processing and working memory skills.

1.2.2.1 Working memory. Functioning as a subcomponent of executive functions, working memory facilitates the temporary retention and manipulation of information even after its presentation ceases (Baddeley & Hitch, 1974; Diamond, 2013). Baddeley (2000) finalized a model comprising the central executive, visuospatial sketchpad, phonological loop, and episodic buffer. The phonological loop processes verbal information, while the visuospatial sketchpad handles visual and spatial data (Baddeley, 2000). The central executive serves as the control center, coordinating information from these subcomponents and long-term memory, and the episodic buffer integrates information from various sources into coherent episodes. Together, these subcomponents constitute the foundation of the working memory system (Baddeley, 2000). Visuospatial working memory has been involved in the process of temporary storage for movements (Cortese & Rossi-Arnaud, 2010). As a subcomponent of working memory proposed by Baddeley and Hitch (1974), the visuospatial sketchpad assumes a significant role in daily life scenarios. Activities such as driving, following directions, and locating items all depend on this component.

Visuospatial skills encompass a variety of cognitive abilities associated with processing and manipulating visual information concerning spatial orientation and relationships. These aptitudes are crucial for tasks like mentally rotating objects, perceiving spatial arrangements, navigating environments, and interpreting visual representations. The research conducted by Shepard and Metzler in 1971, focusing on mental rotation, illustrated the skill of mentally manipulating objects in three dimensions. Likewise, O'Keefe and Nadel's research (1978) highlighted the significance of spatial memory and navigation in recalling spatial layouts and traversing surroundings. Treisman and Gelade's study (1980) illustrated how visual attention and search enable selective focus and target identification. Furthermore, Sorby's investigation (2009) underscored the importance of spatial visualization, particularly relevant in fields like engineering for mentally transforming objects. Gesture, as discussed by Goldin-Meadow and Alibali (2013), serves as a form of spatial communication. Map reading and spatial reasoning, studied by Hegarty and Waller (2004), involve interpreting maps and solving spatial problems. Lastly, constructional abilities, as described by Kessels et al. (2000), entail replicating complex visual patterns. Together, these aspects underscore the multifaceted nature of visuospatial skills and their diverse applications across cognitive and practical domains.

1.2.2.2 Working memory and dance. Buszard and Masters (2017) suggested that the ability to retain and manipulate visual and spatial information in memory is related to learning to execute movement sequences. The relationship between dance and working memory unveils a connection between physical movement and cognitive processes that govern the temporary storage and manipulation of information. Dance, characterized by complicated choreography and coordinated movement patterns, engages working memory through the need to remember and execute sequences of steps (Buszard & Masters, 2017). Expert dancers may employ a coding strategy involving the integration of movement and spatial information and this strategy could be a more commonly adopted process when individuals need to encode a combination of two types of information (Cortese & Rossi-Arnaud, 2010). Research by Noguera et al. (2020) demonstrated that expert dancers exhibit enhanced working memory capacity, potentially attributed to the demands of memorizing complex routines. The memorization and execution of choreography involve precise spatial coordination, which may enhance participants' ability to mentally manipulate and navigate spatial environments. Dancers need to adapt their movements based on spatial orientation, tempo, and rhythmic patterns, accurately reproducing the movements as instructed by the choreographer's demonstration or preferences (Bläsing et al., 2012). The dynamic interplay between spatial awareness, motor execution, and rhythmic synchronization in dance highlights its potential to nurture working memory skills. Voyer and Jansen (2017) found that individuals experienced in motor activities tend to outperform non-motor experts in spatial tasks. Merom et al. (2016) demonstrated in their study that when comparing a group receiving dance training twice a week with a group engaged in walking only, the group receiving dance training exhibited improved visuospatial skills after 8 months, rather than executive function in general. Working memory becomes engaged when learners attempt to replicate a sequence of movements based on a cognitive representation (Buszard & Masters, 2017). Working memory also contributes by retaining information about dance moves through the visuospatial sketchpad, sequencing movements according to the music using the phonological loop and memorizing choreography through the episodic buffer (Pivec, 2008). The coordination of movements to music enhances rhythmic processing and temporal working memory skills. This suggested that dance not only challenges working memory but also offers a platform for its augmentation (Sevdalis & Keller, 2011). Dancers use visual and verbal information to translate complex movements into motor actions, particularly in partnered and non-partnered dancing practices (Bläsing et al., 2012). Bonny et al. (2017) stated that dancers encounter the task of not only synchronizing various sensory inputs (e.g., music, movement, visual) but also preserving their spatial orientation on the dance floor based on a predefined sequence of movements during the process of learning or creating choreography for a routine. Since learning choreography gets better and faster over time, working memory capacity may be improved through regular dance practices. Dancers experienced in hip-hop dance excel in visual recognition due to improved visual and spatial abilities fostered by years of dance practice (Bonny et al., 2017). The utilization of the visuospatial sketchpad in learning new dance moves might support the role of dancers' visuospatial skills. Based on the findings of the study conducted with both expert dancers and a control group with no dancing experience, motor training was associated with improved spatial working memory skills (Barhorst-Cates, 2018). The author argued that it is difficult to elucidate the direction of the relationship between movement execution and spatial working memory, whether individuals with better spatial working memory are more likely to excel in motor activities or whether motor activities enhance spatial working memory over time (Barhorst-Cates, 2018). By exploring the relationship between dance and working memory, we may gain insights into how embodied movement shapes cognitive processes and contributes to cognitive enhancement.

1.3 Present Study

The current study aimed to examine the unidirectional relationship, specifically whether dance practice as a form of motor execution enhances spatial working memory, by analyzing differences in spatial span task performance among dancers with varying amounts of dancing experience. Thus, the primary objective of the present study was to investigate the effects of dance training on visuospatial working memory among young adults. The majority of the studies have been conducted with either the elderly or children in terms of examining the effect of dance practice on cognition. Despite the abundance of research involving elderly individuals and children, studies focusing on healthy young adults remain scarce in the literature. Therefore, the present study addressed the potential benefits of dance practice for young adults. It was hypothesized that participants engaged in dance training would demonstrate improved visuospatial working memory compared to those not participating in dance practice. Furthermore, it was expected that expert dancers would outperform beginner dancers on the visuospatial working memory task, reflecting their higher experience level.

Two hypotheses of the study are as follows:

H_1: Participants in the dancing groups would show enhanced visuospatial working memory abilities compared to the ones who do not engage in any dance practice and, therefore, have higher visuospatial working memory span scores compared to the participants who have not engaged in dancing activity.

H_2: Participants who had three years or longer dance experience would have the best visuospatial working memory skills compared to participants who had dance experience for at least three months or not at all, therefore, score the highest in visuospatial working memory span scores.

Chapter 2

Method

2.1 Participants

A total of 74 participants took part in the study, comprising 46 females (62%) and 28 males (38%) who exhibited normal hearing and did not have any significant prior health concerns, drug usage, medication intake, or history of mental illness based on the statements provided by individuals in the demographic form. There were four groups in this study, determined according to participants' dance experience levels. Group 0, comprising 20 participants who were not engaged in any dancing activity, constituted 27% of the total participants in the study. Group 1, which consisted of 16 participants who had been dancing between 3 and 12 months, represented 22% of the total participants in the study. Group 2 comprised 18 participants who had been dancing between 1 and 3 years, representing 24% of the total participants, whereas Group 3 consisted of 20 participants who had been dancing for 3 years or more, accounting for 27% of the total participants. Participants' dance experience ranged from 6 months to 19 years among the dancing groups. Additionally, participants in the dancers' group were dancing on a regular basis (e.g., at least once or twice a week). Table 3 represents the frequency of dance training. Out of the participants, 61 individuals (82% of the sample) held undergraduate degrees, while 13 participants (18% of the sample) had attained graduate degrees. The age of participants ranged from 19 to 25 years (M = 23.3, SD = 1.72). Table 1 represents the demographic characteristics of participants and Table 2 represents the means and standard deviations of age for all groups.

Table 1

Demographic Characteristics of Participants

	Group 0		Group 1		Group 2		Group 3	
	n = 20		*n = 16*		*n = 18*		*n = 20*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Sex								
Female	14	70	9	56	10	56	13	65
Male	6	30	7	44	8	44	7	35
Education								
Undergraduate	14	70	16	100	14	78	17	85
Graduate	6	30	0	0	4	22	3	15
Dance Style	N/A	N/A						
Hip-hop								
Salsa								
Dance Frequency	N/A	N/A						
None			0	0	0	0	0	0
1-2 Times a week			10	63	8	44	5	25
2-3 Times a week			3	19	10	56	4	20
Everyday			3	19	0	0	11	55

Table 2

Means and Standard Deviations of Age Between Groups

	Group	*M*	*SD*	*n*
Age	0	24.2	1.20	20
	1	23	1.71	16
	2	23	1.75	18
	3	22.8	1.93	20

The inclusion criteria for the control group (group 0) were that all participants should not have had any prior engagement in physical, musical, or dancing experiences before the study. For the participants in the dancing groups, the inclusion criteria require that they must have started their dance lessons a minimum of three months ago, and there is no maximum limit for the dancing experience level. The inclusion criteria for all of the participants was they should get a score that was above 21 in the Montreal Cognitive Assessment test in order to examine whether they were cognitively eligible to participate in the study.

Participants in the dancing groups (1, 2, 3) were recruited from private dance schools in Istanbul that gave permission to collect data from the students such as ODA Dance Academy located in Levent, MADY Dance Academy located in Maltepe, and Yildiz Dance and Music Academy located in Acibadem. In each group of dancing participants, it did not matter the type of dance they practiced because the main effect of the dancing activity itself on visuospatial working memory was examined, however, the main branch in which 27 participants dance was salsa whereas the other 27 participants' main branch was hip-hop. Participants in the control group (0) were recruited from social networks and social media. All of the participants obtained a score that is above 21 in the Montreal Cognitive Assessment, therefore, all of them were eligible to participate in the study.

2.2 Materials

2.2.1 Demographic information form. Participants were asked to complete the demographic information such as education level, age, history of mental illness, use of drugs, and prior dancing/musical/physical activity. For the dancers, there was an additional section that included questions about their dance history such as how often they practice in a week and how many years of dance experience they have (see Appendix A). It took approximately three to four minutes to administer.

2.2.2 The positive affect negative affect schedule (PANAS). To measure the participants' emotional state at the time when the study was conducted the Turkish Version of PANAS was used. The scale was originally developed by Watson et al. (1988) and the Turkish adaptation was developed by Gencoz (2000). There were 20 items of which 10 items measured the positive affect (e.g., interested, excited, inspired), whereas the other 10 items measured the negative affect (e.g., upset, hostile, afraid). Items were rated based on a 5-point Likert Scale that ranges from 1 (not at all) to 5 (extremely) indicated the intensity of that emotional experience at that moment. The original scale exhibited internal consistency scores of .88 for positive affect and .87 for negative affect, whereas the Turkish adapted version demonstrated internal consistency scores of .88 for positive affect and .83 for negative affect in a study conducted by Gencoz in 2000 (see Appendix B). In the scoring process, both the Positive Affect Score and the Negative Affect Score are determined by summing the scores on specific items. For the Positive Affect Score, the sum includes items 1, 3, 5, 9, 10, 12, 14, 16, 17, and 19, with a scoring range from 10 to 50 where higher scores indicate increased levels of positive affect. On the other hand, the Negative Affect Score is calculated by summing scores from items 2, 4, 6, 7, 8, 11, 13, 15, 18, and 20, with a scoring range also from 10 to 50, where lower scores correspond to reduced levels of negative affect. It took approximately 5 minutes to administer the Turkish version of PANAS.

2.2.3 The Turkish version of the Montreal cognitive assessment (MoCA-TR). The impact of physical exercise on cognitive function is frequently evaluated through the measurement of overall cognitive performance using the MOCA or MMSE assessments in the literature (Hewston et al., 2021). Therefore, the Turkish version of the Montreal Cognitive Assessment which was originally developed by Nasreddine et al. (2005) was used as a control variable to assess whether all participants were cognitively eligible to participate in the study. The Turkish validation study was conducted by Ozdilek and Kenangil (2014). It was indicated that the Cronbach's alpha of the MoCA-TR as an internal consistency was .66, whereas the test–retest reliability of MoCA-TR was .74. MoCA is a practical screening tool for detecting cognitive dysfunction, and it measures different aspects of cognition (Julayanont et al., 2013; Nasreddine et al., 2005). It includes subtests on executive functions/visuospatial skills that assess participants' organizing and planning skills (5 points); naming that assesses participants' skills in identifying objects by their name correctly (3 points); memory that assesses how well participants learn and remembers new information (no point because of learning the words for recall). Tasks that measure attention include tasks like continuous subtraction that require participants' sustained attention (6 points); language tasks include repeating sentences and recalling words continuously starting with the letter K (3 points); the abstraction section includes understanding the relationship between two words such as "banana + orange = fruit" (2 points); delayed recall task includes recalling information after a gap while conducting other subtests (5 points); and finally orientation task includes general information such as time and place to indicate participants' level of awareness (6 points). The highest score that can be obtained is 30. A score of 21 and above is considered within the normal range. It took approximately 10 minutes to administer (see Appendix C).

2.2.4 Corsi block tapping test. To measure participants' visuospatial working memory capacity a computerized version of the Corsi Block Tapping Test (Corsi, 1972) was used. It takes its name from its creator Philip Michael Corsi, who designed this assessment during the course of his doctoral education. Initially, this assignment was not intended to be a computer-based task. During the original task, the experimenter, who is responsible for conducting the study, displays a configuration of nine blocks in front of the participant. Subsequently, the experimenter proceeds to tap a sequence of blocks, typically involving three distinct blocks, in consecutive order. The participant's role involves replicating the sequence by tapping the same blocks in the same sequence as demonstrated by the experimenter. This sequence of actions is repeated multiple times, each iteration featuring blocks of varying lengths. In the present study a computerized version of the Corsi Block Tapping Test was used and the experiment was conducted and exhibited online through the utilization of the existing Corsi Block Tapping Test in the PsyToolkit platform (Stoet, 2010; 2017). The task measures the working memory span by evaluating participants' accurate recollection of spatially arranged objects on a computer screen. Subjects were presented with an array of blocks on the screen, wherein the block colors underwent random changes for a brief one-second interval. Subsequent to the display of these blocks, an auditory cue of "go" was played to signal participants. They were instructed to diligently observe the color alterations and maintain their sequential order in memory, as they were subsequently required to indicate the sequence of blocks according to their earlier observations of color changes. The task involved selecting the correct blocks in the precise order using a mouse pad and confirming their response by clicking "done" located in the screen's lower right corner. For accurate responses, participants received positive feedback in the form of a smiling emoticon placed on the "done" button. Additionally, the subsequent sequence length increased incrementally. In instances of errors, an unhappy emoticon was displayed, granting participants an additional attempt. However, upon committing two consecutive errors, the test concluded, yielding the Corsi block span score. The assessment began with a two-block sequence and progressively advanced, culminating in a maximum sequence length of nine blocks. According to the study conducted by Kessels and his colleagues (2000), including both individuals without any brain impairment and those with varying degrees of brain damage, healthy young adults were expected to get scores around 5. The test was administered on the 13-inch computer screen, and it took approximately 5 to 10 minutes to complete the task. According to the given task, working memory capacity was defined as the maximum numerical sequence that was accurately recited in the proper sequence by the participants.

2.3 Procedure

The study received approval from the Bahçeşehir University Ethics Review Board. To recruit participants for the dancers' group, the researcher contacted the dance schools mentioned in section 2.1 and explained the data collection process. Participants in the non-dancing group were carefully screened to ensure they had no prior experience in dancing, music, or physical activities. The researcher made regular visits to the relevant dance schools for data collection. During the data collection process, the procedure was briefly explained to participants without disclosing the study's nature. Once participants provided written consent, they completed a demographic information form. Prior to the actual measurements, all participants completed the Turkish version of the Positive Affect Negative Affect Scale (Gencoz, 2000; Watson et al., 1988) to assess their emotional status at the moment. The researcher administered the Turkish version of the Montreal Cognitive Assessment test (Nasreddine et al., 2005; Ozdilek & Kenangil, 2014), for which they had previously received training, to all participants following the guidelines, and calculated their overall scores based on the scores obtained from each section. Subsequently, all participants were positioned in front of a 13-inch computer screen. The researcher provided a detailed explanation of the Corsi Block Tapping Test procedure before its administration. Some participants made errors during their initial attempts due to a slower grasp of the task, prompting all participants to be granted a fresh start following the occurrence of initial errors. Using the computer screen, participants tracked the flashing blocks and utilized the computer's mouse pad to make block selections. The Corsi Block Tapping Test represented the final applied segment of the research and following this step the researcher expressed gratitude to all participants for their contributions. All participants underwent the tasks once, and the entire procedure took approximately 25 minutes. At the end of the study, the researcher debriefed participants. No incentives were provided to participants for their participation in the study.

2.4 Study Design

The design of the study was between subjects with dance experience level as an independent variable and visuospatial working memory measurements based on a computerized version of the Corsi Block Tapping Test as a dependent variable. There were four groups in total. As dancing groups, group 1 (3-12 months), group 2 (1-3 years), group 3 (3 years and more), and group 0 (no-dancing experience) were tested on the visuospatial working memory span task.

Chapter 3

Results

The present study employed a one-way Analysis of Variance (ANOVA) to examine the effect of dance experience level on visuospatial working memory. The independent variable was a dancing experience, categorized into four groups based on the duration of dance engagement: group 0 (no dancing experience), group 1 (3 to 12 months of dancing experience), group 2 (1 to 3 years of dancing experience), and group 3 (3 years and more dancing experience). The statistical analysis was conducted using the Statistical Package for Social Sciences version 25.0 (SPSS; IBM Corp., 2017), with post-hoc analysis performed through Tukey's Honestly Significant Difference (HSD) test to investigate the impact of dancing experience in greater detail.

3.1 Data Screening

Prior to analysis, data were screened for both missing values and outliers (Tabachnick & Fidell, 2013). Frequency analysis was conducted to identify if there was any missing value in the data and no missing value was found. Descriptive analysis was conducted for the data screening procedure in order to check if there were any outliers. When data transformed to the z-scores as univariate outlier analysis, all variables were between -3.29 and +3.29 (Tabachnick & Fidell, 2013). Therefore, they were used in the following analysis with their raw form.

Descriptive analysis was conducted to determine whether PANAS, MoCA, and Corsi Block Tapping Test data was normally distributed and according to analysis, all of the variables were between -2 and +2 in terms of skewness and kurtosis values therefore, considered in the normal range (Hair et al., 2021). Table 3 represents the mean values, minimum and maximum values, and skewness and kurtosis values of the variables.

Table 3

Descriptive Statistics of the Variables

	M	*SD*	*Min*	*Max*	*Skewness*	*Kurtosis*
PANAS_Pos	39	0.76	18	49	-1.02	.82
PANAS_Neg	14.4	0.58	10	27	1.23	.51
MOCA	27.8	0.19	23	30	-.61	-.12
CORSI	4.95	0.14	3	8	.44	.05

3.2 Comparison of PANAS and MoCA Scores Between Groups

One-way Analysis of Variance was conducted to investigate whether groups differed in terms of both PANAS and MoCA scores. There was no significant difference between groups in terms of both positive items, F (3, 70) = 2.817, p = .05, and negative items, F (3, 70) = 1.343, p =.27 in the PANAS scale. According to the second one-way analysis of variance, there was no significant difference in MoCA scores between all groups, as well, F (3, 70) = 2.540, p = .06. Therefore, there was no need to control these variables in further group comparisons. Table 4 represents the mean scores for positive and negative items in the PANAS, and MoCA scores for each group.

Table 4

Means and Standard Deviations on the Measure of PANAS and MoCA

	Group	*M*	*SD*	*n*
PANAS_Pos	0	35.95	7.52	20
	1	38.75	5.60	16
	2	41.77	3.60	18

Table 4 (continued).

	3	39.70	7.29	20
	Total	38.98	6.53	74
PANAS_Neg	0	14.50	5.91	20
	1	14.56	4.64	16
	2	12.61	2.33	18
	3	15.80	5.67	20
	Total	14.40	4.95	74
MoCA	0	28.05	1.60	20
	1	26.81	2.00	16
	2	28.00	1.32	18
	3	28.15	1.53	20

Note. Group 0: no dance experience, Group 1: 3-12 months, Group 2: 1-3 years, Group 3: 3 years and more.

3.3 Comparisons of Corsi Block Tapping Test

A one-way between-subjects ANOVA was conducted to investigate the effect of dance experience level on the Corsi Block Tapping Test measuring the visuospatial working memory span of the participants in group 0 (no dancing experience), group 1 (3 to 12 months of dancing experience), group 2 (1 to 3 years of dancing experience), and group 3 (3 years and more dancing experience). Levene's test of equality of error variances indicated that homogeneity was not violated ($p > .05$). Results of the analysis revealed that there was a significant main effect of dance experience on Corsi Block Tapping test, F (3, 70) = 12.610, $p < .001$, $\eta_p^2 = .35$. Table 5 presents the results in detail.

Table 5

One-Way Analysis of Variance of Corsi Block Tapping Test

	SS	*df*	*MS*	*F*	*p*	η_p^2
Between Groups	35.391	3	11.797	12.610	<.001	.351
Within Groups	65.488	70	.936			

Tukey's HSD test was conducted to further examine the group comparisons in detail and analysis revealed that only experienced dancers in the dancing group who have danced 3 years or more (Group 3) (*M* = 6, *SD* = 1.08) performed significantly different at Corsi Block Tapping test compared to other groups. There was no significant difference between group 0, group 1, and group 2. According to the results of Tukey's HSD test, our second hypothesis was supported. Table 6 represents the descriptive statistics for each group on the Corsi Block Tapping Test and Table 7 represents Tukey's HSD analysis in detail.

Table 6

Means and Standard Deviations on the Measure of Corsi Block Tapping Test

	M	*SD*
Group 0 (no dance exp)	4.15	.88
Group 1 (3-12 months exp)	4.81	1.11
Group 2 (1-3 years exp)	4.83	.79
Group 3 (3 years and more exp)	6.00	1.08
Total	4.96	1.18

Table 7

Tukey's HSD Comparison for Dancing Experience Level

(I) Group	(J) Group	Mean Diff (I-J)	Std. Error	95% CI Lower Bound	95% CI Upper Bound
0	1	-.66	.32	-1.52	.19
	2	-.68	.31	-1.51	.14
	3	-1.85*	.31	-2.65	-1.05
1	0	.66	.32	-.19	1.52
	2	-.02	.33	-.90	.85
	3	-1.19*	.32	-2.04	-.33
2	0	.68	.31	-.14	1.51
	1	.02	.33	-.85	.90
	3	-1.17*	.31	-1.99	-.34
3	0	1.85*	.30	1.05	2.65
	1	1.19*	.32	.33	2.04
	2	1.17*	.31	.34	1.99

*p < .05

Note. Group 0: no dance experience, Group 1: 3-12 months, Group 2: 1-3 years, Group 3: 3 years and more.

3.4 Exploratory Analysis: Comparison of the Dance Style

An independent samples t-test was performed to investigate variations in Corsi Block Tapping Test scores among dancers within Groups 1, 2, and 3, considering their dance specialties such as salsa and hip-hop. Homogeneity of variances was controlled by Levene's test, and it was found non-significant. The t-test was not significant t (52)

= -.72, $p = .97$. There was not a significant difference between hip-hop dancers (M = 5.14, SD = 1.19) and salsa dancers (M = 5.37, SD = 1.07) in terms of visuospatial working memory span. Certainly, while this comparison has been conducted exploratorily, it should be noted that the dance experience in terms of duration among participants in the two dance genres is significantly disparate and does not exhibit an equal distribution. Therefore, this comparison has not yielded a fully meaningful outcome. Table 8 represents the dance style comparisons in detail.

Table 8

Means and Standard Deviations of Dance Style Comparisons

	Dance Style	*M*	*SD*	*SE*	*n*
CORSI	Hip-hop	5.14	1.19	.23	27
	Salsa	5.37	1.07	.20	27

3.5 Summary of Results

In summary, the analyses conducted partially supported our first hypothesis, which posited that participants in dancing groups would exhibit higher visuospatial working memory span scores compared to those not engaged in dancing activities. Specifically, the analyses indicated that individuals with more years of dance experience showed a significantly better performance in the Corsi Block Tapping Test, a measure of visuospatial working memory skills, compared to those who had never danced or had less dance experience. However, this difference was not observed between participants with fewer years of dance experience and those who had never danced. According to the analyses, our second hypothesis, which posited that participants with three years or more of dance experience would demonstrate superior visuospatial skills compared to those with dance experience of at least three months or none, has been supported.

Chapter 4

Discussion

4.1 Overview

The primary objective of the present study was to investigate the effect of dance experience on visuospatial working memory among young adults. The first hypothesis stated that participants with a history of dance practice would outperform those without such experience in the Corsi Block Tapping Test, due to their enhanced visuospatial working memory capabilities. The study results indicate that individuals who participated in dance for a specific duration demonstrated better visuospatial working memory skills compared to both non-dancers and less experienced dancers. Therefore, there was a significant effect of dance experience on visuospatial working memory skills indicating the partial fulfillment of the first hypothesis. The secondary objective of the present study was to investigate whether experienced dancers exhibit the best performance on visuospatial working memory skills compared to participants in all other groups. According to the analysis of group comparisons, only dancers with more years of experience demonstrated significantly better performance on the test measuring visuospatial working memory span compared to participants who had never danced and participants who were less experienced. This suggests that, for dance to have a positive impact on visuospatial skills, dancers need to have engaged in dance for many years. Therefore, the second hypothesis was confirmed. These results suggest that enhanced visuospatial working memory performance may be a skill associated with individuals engaged in dance for an extended period, potentially reflecting expertise gained through years of specialization in this domain. Upon conducting post-hoc analysis, it became evident that the temporal extent of engagement in dance practice may carry greater significance compared to the specific genre or style of dance that individuals choose to pursue. These findings offer valuable insights into the cognitive benefits of dance engagement and its potential to enhance visuospatial cognitive functions.

4.2 Discussion

The findings of the present study contributed to the expanding body of research on the relationship between dance practice and cognitive processes, particularly visuospatial working memory. The results aligned with previous literature that indicated the positive impact of physical activity, including dance, on cognitive functions (Penedo & Dahn, 2005; Siddiqui et al., 2010). Previous literature showed that dancers with more years of experience indicated notably higher levels of self-perceived advantages in terms of physical, social, and cognitive aspects compared to dancers with less experience (Lakes et al., 2016) and the present study's findings are in line with these studies. The observed connection between dance and enhanced cognitive abilities supported the embodiment approach in cognitive science, which posits that cognitive functions are grounded in bodily experiences and interactions with the environment (Barsalou, 2008). This connection was particularly evident in dance's engagement of mirror neuron systems through observing and performing dance movements (Calvo-Merino et al., 2005), providing empirical evidence for the embodied nature of cognition. Expert dancers' improved working memory capacity further supported the connection between dance practice and enhanced cognitive capabilities (Noguera et al., 2020).

Dance, as a form of expressive movement, emerges as a unique way of investigating the connection between bodily experiences and cognitive functions. Research indicated that dance engages sensory perceptions, motor actions, and cognitive processes, aligning with the principles of embodied cognition (Calvo-Merino et al., 2005). This aligned with the embodiment approach in cognitive science, asserting that cognition is fundamentally rooted in bodily experiences and interactions with the environment (Barsalou, 2008). Dance's multifaceted nature, involving complex bodily expressions and coordinated movements, provides a fertile ground for studying various aspects of cognition, including perception, memory, and emotional expression. The connection between dance and executive functions, highlighting the active role of executive processes in tasks like learning choreography and managing attention and inhibition during dance practice might be the reasons why expert dancers exhibited the best performance (Blumen et al., 2020; Noguera et al., 2020).

Unlike the previous study conducted by Furley and Memmert (2010) which did not find any difference between experienced athletes and non-athletes in the Corsi Block Tapping Test, the findings of the present study revealed that expert dancers showcased improved visuospatial working memory, reflecting the possible results of cognitive demands in terms of memorizing complex routines (Noguera et al., 2020). The findings of the present study were consistent with the notion that dance, as a complex art form involving choreography and coordinated movements, requires the engagement of working memory for the retention and execution of movement sequences (Buszard & Masters, 2017). This aligned with Buszard and Masters (2017), who suggest that the ability to manipulate visual and spatial information in memory correlates with learning movement sequences. Dance's potential to foster working memory skills through rhythmic processing, temporal coordination, and visual-spatial demands is highlighted, enriching our understanding of the link between movement and cognition (Barhorst-Cates, 2018; Bonny et al., 2017). Since expert dancers often excel in memorizing sequences of spatial locations, representing dance spaces as combinations of straight lines across the stage, this proficiency in memorization might arise from their specialized training and the adoption of coding strategies that involve binding movement and spatial information (Cortese & Rossi-Arnaud, 2010). This suggests that the study conducted by Coretse and Rossi-Arnaud (2010) which is conducted with expert ballet dancers may employ a unique strategy, or it could be a more widely adopted process when individuals need to encode a combination of different types of information. This strategy could account for the superior performance exhibited by expert dancers relative to novice dancers and individuals with no dance experience in the current study.

Unlike the present study, Bonny et al. (2017) did not find a significant relationship between hip-hop dance and spatial working memory. There were also experienced dancers as participants in Bonny et al. (2017)' study, and their level of experience varied similarly to that of the participants in this study. However, they employed an additional task between the presentation of Corsi blocks, which required participants to determine whether a figure displayed on the screen was symmetrical or not (Bonny et al., 2017). This additional task was implemented to prevent participants from rehearsing the information regarding the blocks that were changed in color and their specific order, thereby providing a clearer assessment of actual working memory capacity. Although employing an additional task between Corsi blocks could be a valuable strategy to assess spatial working memory exclusively, it did not effectively prevent participants from rehearsing the previous sequence of blocks (Bonny et al., 2017).

Similar to the present study, Barhorst-Cates (2018) aimed to find that motor expertise should primarily affect spatial working memory, rather than overall working memory, which includes both verbal and spatial aspects due to the strong connection between motor processes and spatial cognition. Besides a traditional measure of visuospatial working memory as a Corsi Block Tapping Test (Corsi, 1972) they invented a bodily spatial task called "Twister Task" (Barhorst-Cates, 2018). By employing both of these tasks to assess working memory, they were able to examine the impact of movement expertise on two distinct measures of spatial working memory: the Twister task, which required full-body movements and was more specific to the motor domain, and the Corsi Block Tapping Test, which was less motor-demanding and considered a more general measure of spatial working memory (Barhorst-Cates, 2018). In the current study, there was only one measurement tool for visuospatial working memory skills, namely the Corsi Block Tapping Test, which was previously mentioned as a traditional measure of assessing visuospatial abilities and has been utilized. Thus, the utilization of multiple measurements, as mentioned in the study of Barhorst-Cates (2018) instead of a single assessment of visuospatial memory, could have increased the validity of the present study. Moreover, in the study conducted by Barhorst-Cates (2018) not only experienced dancers and a control group of individuals with no dance experience were used as participant groups, but also experienced athletes were included. This was intended to highlight the distinction between dance compared to other physical activities.

While the current study aimed to investigate the impact of dance experience, the inclusion of a different type of physical exercise apart from dance in the participant groups as mentioned in the previous study could have enhanced the validity of the present study. In future studies concerning this topic, in addition to traditional visuospatial measurements, a motor task may be included, and participant groups could be expanded by adding a group engaged in physical activity other than dance, allowing for a comparison of the importance of expertise and years of experience once again. In the present study, there was no difference between different dance styles as salsa and hip-hop, however, since there are not many study that examined the difference of dance types in terms of the effectiveness of dance on cognitive abilities (Hewston et al., 2021), further studies should examine the effect of type of dance (as partnered vs non-partnered), as well. As Barhorst-Cates (2018) and Voyer and Jansen (2017) stated, it is challenging to differentiate the nature of the relationship between motor expertise and spatial tasks, whether movement expertise affects spatial abilities, or if individuals with enhanced spatial skills are naturally inclined towards and excel in motor activities. They also stated that if being an expert in movement predicts spatial abilities, then the causal relationship between these two phenomena should be examined in the future as a longitudinal study (Barhorst-Cates, 2018).

The outcomes, indicating that expert dancers excel in visuospatial skills, aligned with existing research suggesting that dance training enhances cognitive functions (Barhorst-Cates, 2018; Buszard & Masters, 2017). The exploration of executive functions, particularly working memory, within dance provided a nuanced understanding of how physical movement could impact cognitive abilities. The present study's focus on young adults added to its applicability, emphasizing dance's potential contribution to cognitive enhancement (Shen et al., 2020). This study's unique contribution lay in its emphasis on expert dancers, demonstrating how years of dance practice could manifest in improved visuospatial working memory, advancing our comprehension of the cognitive benefits of dance engagement (Bonny et al., 2017; Merom et al. 2016). Since expert dancers displayed significantly better performance compared to participants who had never had dance experience before in terms of visuospatial skills, enhanced visuospatial skills may offer a range of daily benefits that significantly contribute to an individual's cognitive and practical functioning. They facilitated tasks such as navigation, understanding maps, perceiving spatial arrangements, and interpreting visual representations (Furley & Memmert, 2010). Moreover, improved visuospatial skills could enhance one's ability to mentally rotate objects, solve puzzles, and engage in creative problem-solving (Hegarty & Waller, 2004). This heightened spatial awareness is particularly valuable in professions that require tasks like architectural design, engineering, and artistic endeavors, where individuals need to envision and manipulate complex spatial relationships (Sorby, 2009). For instance, professions like engineering and architecture heavily rely on spatial visualization therefore individuals with superior spatial skills may find these fields more accessible and may excel in tasks involving design and spatial planning (Kessels et al., 2000; Sorby, 2009). In everyday scenarios, individuals with refined visuospatial skills may tend to excel in activities like driving, following directions, and organizing spaces efficiently. People with strong spatial skills tend to be better at navigation and orientation in both familiar and unfamiliar environments. This can be advantageous in daily life, outdoor activities, and even specific professions (O'Keefe & Nadel, 1978, Hegarty & Waller, 2004). Moreover, these skills extend to tasks involving hand-eye coordination, such as playing sports, cooking, or assembling furniture (Hegarty & Waller, 2004). The ability to efficiently navigate physical environments translates into better adaptability during travel, whether it be in a new city or while exploring unfamiliar terrain. Furthermore, enhanced visuospatial skills support the interpretation of visual information, aiding in the understanding of diagrams, charts, and graphs, thus bolstering performance in academic and professional contexts (Sorby, 2009). Overall, the advantages of improved visuospatial skills are numerous and contribute to both cognitive mastery and practical proficiency in daily life.

4.2.2 Neuropsychological perspective. From the neuropsychological point of view, since dance movements are generated in coordination with musical rhythms, resulting in their perception within audio-visual contexts, in a study by Brown et al. (2006), the findings indicated that the involvement in a consistent, measurable pattern of motion was connected to the right putamen. Synchronization of dance movements with musical beats was aided by the front part of the cerebellar vermis, and in addition to this, guiding the spatial positioning of leg motions while dancing triggered activity in the medial superior parietal lobule, which reflects the integration of proprioception and somatosensory inputs (Brown et al., 2006). These findings demonstrated the multifaceted demands of dance, involving the integration of information from various brain areas responsible for synchronizing movement with music, coordinating movement temporally according to metric rhythms, and guiding limb movements spatially (Sevdalis & Keller, 2011). The findings aligned with the concept of cognitive reserve, which suggests that engaging in cognitively demanding activities, such as dance practice, may build cognitive resilience by promoting neuronal efficiency and adaptation (Stern, 2002). This is particularly relevant when considering expert dancers' superior visuospatial skills, as dance entails intricate spatial coordination and precise execution (Bonny et al., 2017; Buszard & Masters, 2017). The skilled dancers' ability to manipulate spatial information aligned with neuropsychological theories on visuospatial processing, where neural networks underlying spatial cognition are involved (Ungerleider & Mishkin, 1982). This might be the reason why the most experienced dancers had a better performance. Moreover, expertise in dancing is linked to heightened activity in the ventral premotor cortex when observing familiar dance movements (Pilgramm et al., 2010). Conversely, internal viewpoint observation, as opposed to an external viewpoint, triggers increased activation in the dorsal premotor cortex. This suggests that the enhanced ventral premotor cortex activation in experts may indicate their proficiency in aligning visual-spatial information with their motor representations, while dorsal premotor cortex activation could be associated with observing actions from a personal perspective (Pilgramm et al., 2010). This also supported the notion that dance training might have potential benefits in terms of working memory. On a different note, utilizing intensive dance training as a framework to study brain plasticity could be a valuable approach. A study revealed reduced volumes of gray and white matter in brain regions associated with motor functions among professional ballet dancers, highlighting the potential influence of skill enhancement through experience (Haenggi et al., 2010; Sevdalis & Keller, 2011).

To gain a more comprehensive understanding of the effects of dance experience, further studies should investigate its neuroscientific implications. As Burzynska et al. (2017) stated, considering the potential variability of outcomes resulting from various forms of amateur dance activities, the effect of dance training on the healthy human brain should be investigated with extensive systematic dance training among young adults.

To sum up, the study's results aligned with neuropsychological perspectives on neuroplasticity, cognitive reserve, and embodied cognition. By investigating the impact of dance experience on visuospatial working memory, the present study offered insights into how motor activities like dance can shape cognitive functions through neural adaptations and cognitive enhancements. The findings highlighted the intricate relationship between body and mind, emphasizing the value of dance as a medium for exploring the neurocognitive mechanisms that underlie cognitive enhancements associated with physical activity.

4.3 Implications, Limitations and Future Studies

The implications of these findings extended beyond the context of dance itself. The positive relationship between dance practice and working memory highlighted dance as a unique way of enhancing cognitive functions. Moreover, the observed connection between dance and cognitive enhancement contributed to the existing body of literature on embodied cognition, offering a novel perspective on the interactions between the body, movement, and cognitive processes (Foglia & Wilson, 2013). The findings offered insights into the potential applications of dance within educational and therapeutic settings. Educators and trainers could integrate dance activities into curriculum to potentially foster visuospatial cognitive skills among students. Moreover, dance-based interventions could be designed for populations with cognitive impairments, such as the elderly or individuals with certain neurological conditions, to promote cognitive health and functioning. By showcasing the impact of embodied movement on cognitive processes, particularly visuospatial working memory, the present study supported the theoretical framework of embodied cognition. The present study involving young adults, as opposed to solely focusing on elderly individuals or children, further diversified the age groups investigated in this area of research. Conducting the present study with young adults holds crucial implications for understanding the relationship between dance experience and cognitive functions. Young adulthood marks a pivotal stage in cognitive development, and investigating the impact of dance engagement during this period provides valuable insights (Kapfhammer, 1993). By establishing baseline effects before factors like aging come into play, the present study offered a reference for future longitudinal research. The phase of young adulthood is fundamental for forming lifelong habits and skills (Kapfhammer, 2013), making it an opportune time to examine how dance might enhance cognitive abilities. Additionally, the findings could inform educational approaches by integrating dance-based activities for cognitive enhancement. The present study's public health implications were noteworthy, as promoting dance engagement among young adults could contribute to cognitive resilience later in life. Bridging generational gaps in existing research, the present study enriched our understanding of the lifelong cognitive benefits of dance and aligns with efforts to promote cognitive health at a population level. In essence, the present study enhanced our comprehension of how dance can optimize cognitive functions during a period of neural plasticity, highlighting its potential as a means of cognitive enhancement and well-being.

However, it was crucial to acknowledge the limitations of this study, such as the relatively small sample size and potential confounding variables. Notably, among these potential confounders, it should be acknowledged that individuals with considerable expertise in dance often partake in a diverse array of dance styles or engage in other forms of physical activities that could impact the observed outcomes. The lack of a control group engaged in alternative forms of physical activity or cognitive training limited the ability to isolate the specific effects of dance. Moreover, the use of self-report questionnaires for emotional states may introduce subjectivity and social desirability bias. Furthermore, the study did not investigate potential confounding factors like socioeconomic status, cultural background, or individual differences in learning strategies.

In terms of measurement of visuospatial working memory, there are some advantages and disadvantages of using the Corsi Block-Tapping Test. Its quick administration makes it practical while the objectivity of measurement minimizes subjective interpretation. The test's cross-cultural applicability is noteworthy, as it is less influenced by cultural or linguistic factors, allowing for a broader application across diverse populations. Standardized procedures for administration contribute to consistency in scoring, enhancing the reliability of the test results (Arce & McMullen, 2021). However, certain limitations should be considered when employing the Corsi Block Tapping Test. The test primarily focuses on visuospatial working memory, providing a relatively narrow cognitive assessment that may not capture the complexity of other cognitive functions (Bonny et al., 2017). Additionally, there is a risk of practice effects, where individuals may improve their performance with repeated exposure, potentially confounding the results (Bonny et al., 2017). The dependence on motor skills for successful completion is another drawback, as individuals with motor difficulties may perform poorly even if their visuospatial working memory is intact. In the context of the present study, a significant limitation is the absence of a task assessing participants' motor skills, similar to the one employed by Bonny et al (2017). Despite the Corsi Block Tapping Test effectively measures visuospatial skills, it is imperative for future investigations to incorporate a standardized task that evaluates not only participants' visuospatial skills in a comparable manner but also, as demonstrated in the study, employs a standardized task to concurrently assess both motor skills and visuospatial proficiencies. Additionally, in nearly all groups, scores obtained from the Corsi Block-Tapping Test have remained below the general average of 5 points. This could be attributed to the fact that the experiments were predominantly conducted in dance schools, where occasional exposure to music and external noises may have led to distractions, potentially diverting the participants' attention.

Therefore, in future research endeavors, it is imperative to ensure the stabilization of the experimental environment to mitigate potential confounding factors. Lastly, the present study's sample size, though suitable for the analyses conducted, may limit the statistical power for detecting subtle effects and may not fully captured the diversity of experiences and responses within the population. These limitations highlighted the areas for improvement and suggested avenues for more comprehensive investigations in future research.

Future research could build upon these findings to investigate deeper into the relationship between bodily experiences and cognitive functions. Longitudinal studies could investigate the effects of sustained dance engagement on cognitive functions over time. Additionally, examining the neural correlates of dance-related cognitive enhancements through neuroimaging techniques could provide valuable insights. Future research could expand upon these findings by employing larger sample sizes, more kinds of dance styles and physical activities, and investigating the potential mechanisms underlying the observed relationship.

4.4 Conclusion

In conclusion, the present study has explored the relationship between dance and cognitive processes, shedding light on the multifaceted impact of movement on visuospatial skills. The recognized significance of physical activity for overall well-being and cognitive function has underscored its relevance in daily life. Dance, as a prominent form of aerobic exercise, transcended mere physical engagement by necessitating attention, memory, and executive functions. The embodiment approach to cognitive science accentuated the interconnectedness of the body and mind, with dance serving as a compelling avenue for investigating this connection. Findings from Foglia and Wilson's (2013) research highlighted the profound influence of bodily experiences on cognition, with dance standing as an exemplary context. Dance not only fosters executive functions such as inhibition, working memory, and cognitive flexibility but also significantly engages visuospatial working memory. The integration of choreography, spatial coordination, and rhythmic synchronization in dance challenges and enhances participants' working memory capacity. The relationship between dance practice and heightened spatial awareness, as well as the synchronization of movement to music, suggested the potential for working memory augmentation through dance engagement. Furthermore, the present study contributed to the literature by investigating the impact of dance experience on visuospatial working memory among young adults, a less explored group in existing research. This investigation has not only revealed the cognitive benefits of dance for young adults but also emphasized its potential to contribute to cognitive enhancement and well-being. The findings aligned with the embodiment perspective, affirming the interconnected nature of bodily experiences and cognitive processes. As dance serves as a rich medium for exploring embodied cognition theories, its potential to enhance cognitive functions, particularly working memory, emerges as a significant avenue for further research and practical applications in cognitive enhancement and overall well-being. In light of the existing literature and the insights gained from the present study, dance emerges as a powerful medium for investigating the complex connections between the body, movement, and cognition. As the research extends to include diverse populations and age groups, a more comprehensive understanding of how dance shapes cognitive processes will be achieved, paving the way for innovative approaches to cognitive enhancement and therapeutic interventions.

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