Dance the Night Away: Exercise Effects on Cognition in Young Adults with Childhood Trauma

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Abstract

A short, single bout of aerobic exercise produces immediate cognitive benefits which are predictive of long-term effects seen with repeated exercise. Dance is moderate-intensity aerobic exercise that is enjoyable, accessible, and cognitively demanding. There is limited research on the cognitive effects of a single bout of dance exercise, especially in populations at increased risk for reporting cognitive complaints and developing Alzheimer's disease, like adults with adverse childhood experiences. This study investigated the effect of acute exercise—specifically moderate-intensity dance and low-intensity stretching—on cognition and exercise enjoyment in young adults with a history of childhood trauma. Using a within-subjects design, participants danced or stretched for 20 minutes, followed by an enjoyment measure and neurocognitive tests. In both dance and stretching conditions, participants had similar neurocognitive test performance, including similar recovery from proactive semantic interference effects, and similar exercise enjoyment. Our results indicate that a single session of dance and stretching have similar effects on memory consolidation and executive functioning skills, and stretching may be as enjoyable as dance.

Keywords: dance, acute exercise, proactive semantic interference, cognition, LASSI-L

Cognitive decline can begin years before people develop neurodegenerative diseases like Alzheimer's disease (AD) (Arehart-Treichel, 2011). As the world's population of older adults continues to increase, prevention of cognitive decline and related brain changes becomes increasingly important. Research on exercise interventions that can prevent cognitive decline is considered a high priority (National Academies of Sciences et al., 2017). There is moderate support that exercise improves cognition and is protective against developing AD (Erickson et al., 2019). Adults with a history of adverse childhood experiences, like abuse and neglect, are more prone to experiencing subjective cognitive complaints later in life (Brown et al., 2023; Corney et al., 2022). Radford et al. (2017) found that they are also 1.8 times more likely to develop AD. Both long-term moderate-intensity aerobic exercise (MIAE) (Ye et al., 2024; Zhu et al., 2020) and a single bout of MIAE (Chang et al., 2012; Griebler et al., 2022) have been found to have positive effects on cognitive performance in a variety of populations, including cognitively healthy young adults (Lambourne & Tomporowski, 2010) and cognitively healthy older adults (Griebler et al., 2022).

A reliable, well-validated measure of memory and verbal learning is the Loewenstein-Acevedo Scales for Semantic Interference and Learning (LASSI-L) (Loewenstein et al., 2016). The LASSI-L can uniquely measure one's ability to recover from proactive semantic interference (PSI), in which previously learned semantic information interferes with learning of new semantic information in the same category. The LASSI-L is especially accurate in detecting subtle cognitive changes that could be early indicators of AD (Loewenstein et al., 2016).

Although a single bout of MIAE has a general positive effect on cognition and serves as a catalyst for long-term effects, few studies have investigated the effects of a single bout of dance exercise on cognitive performance. Dance as a non-pharmacological intervention has the potential to be more enjoyable than traditional forms of MIAE (Hyodo et al., 2021; Jeong et al., 2005). Its accessibility, flexibility in how it is performed, and mood-improvement abilities may contribute to increased adherence compared to other forms of exercise. Additionally, no studies have investigated the relationship between dance and LASSI-L performance. The present study investigated the effects of dance and stretching exercise on neurocognitive performance in young adults with a history of childhood abuse and/or neglect. I hypothesized that 20 minutes of moderate-intensity dance exercise, compared to low-intensity stretching, results in a greater ability to recover from PSI.

A Promising Neuropsychological Measure: LASSI-L

The Loewenstein-Acevedo Scales for Semantic Interference and Learning (LASSI-L) is a reliable, well-validated neuropsychological measure of memory and verbal learning (Loewenstein et al., 2016). The LASSI-L consists of two sets of different, but related, words (i.e., the words in each list are distinct but are in the same categories). The first cued recall of the second set of words is the most negatively impacted by proactive semantic interference (PSI), in which old learning, from the first set of words, interferes with new learning of the second set of words. The second cued recall of the second set of words measures the ability—and failure—to recover from PSI. The ability of the LASSI-L to measure the failure to recover from PSI (frPSI) distinguishes it from traditional neuropsychological tests. frPSI is important in adults with mild cognitive impairment (MCI) and amyloid (abnormal clumps of protein) present in the brain. MCI is a condition in which people experience more memory or thinking problems compared to changes seen in normal aging, but without significant decline in functional ability (Petersen et al., 1997). MCI and amyloid are both early indicators of AD (Caselli et al., 2020). Adults with MCI who were amyloid positive had greater frPSI compared to adults who had MCI but were amyloid negative, as well as compared to those who were cognitively normal (Kitaigorodsky et al., 2021). Cognitively normal participants had no difficulties recovering from PSI, whereas those with subjective memory impairment, preclinical MCI (an intermediate stage between subjective memory impairment and MCI), and MCI did have difficulties recovering from PSI (Loewenstein et al., 2016). Among participants with normal scores on other neurocognitive tests, there was a significant association between frPSI and increased amyloid load in the brain. This suggests that the frPSI may be more sensitive than PSI as an early indicator of cognitive deficits in populations that are at-risk for AD. Since frPSI is measured by the LASSI-L alone, this neuropsychological test seems to be especially sensitive to subtle cognitive changes that could be early indicators of AD. This provides motivation for the inclusion of the LASSI-L in the present study.

Exercise

Exercise is physical activity that is structured, repetitive, and improves fitness (Caspersen et al., 1985). Numerous studies have investigated the effects of exercise on cognition. The present review focuses on acute exercise, which is a single, short bout of exercise. Acute exercise produces immediate cognitive and health benefits that may be predictive of long-term effects seen in repeated exercise. For example, both acute aerobic exercise and regular aerobic training reduced ambulatory blood pressure (blood pressure measured continuously throughout the day) in patients with hypertension (Cardoso et al., 2010). Acute exercise may also initiate cellular pathways that, with time and repeated exercise, will induce changes (e.g., increased neural activity and neurotransmitter concentrations) seen with chronic exercise (El-Sayes et al., 2019). Additionally, beneficial brain-related changes occur after acute exercise, and effects become stronger after aerobic exercise training (Szuhany et al., 2015). Finally, the acute effects of moderate-intensity aerobic exercise (MIAE) on functional connections between crucial brain regions predicted enhancements in the same connections after 12 weeks of aerobic training (Voss et al., 2020). Acute improvements in working memory after MIAE were also seen, and greater improvements also predicted greater improvement after the aerobic training. These results support the rationale for this study's focus on an acute exercise intervention.

MIAE is typically 68-77% of maximum heart rate. Martini et al. (2024) found that a single, 20-minute bout of moderate-intensity exercise had positive effects on inhibitory control (e.g., responding to certain targets and ignoring distractors) and certain aspects of working memory in cognitively healthy older adults. Marchant et al. (2020) found that engaging in acute MIAE compared to a resting control group resulted in better short-term correct recall of a memory task. Another study tested 30 undergraduates who were given lists of 30 words (Zuniga et al., 2019). In both the 10-minute light- and moderate-intensity exercise groups, free recall scores significantly increased compared with the sedentary (control) condition. Additionally, light-intensity exercise similarly improved free recall of words compared to a sedentary condition.

A meta-analysis combined 79 studies that investigated children, young adults, and older adults, with and without cognitive decline (Chang et al., 2012). A single bout of exercise had a small positive effect ($d = 0.097$) on cognitive task performance. There were larger benefits when exercise lasted at least 20 minutes versus 11-20 minutes. The meta-analysis also observed variable effects related to the timing of cognitive testing following exercise completion and choice of neuropsychological measure. Administering the tests after a delay of 11 to 20 minutes following the exercise intervention resulted in the largest positive effects. Positive effects were seen in memory tasks like free recall, but negative effects were seen in an auditory verbal learning test. A similar systematic review investigated the effects of acute exercise on memory of cognitively healthy older adults (Griebler et al., 2022). Both aerobic and resistance exercise, at low and moderate intensities, had positive effects on memory task performance. These studies elucidate the impact of a single, short bout of exercise on cognitive task performance.

Finally, acute exercise has been shown to increase memory function in the hippocampus, seen through functional magnetic resonance imaging (Suwabe et al., 2018). The study found that even a 10-minute bout of very light exercise was able to improve the ability to discriminate between very similar memories.

Dance: Enjoyment and Adherence

Traditional forms of exercise typically consist of repetitive movements. In one study, time was moving slower than participants thought during cycling exercise compared to rest (Edwards et al., 2024). These findings were independent of how intense participants perceived the exercise to be. Thus, this time distortion effect may be due to the repetitive nature of cycling that is more tedious and unpleasant than other forms of exercise, like dance. This is important when considering adherence to exercise. One study investigated differences between dance and cycling, comparing the effects of a six-month challenging dance program versus stationary bicycle exercise (Rehfeld et al., 2018). They found that the dance group experienced increased volumes in brain regions relating to working memory and attention, which are especially affected by age-related decline. They believed that these effects could be explained by the fact that dancing involves many simultaneous processes: spatial orientation, movement coordination, and balance, and the fact that periodically introducing new choreographies facilitated a constant learning process. This study highlights another distinguishing feature of dance—it is cognitively demanding, which is likely to contribute to enduring cognitive benefits with repetition as seen in a study that found lasting cognitive training effects (Rebok et al., 2014).

Dance has also been found to benefit mood. A 10-minute bout of light-intensity aerobic dance exercise was found to improve mood in fifteen older adults aged 65–74 (Hyodo et al., 2021). Jeong et al. (2005) studied the effects of 12 weeks of dance movement therapy in 40 adolescents with mild depression. Psychological distress (e.g., negative symptoms like depression and anxiety) scores decreased significantly after the intervention. Additionally, plasma serotonin concentration increased, and dopamine concentration decreased. The fact that dance exercise is enjoyable is important because mood changes during exercise affect future physical activity—a positive change in the affective response (i.e., emotional experience) during moderate-intensity exercise was linked to engaging in future physical activity (Rhodes & Kates, 2015). Another study seemed to confirm this. Wagener et al. (2012) investigated the effects of a dance-based video game exercise on 40 obese adolescents aged 12-18. Participants in the dance group, compared with the control, experienced increased perceived competence to exercise and to meet challenges of doing so regularly. These studies highlight that adherence to exercise may be influenced by how enjoyable it is. Due to the fun and cognitively demanding characteristics of dance, the present study will investigate its role as a unique and useful intervention for cognitive function.

Acute Dance Exercise and Cognition

Few studies have investigated the effects of an acute dance intervention on cognition. Kimura and Hozumi (2012) tested effects of 20 minutes of aerobic dance in older adults. The study included two groups: a free dance group that learned a few moves in sequence, and another combination dance group that learned the same moves at the same intensity but were required to switch between more complex and challenging combinations. They administered a task switching test which measured reaction time, an aspect of executive function. They found that reaction times were decreased in the combination dance group compared to the free dance group. The authors attributed these results to the task-switching nature of the combination dance group, suggesting that executive functioning was facilitated in a dual-task, cognitively demanding dance intervention.

Pournara et al. (2024) investigated the effect of Greek traditional dance on executive function in children. They used levels of cognitive demand of the dance session and levels of intensity as independent variables. In the low cognitive demand session, participants engaged in repetitive and easy leg movements. In the high cognitive demand sessions, participants engaged in new, more complex movements that involved their entire body. They found that the cognitively demanding dance sessions resulted in better accuracy in an inhibitory control task, while the low-intensity session resulted in better accuracy in a cognitive flexibility task. However, they found no effects on working memory.

Finally, the study by Hyodo et al. (2021) mentioned in the previous section not only found improvements in mood after a 10-minute light-intensity aerobic dance intervention, but also improved executive function, measured by the Stroop test.

These are the only studies that have investigated the effects of an acute dance intervention on cognition. These studies suggest that dance interventions support effects on cognitive function. This, together with the findings described previously on the failure to recover from proactive semantic interference as an early indicator of cognitive deficits, motivates my focus on dance effects on PSI.

Conclusions

A single, short bout of exercise can demonstrate positive effects on cognitive performance, which may be a predictor of long-term benefits with repeated exercise (Szuhany et al., 2015; Voss et al., 2020). Dance is enjoyable (Hyodo et al., 2021; Jeong et al., 2005) and accessible. Because of this, adherence to dance exercise may be stronger than adherence to traditional, repetitive exercise (Wagener et al., 2012). A short bout of dance exercise may have a positive effect on executive function (Hyodo et al., 2021; Pournara et al., 2024). The LASSI-L distinguishes itself from other neurocognitive tests, as it measures failure to recover from proactive semantic interference (frPSI) and is especially sensitive to subtle cognitive changes that could be early indicators of AD (Loewenstein et al., 2016).

This study contributed to the growing body of research on the effect of exercise on cognitive function. Dance exercise could be integrated into various health settings as a fun, accessible, non-pharmacological intervention to support brain health. Understanding the effects of a single bout of moderate-intensity aerobic exercise can inform our understanding of how movement can be used to improve cognition in at-risk populations, like adults with a history of childhood abuse or neglect. Although dance has positive effects on executive functioning, it is unclear if dance can improve other cognitive domains like memory and verbal learning. No studies have investigated how dance can impact LASSI-L performance, specifically the ability to recover from PSI. This study addressed this gap. I hypothesized that a short bout of moderate-intensity dance exercise will result in a greater ability to recover from proactive semantic interference than the same amount of low-intensity stretching exercise.

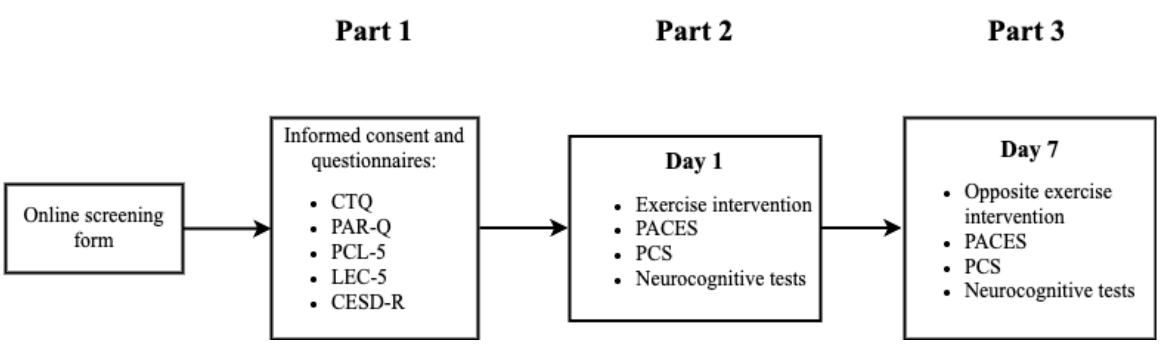
Methods

Design Overview

This study investigated the effects of acute moderate-intensity dance and stretching exercise on cognition. Participants were young adults with a history of childhood abuse or neglect. The experimental conditions were 20 minutes of moderate-intensity dance exercise and 20 minutes of low-intensity stretching exercise. Following an online screening, the study consisted of three parts: (1) informed consent and eligibility confirmation, (2) the exercise intervention, measures of exercise enjoyment and self-perceived competence, and neurocognitive tests, and (3) the opposite exercise intervention and the same measures and tests (see Figure 1). The LASSI-L neurocognitive test measured memory consolidation, and the others measured executive function. I hypothesized that 20 minutes of moderate-intensity dance exercise, compared to 20 minutes of low-intensity stretching exercise, results in: a greater ability to recover from PSI, better executive functioning skills, and greater exercise enjoyment.

Figure 1

Study Overview



Note. Study design overview. CTQ = Childhood Trauma Questionnaire; PAR-Q = Physical Activity Readiness Questionnaire; PCL-5 = Posttraumatic Stress Disorder Checklist for DSM-5; LEC-5 = Life Events Checklist; CESD-R = Center for

Epidemiological Studies Depression Scale – Revised; PACES = Physical Activity Enjoyment Scale; PCS = Perceived Competence Scale.

Participants

Participants were adults of any gender aged 18-39, with a history of child abuse or neglect, native or fluent English speakers, and had normal or corrected to normal vision and hearing. Participants may not have had any of the following: current excessive alcohol or other substance use; bipolar disorder; autism spectrum disorder, unmedicated ADHD, or other neurodevelopmental disorder; a schizophrenia spectrum disorder; a neurocognitive disorder; illnesses or a history of neurological events known to cause neurocognitive disorders; plan with intent to commit suicide; heart disease; uncontrolled hypertension; heart failure; heart rhythm disorders; heart valve disease; chronic obstructive pulmonary disease; pulmonary hypertension; cystic fibrosis; untreated asthma; or orthopedic injury that negatively impacts the ability to exercise safely. These inclusion and exclusion criteria were assessed in a screening form administered through the online platform REDCap.

Power analysis using G*Power 3.1 suggested 34 participants were needed to detect a medium effect of moderate-intensity dance exercise on neurocognitive performance. Participants were recruited via flyers, social media, and word of mouth. Informed consent was administered through the online platform, DocuSign, in which participants were briefed on the study's details, procedures, risks, benefits, data collection, confidentiality, and contact information. Participation in the study was voluntary, and they could choose to withdraw at any time with no consequence. Participants received $50 after participation in the study's entirety (up to Part 3). If they had to withdraw and completed up to Part 2, they received $25. A total of 38 participants enrolled; 34

completed the entire study, and four completed half of the study. Of these 34 participants, 67.65% were female (see Table 1). The average age was 22.82 years (*SD* = 4.93).

Table 1

Demographic data

	n = 34	%	Mean	SD
Sex				
Male	11	32.35	-	-
Female	23	67.65	-	-
Age (years)	-	-	22.82	4.93
Education (years)	-	-	15.25	2.12

Pre-Intervention Measures

Childhood Trauma Questionnaire (CTQ)

The CTQ was a self-report measure of abuse and neglect in childhood (Bernstein et al., 1994). There were 28 items (e.g., "When I was growing up, someone tried to make me do sexual things or watch sexual things"), each rated on a 5-point scale (1 = *never true* to 5 = *very often true*). There were five subscales: Emotional Abuse, Physical Abuse, Sexual Abuse, Emotional Neglect, and Physical Neglect. Each subscale score ranged from 5 to 25. Eligibility was confirmed by determining a history of childhood abuse and/or neglect, which was defined by scores that met or exceeded criterion on at least one subscale: Emotional Abuse subscale score ≥ 9, Physical Abuse subscale ≥ 8, Sexual Abuse subscale ≥ 6, Emotional Neglect subscale ≥ 10, Physical Neglect subscale ≥ 8. The CTQ demonstrated high internal consistency (a = .79 to .94), good test-retest reliability (r = 0.88), and convergent validity (Bernstein et al., 1994).

Physical Activity Readiness Questionnaire (PAR-Q)

The PAR-Q was a self-report measure assessing ability to participate in aerobic exercise (Shephard, 1988). Participants checked *yes* or *no* to seven items (e.g., "Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?"). Like the CTQ, the PAR-Q was administered to confirm eligibility: if participants answered *no* to all the questions, they could start being more physically active and thus participate in the study. If they answered *yes* to any of the questions, they were advised to check with a doctor before becoming more physically active. A modified but similar version of the PAR-Q had high reliability (r = .99) and validity for individuals with hypertension (Warburton et al., 2011).

Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5)

Given the high comorbidity of depression and trauma history, PTSD symptom level was intended to be a covariate (Campbell et al., 2007). The PCL-5 assessed the severity of symptoms of PTSD (Blevins et al., 2015). Participants rated 20 items (e.g., "In the past month, how much were you bothered by repeated, disturbing, and unwanted memories of the stressful experience?") on a 5-point scale (0 = *not at all* to 4 = *extremely*). Summing the scores for each item gave the total severity score, ranging from 0 to 80, using a cutoff score of 31-33 for a provisional PTSD diagnosis. The PCL-5 has good internal reliability (α = .96), test-retest reliability (r = .84), and convergent validity (Bovin et al., 2016).

Life Events Checklist (LEC-5)

The LEC-5 was a 17-item self-report measure of the participant's experiencing, witnessing, or learning of traumatic events (Weathers et al., 2013). An example of an event was "Life-threatening illness or injury," and participants checked one or more responses: *happened to* *me*; *witnessed it*; *learned about it*; *part of my job*; *not sure*; *doesn't apply*. The original LEC, which is almost identical to the LEC-5, demonstrated test-retest reliability and convergent validity in undergraduates (Gray et al., 2004).

Center for Epidemiological Studies Depression Scale Revised (CESD-R)

Given the high comorbidity of depression and trauma history, depression symptom level was intended to be a covariate in analyses (Campbell et al., 2007). The CESD-R was a self-report measure of depression symptoms that demonstrated very high internal consistency, adequate test-retest reliability, and supported construct validity (Radloff, 1977). Participants rated 20 items (e.g., "Nothing made me happy") on a 3-point scale (0 = *not at all or less than 1 day* to 3 = *nearly every day for 2 weeks*). The total score ranged from 0 to 60, with a score of at least 16 indicating risk for clinical depression.

Post-Intervention Measures

Physical Activity Enjoyment Scale – Short Version (PACES-S)

The PACES-S was a self-report measure of enjoyment of physical activity (Chen et al., 2021). Participants rated 4 items (e.g., "I enjoy it") on a 5-point scale (1 = *strongly disagree* to 5 = *strongly agree*). The total score was the sum of each item. The PACES-S demonstrated good test–retest reliability (r = .76), internal consistency (a = .82 to .88) and construct validity (Chen et al., 2021).

Perceived Competence Scale (PCS)

The PCS was a 4-item self-report measure of perceived competency for regular exercise, which was derived from a generic content model (i.e., it measures four concepts in general:

confidence perception, ability, goal achievement, and overcoming challenges) (Williams et al., 1998). An example item from the current derivation for exercise competency is “I feel confident in my ability to regularly exercise in the future.” Items were scored on a 7-point scale (1 = *not at all true* to 7 = *very true*), and the total score was the average of the responses. In adaptations for health interventions, internal consistency was high (α > .80) (Williams et al., 1998).

Neurocognitive Tests

Loewenstein-Acevedo Scales for Semantic Interference and Learning (LASSI-L). The LASSI-L is a measure of verbal learning and memory (Loewenstein et al., 2016). There were two lists (A and B) of 15 words each, grouped into three categories: fruits, musical instruments, and articles of clothing. The two lists had different words in the same category (e.g., list A had “pear” while list B had “coconut”). Participants read each list aloud twice. Then, participants recalled the words freely (e.g., “Name all the words in List A that you can”) and with a cue (e.g., “Name all the words in list A that are fruits”). Overall, the test is ordered as follows: first reading of list A, A1 free recall, A1 cued recall, second reading of list A, A2 cued recall, first reading of list B, B1 free recall, B1 cued recall, second reading of list B, B2 cued recall, A3 free recall, A3 cued recall, and delayed recall (after 20 minutes) of both lists. A1 refers to the first recall of list A, A3 refers to the third recall of list A, B2 refers to the second recall of list B, and so on. A brief, computerized version of the LASSI-L demonstrated high test-retest reliability and discriminative validity (Curiel Cid et al., 2021). Although the LASSI-L is validated for older adults, this study used the raw scores in analysis instead of the normative data. Scores include the total number of words correctly recalled in each part. The primary analysis used B2 cued recall scores, as they demonstrated recovery from proactive semantic interference (PSI).

Wechsler Adult Intelligence Scale – Fourth Edition Digit Span (DS) and Letter-Number Sequencing (LNS). The DS and LNS tests were measures of the executive function of working memory (Webber & Soble, 2018; Wechsler, 2008). DS had three parts: forward, backward, and sequencing. In DS forward, participants were read a sequence of numbers and had to verbally recall them in the same order (e.g., "4…7…3"). They recalled the numbers in reverse order in the backward part (e.g., if I said "1…2…3" participants should have said "3…2…1"). In DS sequencing, participants recalled the numbers in numerical order (e.g., if I said "8…1…9" participants should have said "1…8…9"). Sequences started with two numbers and increase by one until a maximum of nine numbers may be recalled. There were two trials for each number length. Each part ended when participants incorrectly recalled two trials of the same length numbers. The total raw score was calculated by summing the forward, backward, and sequencing scores. Since there were 8 trials of 2 points each, the maximum score for each of these parts is 16. The maximum total raw score for the entire test is 48. This score was used in analysis. DS had strong internal consistency reliability (Gignac et al., 2019) and validity (Resch et al., 2023).

In the LNS, participants were read a sequence of numbers and letters and had to recall the numbers in numerical order followed by the letters in alphabetical order (e.g., if I said "V-1-J-5" participants should have said "1-5-J-V"). Sequences began at 3 letters/numbers and ended at 8 letters/numbers. The total raw score was calculated by summing each sequence score. Since there were 10 trials of 3 points each, the maximum total raw score was 30. This score was used in analysis. There is support for the validity of Letter-Number Sequencing across different age groups (Pezzuti & Rossetti, 2017) and for performance validity in ADHD evaluations (Finley et al., 2024).

Trail Making Test (TMT). The TMT was a measure of visual attention, processing speed, and executive function (Bowie & Harvey, 2006). There were two parts: A and B. In TMT A, there were 25 encircled numbers scattered on a page, and the participant used a pen to connect them in numerical order (e.g., the participant should draw a line from the "1" to the "2" to the "3," and so on). In TMT B, the participant connected 25 total encircled numbers and letters in order, alternating between the two (e.g., the participant should draw a line from the first number "1" to the first letter "A," to the second number "2" to the second letter "B," and so on). Scores were the total times to complete both parts. The TMT demonstrated construct validity (Sánchez-Cubillo et al., 2009) and high test-retest reliability in patients with Major Depressive Disorder (Wagner et al., 2011).

Symbol Digit Modalities Test (SDMT). The SDMT was a measure of visual working memory, processing speed, and executive function (Smith, 1973). At the top of a stimulus sheet, symbol-digit pairs were presented in boxes in a key. Symbols were randomized presentations of geometric figures, and digits include 1 through 9. Below the key are rows of symbols with blank spaces below. Participants completed the SDMT in two, 90-second trials: first physically copying the corresponding digits underneath the given symbol, then orally saying the corresponding digits. The score was the number of correct responses in each 90 second interval (e.g., 36 correct substitutions and 3 incorrect substitutions gave a score of 36). The SDMT demonstrated construct validity and excellent test-retest reliability, in both healthy samples and in patients with multiple sclerosis (Benedict et al., 2017).

Controlled Oral Word Association Test (COWAT-FAS). The COWAT-FAS was a measure of language and executive function (Benton et al., 2017). Participants named all the words they can that begin with the letters F, A, and S, with 60 seconds for each letter. The total score was total valid words produced across the 3 letters. The COWAT-FAS had good test-retest reliability, inter-rater reliability, and validity (Fox-Fuller et al., 2022; Ross et al., 2007).

Procedures

Exercise Manipulation

Heart rate was monitored throughout the exercise interventions using the Polar H10 heart rate sensor (Polar Electro Oy, Kempele, Finland; app software: Polar Beat app, Version 3.5.9) strapped to the chest. The Polar H10 heart rate sensor demonstrated high convergent validity for heart rate variability in exercise settings (Schaffarczyk et al., 2022).

Each exercise had a pre-recorded, 30-minute video. Both conditions included a five-minute warm-up and five-minute cool-down of low-intensity stretching, with a target of 40-50% maximum heart rate (MHR). The warm-up consisted of neck rolls, wrist stretches, side-to-side twists, arm circles, side-to-side lunges, leg kicks, hip openers, ankle rolls, etc. The cool-down consisted of a seated leg stretch, arm and quadricep stretches, cobra pose, child's pose, a seated twist, etc.

Low-intensity stretching exercise was 20 minutes of stretching, with a target of 40-50% MHR. It consisted mostly of leg stretches like lunges and various quadricep and hamstring stretches. It also included arm and shoulder stretches, ankle rolls, hip stretches like circles and butterfly position, a half straddle position, back stretches, etc.

Moderate-intensity dance exercise consisted of five *Just Dance* (Ubisoft, via YouTube) songs (in order: Where Have You Been, California Gurls, Juice, Moves like Jagger, What Makes You Beautiful) for 20 minutes, with a target of 65-75% MHR. *Just Dance* is a virtual video game in which players must mimic an avatar dancing. Songs were selected based on personal preference and moderate difficulty. If heart rate did not reach the moderate-intensity range, participants were told to really use those legs and get those arms up in subsequent songs. If heart rate overly exceeded the moderate-intensity range, participants were given a slightly longer break in between certain songs.

Sequence of Procedures

Interested participants filled out the online screening form on REDCap. Participants who met the general inclusion and exclusion criteria were emailed to return for Part 1 via a private University of Texas at Austin Zoom account. After undergoing the consenting process, five questionnaires were emailed for them to fill out immediately on REDCap: CTQ, PAR-Q, PCL-5, LEC-5, CESD-R. Part 1 lasted no more than 30 minutes. If participants continued to meet inclusion criteria following this, dates and times were set for Parts 2 and 3.

Parts 2 and 3 used a counterbalanced, within-subjects design and took place in-person in private offices of the Dell Medical School – Health Discovery Building on the University of Texas at Austin campus. Participants did either the dance or stretching exercise intervention, then completed the PACES-S and PCS questionnaires on REDCap and a series of neurocognitive tests on paper (in order: LASSI-L, SDMT, DS, LNS, TMT, FAS). Upon returning six to eight days later for Part 3, participants completed the opposite exercise condition (i.e., if they did the dance exercise in Part 2, they did the stretching exercise in Part 3, and vice versa). This was followed by the PACES-S, PCS, and same series of neurocognitive tests. Parts 2 and 3 lasted no more than 1.5 hours each.

Statistical Analysis

A one-tailed, paired samples t-test was used to determine a significant difference ($p < .05$) in the means of the LASSI-L B2 Cued Recall scores between the dance and stretching conditions. A multivariate analysis of variance (MANOVA) was used to determine a significant difference ($p < .05$) in the scores of the other neurocognitive tests between the two exercise conditions. These scores included: total correct responses for written and oral SDMT, total DS, total LNS, TMT A and B times, and total FAS. A one-tailed, paired samples t-test was used to determine if the PACES-S questionnaire score differed significantly ($p < .05$) between exercise condition.

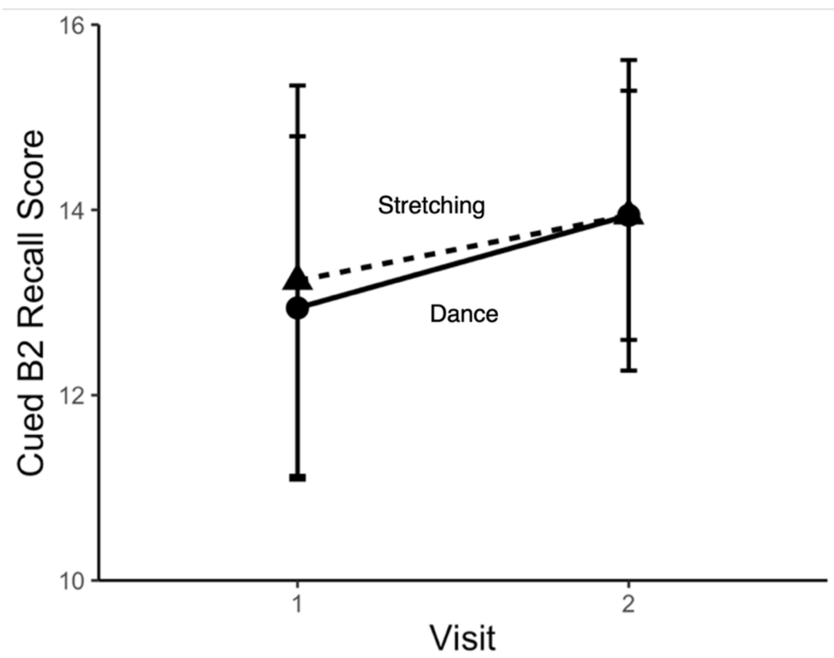
Results

Recovery from Proactive Semantic Interference

Mean LASSI-L B2 cued recall scores were similar for the dance (Visit 1: $M = 12.94$, $SD = 1.85$; Visit 2: $M = 13.94$, $SD = 1.68$) and stretching (Visit 1: $M = 13.24$, $SD = 2.11$; Visit 2: $M = 13.94$, $SD = 1.34$) conditions (see Figure 2). A paired-samples t-test (one-tailed) revealed no significant difference in mean scores between the dance and stretching conditions, $t(33) = 0.45$, $p = .67$.

Figure 2

LASSI-L B2 Cued Recall Scores by Condition



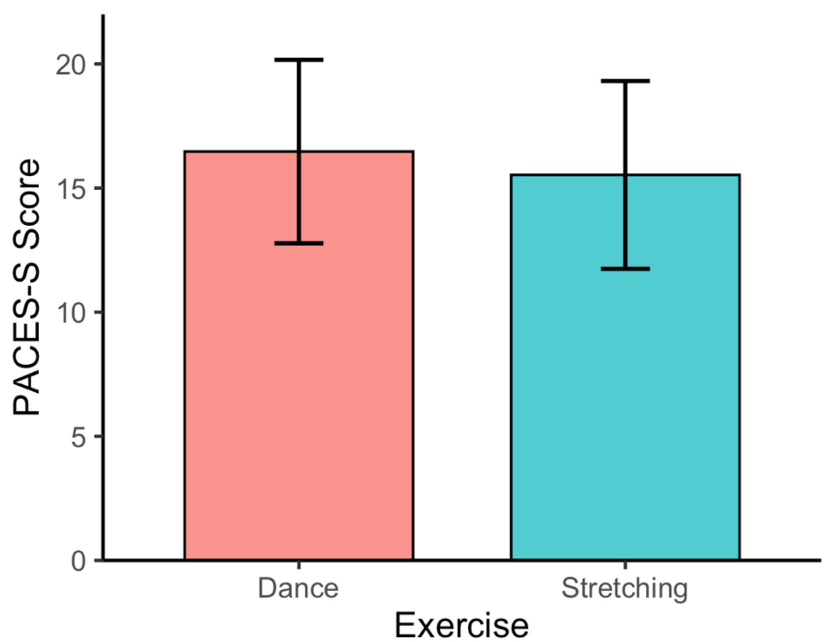
Note. Performance on the B2 cued recall of the LASSI-L test between exercise and visit. Data are M ± SD.

Exercise Enjoyment

Enjoyment for both dance (*M* = 16.47, *SD* = 3.69) and stretching (*M* = 15.53, *SD* = 3.78) exercises was high (see Figure 3). A paired-samples t-test (one-tailed) revealed no significant difference in mean PACES-S questionnaire scores between the two conditions, $t(33) = -1.04$, $p = .15$.

Figure 3

Exercise Enjoyment by Condition



Note. PACES-S questionnaire scores by condition. Data are M ± SD. PACES-S = Physical Activity Enjoyment Scale (Short Version).

Executive Functioning

A MANOVA revealed no significant effect of dance versus stretching exercise on the combined neurocognitive test scores (see Table 2), WTS = 9.36, *df* = 7, *p* = .23.

Table 2

Neurocognitive Test Scores Measuring Executive Function

Visit and task	Stretching	Dance
Visit 1		
SDMT (written)	60.29 (15.92)	63.12 (12.98)
SDMT (oral)	71.06 (16.25)	71.29 (17.60)
Digit span task	27.94 (4.78)	27.88 (5.93)
Letter-Number Sequencing task	20.88 (3.20)	19.71 (2.91)
Trail Making Test A (sec)	21.59 (9.40)	17.14 (4.09)
Trail Making Test B (sec)	54.40 (25.40)	50.90 (17.59)
COWAT-FAS	47.35 (11.57)	42.29 (10.44)
Visit 2		
SDMT (written)	73.82 (16.46)	72.35 (17.94)
SDMT (oral)	83.76 (16.42)	84.41 (16.58)
Digit span task	29.18 (4.39)	29.94 (5.49)
Letter-Number Sequencing task	20.47 (3.20)	20.59 (3.08)
Trail Making Test A (sec)	16.00 (4.01)	18.21 (8.23)
Trail Making Test B (sec)	41.72 (10.84)	46.13 (25.12)

Visit and task	Stretching	Dance
COWAT-FAS	45.94 (11.04)	51.06 (12.58)

Note. Data are M (SD). SDMT = Symbol Digit Modalities Test; COWAT-FAS = Controlled Oral Word Association Test.

Discussion

This study showed that young adults with childhood trauma performed similarly on neurocognitive tests measuring executive function and similarly recover from proactive semantic interference effects after a single bout of dance/stretching exercise. A single bout of stretching may be as enjoyable as dance.

Although there was no significant difference in mean LASSI-L B2 cued recall scores between condition, participants in both the dance and stretching conditions scored high. That is, participants in both conditions were able to recall List B words well, without interference from List A words. Thus, there were no significant differences in memory consolidation ability. Previous research has found that 0% of a sample of cognitively healthy adults failed to recover from PSI, compared to 61% of adults with mild cognitive impairment (Loewenstein et al., 2016). Our results align with these results, since our sample was cognitively healthy.

Additionally, there was no significant effect of dance versus stretching exercise on neurocognitive test scores measuring executive function. This was the first study to compare dance and stretching effects on executive function and recovery from PSI. However, these results seem to be inconsistent with previous research that found better executive functioning skills of task switching (Kimura & Hozumi 2012) and inhibitory control (Pournara et al., 2024) after cognitively demanding acute dance interventions.

We found that participants rated low-intensity stretching to be as enjoyable as moderate-intensity dance, and enjoyment was high for both exercises. This might be due to the type of stretching involved, which was taken from my previous dance training and incorporates subjectively pleasant stretches, which might be particularly enjoyable for those who typically do not stretch. This might also be because the *Just Dance* dances are unfamiliar and hard to follow, and the song choices may not align with participant preference. Repeatedly doing the same dances would be more familiar, and we speculate that, if the song were of the individual's preference, doing so would increase dance enjoyment.

Limitations

During the exercise interventions, heart rates varied greatly between participants. During dance, heart rates often exceeded the moderate-intensity range (65-75% of maximum heart rate), and some did not meet the range. During stretching, heart rates sometimes exceeded the low-intensity threshold (50% of maximum heart rate). Future research would benefit from including another exercise metric like rate of perceived exertion and incorporating longer breaks in between dance songs. This study design did not include a condition in which participants did not exercise at all. This could potentially be a better control than low-intensity stretching.

While this study's sample was adequately powered, increasing the sample size would be beneficial for detecting smaller effects. Participants were cognitively healthy young adults with childhood trauma. There are differences in recovery from PSI between cognitively healthy adults and those with cognitive impairment. Additionally, adults with a history of childhood trauma are more likely to report cognitive complaints (Brown et al., 2023; Corney et al., 2022) and develop Alzheimer's disease (Radford et al., 2017). Further exercise research should incorporate these populations and recovery from PSI using the LASSI-L test.

Conclusion

In both dance and stretching conditions, participants had similar neurocognitive test performance, including similar recovery from proactive semantic interference effects, and similar exercise enjoyment. Our results indicate that a single session of low-intensity stretching may be as enjoyable as moderate-intensity dance, and dance and stretching have similar effects on memory consolidation and executive functioning skills. This suggests that exercise preference may be more important than specific modality, and both dance and stretching may be beneficial for cognition. This was the first study to compare dance and stretching effects on recovery from proactive semantic interference and executive function. Since recovery from proactive semantic interference is particularly important for adults with cognitive impairment, further exercise research should be done with this population.

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