5-24-2023

Dance: A Stimulus for Memory

Emma Rutter

Dance: A Stimulus for Memory?

By: Emma Rutter
Advisors: Patti Simone, PhD., David Popalisky, MFA
With support from Santa Clara University's Center for the Arts and Humanities

INTRODUCTION

Past studies show that dance interventions improve working memory, increase hippocampal volume, and induce expressive brain plasticity in older adults aged 55+ after beginning dance classes (Teixeira-Machado et al., 2019, Rehfeld et al., 2017, Rehfeld et al., 2018). Other findings show that aerobic exercise induces growth factors that increase neural plasticity resulting in the preservation of cognitive functions. There is limited research between dance and cognitive function in people ages 14-24 years. Furthermore, not all styles of dance maintain aerobic conditions as discussed in previous research on exercise interventions for memory. This study was formulated to explore this literature gap.

METHOD

Approval for this study was obtained from the Institutional Review Board of Santa Clara University. All subjects signed informed consent. An additional guardian informed consent was signed for subjects under eighteen years of age. Participants were recruited ages 14- 24 years (average age) currently enrolled in dance classes in California and Colorado. Participants completed surveys both before and after one hour of a dance class. The dance classes were taught by their regular instructor in the respective style each subject had been taking classes in. Dance interventions included ballet, jazz, and modern classes. Overall, 65 participants completed the study (27 in a ballet class, 26 in a modern class, and 12 in a jazz class). All tests and surveys were completed digitally on the subjects' personal devices via Qualtrics. Pre and post-surveys were connected utilizing a random ID that each subject received at the end of the pre-dance survey to be entered into the post-dance survey.

Demographic Survey
Participants filled out a demographic questionnaire including questions on age, race, and/or ethnicity, dance training (years, classes per week, styles), and the type of dance intervention they completed.

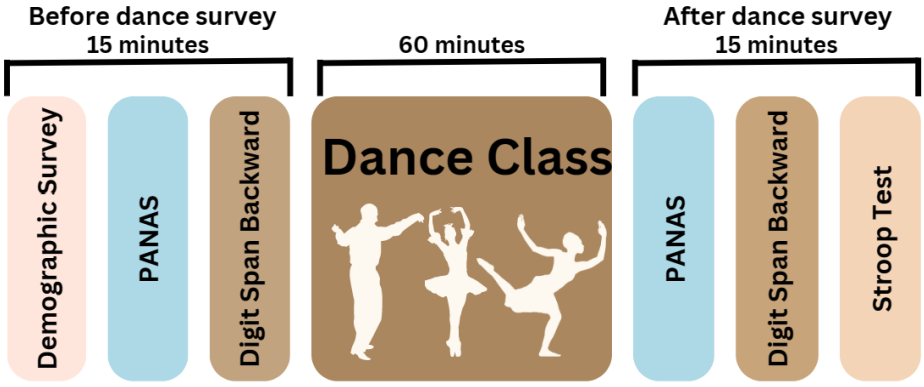

Figure 1. Study Session Design

The Positive and Negative Affect Schedule (PANAS) questionnaire is a self-report instrument that measures positive and negative affect. Positive Affect (PA) reflects the extent to which a person feels enthusiastic, active, and alert (Watson & Clark 1988). Negative Affect (NA) is a dimension of subjective distress and unpleasurable engagement. NA mood states include anger,

contempt, disgust, guilt, fear, and nervousness (Watson & Clark 1988). Low PA is characterized by sadness and lethargy while low NA is a state of calm and serenity (Watson & Clark 1988).

Digit Span Backward Task is a measurement of working memory. This task assesses the participants' ability to hold numerical information in short-term memory and manipulate the information to produce the backward sequence (Wechsler 1987). Digit strings of increasing length were presented to the participant and the participant was asked to type each string backward in the Qualtrics survey. Each digit of the string was shown individually for two seconds prior to the survey auto-advancing to the next digit. The score is the number of correctly retrieved strings in each part (Wechsler 1987).

The **Stroop test** is a cognitive test that measures the ability to inhibit cognitive interference. Participants were shown the words "blue", "orange", "green", and "red" but the words were written in text that was different in color to the word. The brain needs to direct its attention to selecting the color of the letters (McMorris 2016). For the digital implementation via Qualtrics participants selected the color of the letters from a multiple choice menu. In order to emulate the time constraints of a verbal administration of the Stroop test participants were instructed to make selections as fast as possible and each question auto-advanced after three seconds. The timing of the selection of the answer was recorded. The error rate of the Stroop test was calculated by dividing the number of errors by the time (sec) it took the participant to complete the test (Scarpina & Tagini 2017).

Statistical analysis

The data was exported from Qualtrics to a CSV file and organized for data analysis. R was used for all statistical analysis and the generation of visualization of the data. Additional assistance in R was provided by Brody Sandel, Ph.D.

RESULTS

Demographic Survey

All of the participants were between 14 to 24 years old and had previous dance experience from 0-16 years. The participants danced between 3-25 hours a week. A Pearson correlation coefficient was computed to assess the linear relationship between age and dance experience. There was a negative correlation between age and years of dance training ($r(63)= -0.3541$, $p= 0.0038$)(Fig 2A). There was a negative correlation between age and hours of dance training ($r(58)= -0.6589$, $p= 1.04e-08$)(Fig 2B). Therefore, the younger participants in this study had more years of dance training and are currently dancing more hours per week compared to the older participants.

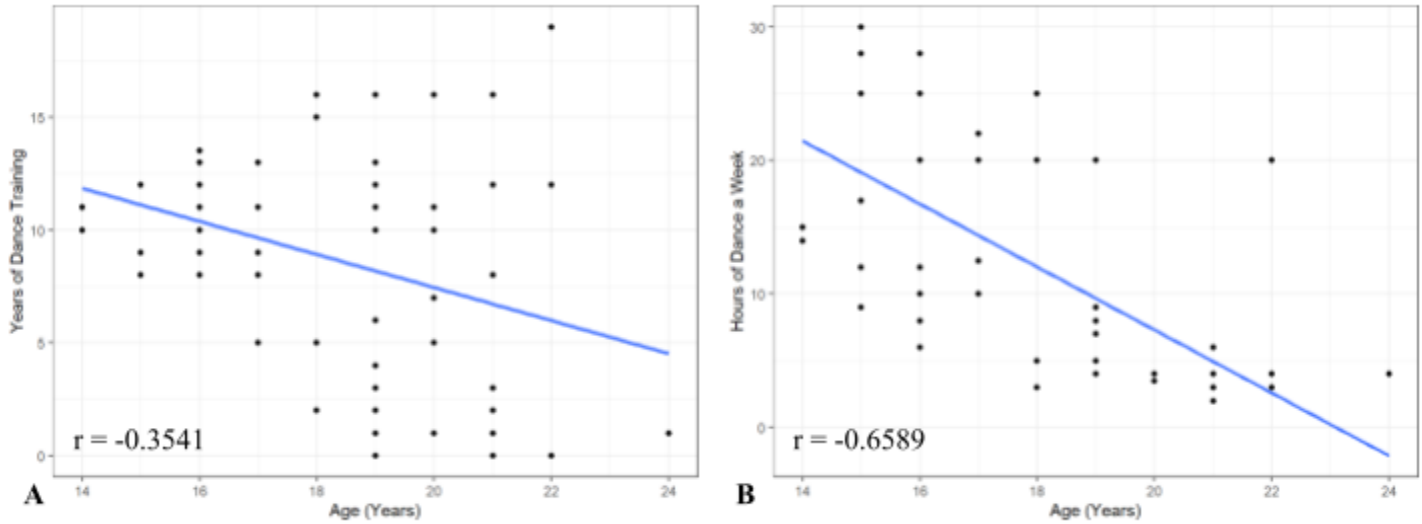

Figure 2. Participants' Age Correlated with Dance Experience Level
The blue line represents the linear regression of the data. All "NA" responses were omitted from the data. **A)**There was a negative correlation between age and years of dance training (r(63)= -0.3541, p= 0.0038). **B)**There was a negative correlation between age and hours of dance training (r(58)= -0.6589, p= 1.04e-08).

PANAS Score Changes
To assess potential differences in positive and negative affect before and after dance class the positive and negative affect score for each test were calculated. Scores can range from 10-50 with higher scores associated with higher levels of positive or negative affect.

Positive Affect Changes
A paired sample t-test was performed to compare the positive affect score before the dance class and after the dance class. Outliers were removed from the data using the interquartile range method. There was a significant difference between the before-dance class scores (M=26.954, SD=6.82) and the after-dance class scores (M=30.415, SD=9.097); (t(64)=3.5433, p=0.00074) (Fig. 3A).

Negative Affect Changes
A paired sample t-test was performed to compare the negative affect score before and after the dance class. Outliers were removed from the data using the interquartile range method. There was a significant difference between the before-dance class scores (M=16.644, SD=5.378) and the after-dance class scores (M=14.288, SD=4.068); (t(58)=3.8113, p=0.000337) (Fig. 3B). A Pearson correlation coefficient was computed to assess the linear relationship between hours of dance training per week and survey scores. Only one correlation was significant between hours of dance a week and after-dance NA scores. There was a positive correlation between hours of dance a week and after-dance NA scores. (r(53)= 0.3571, p= 0.00743)(Fig.4).

In order to explore if the type of dance class affects the after-dance scores, a one-way analysis of variance (ANOVA) was conducted for both PA and NA. A one-way ANOVA revealed that there was not a statistically significant difference in positive affect scores between at least two groups (F(5) = 1.185, p = 0.328). A one-way ANOVA revealed that there was not a statistically

significant difference in negative affect scores between at least two groups ($F(4) = 2.426$, $p = 0.059$).

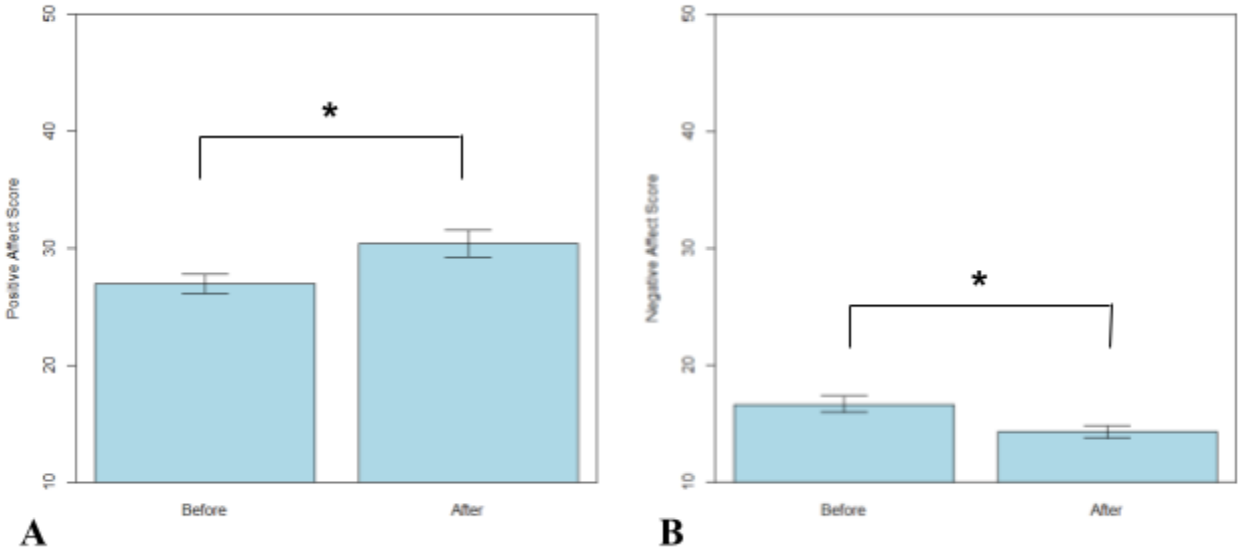

Figure 3. Change in the Average Positive and Negative Affect Score
Error bars represent the standard error of the mean. Each bar is the average score on the PANAS scale before and after affect one hour of dance. Outliers were removed from the data using the interquartile range method. **A)** There was a significant difference in positive affect between the before-dance class scores ($M=26.954$, $SD=6.82$) and the after-dance class scores ($M=30.415$, $SD=9.097$); ($t(64)=3.5433$, $p=0.00074$). **B)** There was a significant difference in negative affect between the before-dance class scores ($M=16.644$, $SD=5.378$) and the after-dance class scores ($M=14.288$, $SD=4.068$); ($t(58)=3.8113$, $p=0.000337$)

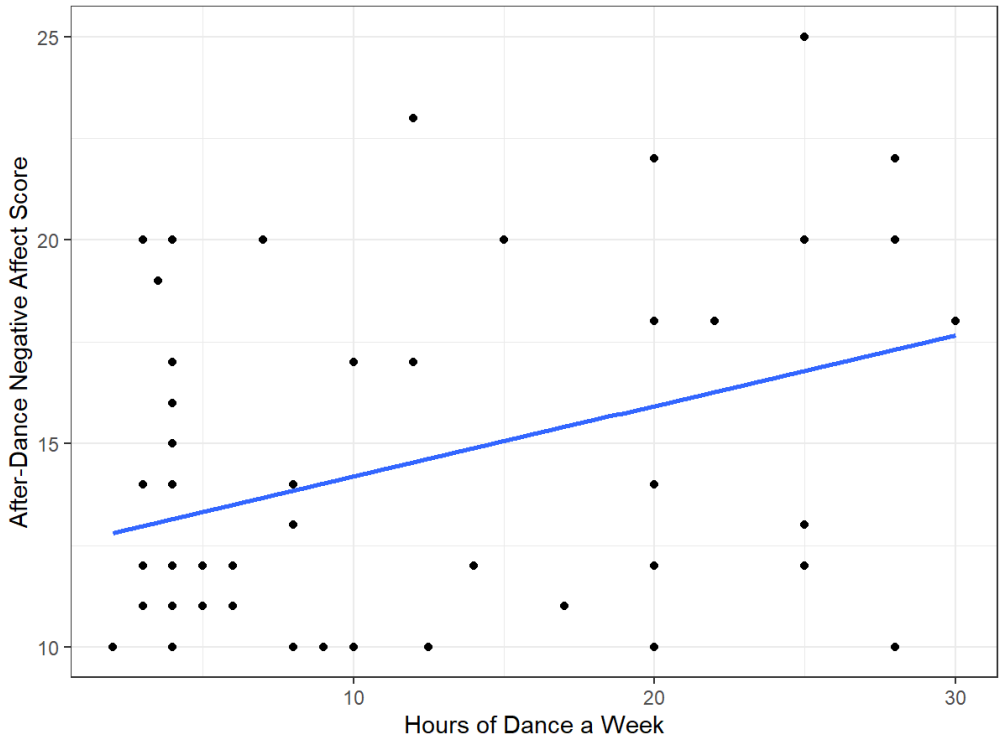

Figure 4. Correlations between Hours of Dance a Week and After-Dance NA Score
The blue line represents the linear regression of the data. All "NA" responses were omitted from the data. Outliers were removed from the data using the interquartile range method. There was a positive correlation between hours of dance a week and after-dance NA scores. ($r(53)= 0.3571$, $p= 0.00743$).

Digit Span Backwards Score Changes

To assess potential differences in digit span backward before and after dance class, the score for each test was calculated. The maximum score possible is 14. A paired sample t-test was performed to compare the digit span backward score before dance class and after the dance class. Outliers were removed from the data using the interquartile range method. There was no significant difference between the before-dance class scores ($M=8.852$, $SD=2.0778$) and the after-dance class scores ($M=8.4814$, $SD=1.269$); ($t(53)=1.2669$, $p=0.2107$) (Fig. 3).

In order to explore if the type of dance class affects the after-dance digit span backward score one-way analysis of variance (ANOVA) was conducted. A one-way ANOVA revealed that there was not a statistically significant difference in digit span backward score between at least two groups ($F(5) = 2.149$, $p = 0.0755$).

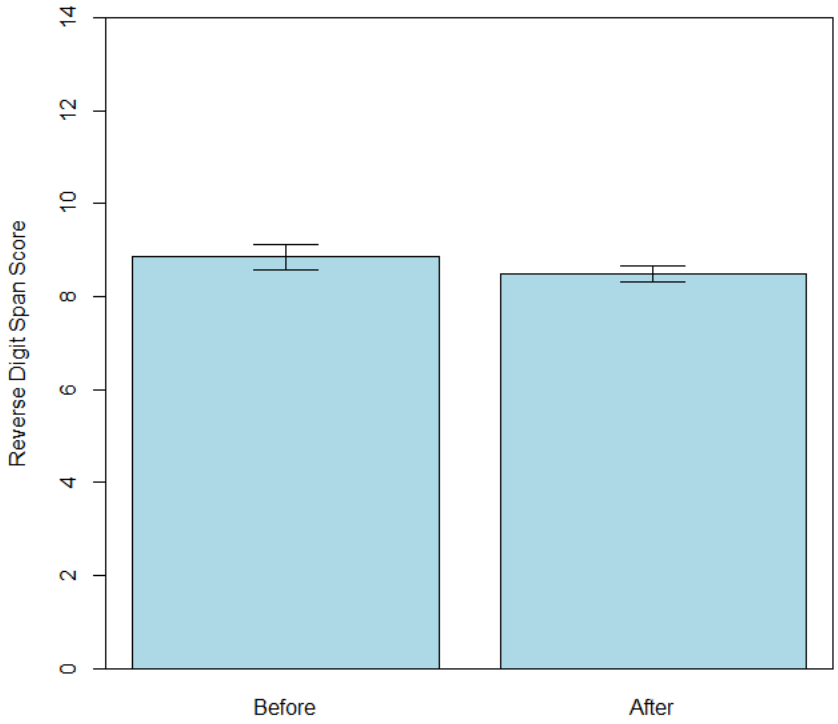

Figure 5. Changes in Reverse Digit Span Score
Error bars represent the standard error of the mean. Each bar is the average of the before and after digit span backward score. There was no significant difference between the before-dance class scores (M=8.852, SD=2.0778) and the after-dance class scores (M=8.4814, SD=1.269); (t(53)=1.2669, p=0.2107).

Stroop Error Rates
A Pearson correlation coefficient was computed to assess the linear relationship between years of dance training and survey scores. There was a positive correlation between the years of dance training and the error rate of the Stroop test (r(63)= 0.2922, p= 0.0182)(Fig 6). A one-way ANOVA revealed that there was not a statistically significant difference in the error rate of the Stroop test between at least two groups (F(5) = 2.108, p = 0.077).

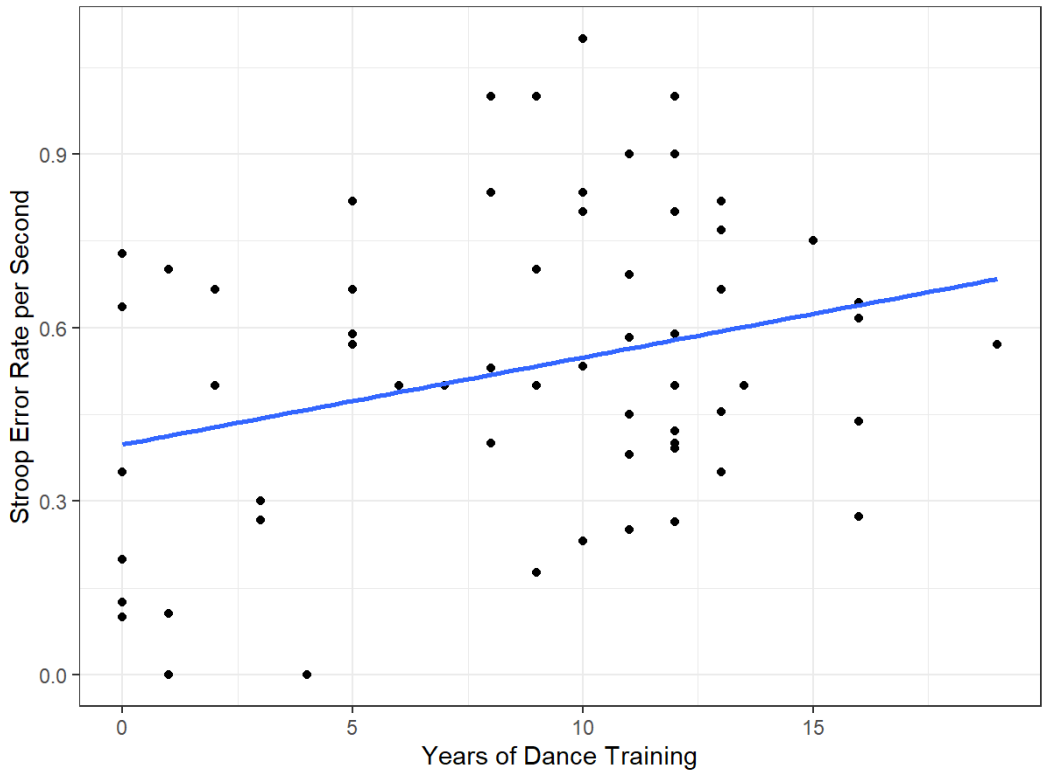

Figure 6. Correlation between Years of Dance Training and Stroop Error Rate per Second The blue line represents the linear regression of the data. There was a positive correlation between the years of dance training and the error rate of the Stroop test ($r(63)= 0.2922$, $p= 0.0182$).

DISCUSSION

This current study examined the relationship between dance and emotional affect in people ages 14-24 years, some of whom were new to dance, and some who had been dancing a long time. The younger participants in this study had more years of dance training and are currently dancing more hours per week compared to the older participants (Fig 2).

The data analysis of the PANAS questionnaire illustrates that participants in all dance classes perceived more positive emotions and less negative emotions after class independent of the type of dance class or length of experience with dance (Fig 3). This finding suggests that dance classes can contribute to altering the perceived emotions of the participants and can be beneficial for the participants. Although, there was a positive correlation between hours of dance a week and after dance class negative affect scores ($r(53)= 0.3571$, $p= 0.00743$). Lower NA is ideal because low NA is a state of calm and serenity (Watson & Clark 1988). Therefore, as participants increase the hours of dance classes per week the after-dance NA increases. This could be due to the large range of 3-25 hours the participants' dance per week. The participants at the higher end of the training hours are on a pre-professional track and participate in dance classes daily. It is possible at this training level the participants perceive more negative emotions due to the rigor and repetition of the training. Further research needs to be conducted to confirm

this speculation. At high hours of dance per week, the effects of decreased NA are dampened but the PA in participants is increasing. Regardless of the type of dance, years of dance training, and hours of dance per week, participants did perceive more positive emotions after dance class.

Regarding cognitive performance, this current study examined the relationship between dance and cognitive performance in people ages 14-24 years with a variety of experiences in dance. The Stroop test and Backwards Digit span (BDS) test were used to measure cognition, particularly executive function (Stroop) and working memory (BDS).

The digit span backward task scores did not differ before and after the class suggesting that one hour of dance instruction does not have a significant impact on working memory measured by the task. This finding suggests that either dance has no impact on memory or a more rigorous memory task needs to be performed to accurately evaluate the potential relationship between memory and dance. Since this study was conducted on a younger age group, working memory performance is difficult to evaluate due to a high level of proficiency in working memory skills. As we age, our working memory skills are altered. It is possible that in an older population, a potential effect on working memory could be observed. Additionally, the dance class only lasted one hour between the surveys. Other studies outline that in older adult groups (55+) researchers have found significant improvement in digit span backward scores after eight months of dance intervention (Aguiñaga et al., 2022). It is possible that the hour-long dance class was too short to observe any potential changes in working memory. Further research on dance and memory with a variety of age groups or a longitudinal study with longer-term dance interventions is needed to expand the knowledge of dance and memory.

There was a positive correlation between the years of dance training and the Stroop error rate per second ($r(63)= 0.2922$, $p= 0.0182$)(Fig 6). A low error rate per second indicates executive function abilities, specifically attention, and inhibition. This suggests that participants with more years of dance training had a lower ability to inhibit inappropriate responses on this task. In this study, the younger participants had more dance experience. This result is perplexing because there was not a significant correlation between age and the Stroop error rate per second. In order to fully understand the correlation between years of dance training and the Stroop error rate per second more research needs to be conducted with a larger sample size, variety of ages, and variety of dance experience.

LIMITATIONS

Limitations of this research include a small sample size of sixty-eight participants, three dance styles examined, short dance class intervention, and a small range of ages. Furthermore, this study was limited to survey-based responses. Additional information involving brain activation and structural imaging would expand the findings and field of research. Overall, further research is necessary to explore the potential relationship of dance with cognitive function and emotional effect.

PERSONAL REFLECTION

When I tell people about my two majors, neuroscience and dance, I often get confused looks. When I started at SCU I often explained my dance major as a side passion project and automatically discredited the theatre arts education I was receiving. I felt that in order to be a

"serious" STEM student I needed to shift my focus and relegate dance to a hobby. Now as I finish out my last year at SCU, I can confidently state that my interdisciplinary education is invaluable. I have cultivated creative problem-solving and leadership goals in both areas of study. I am grateful for the opportunity that the Center for the Arts and Humanities has given me to explore the connection between memory and dance. Through the completion of this study, I have refined my skills as a researcher and as a critical thinker. I did not know the full extent of what this journey would entail and I am grateful for all the problems that arose. With each problem, I learned something new about myself and my field of interest. While many of the results of my data only lead to more questions I am thankful for the opportunity to begin my exploration into the possibilities for dance interventions. I hope to further my education and explore the potential of dance interventions in the future.

ACKNOWLEDGEMENTS

Thank you to Dr. Patti Simone for the direction and knowledge to conduct this study. I appreciate all the time and energy you put into going through data with me and reviewing multiple drafts of my poster and paper. Thank you to David Popalisky for the connections within and outside of Santa Clara University needed to conduct my study on a larger population. Thank you to both the Neuroscience and Theatre and Dance Departments for allowing me to pursue both my passions simultaneously. Thank you to the Center for the Arts and Humanities for their generous support to give this project a platform. Thank you to Michelle Burnham, Amy Randall, and Britt Cain for organizing monthly meetings and facilitating a welcoming space for me to explore my project. Thank you to Maddie Moran, Alexandria Perez, and Bianca Romero for sharing insights on their projects and expanding my knowledge. Thank you to the faculty fellows Julianna Blair Watson, Sonia Gomez, Tony Hazard, Amy Lueck, Lee Panich, and Mukta Sharangpani for sharing their work and offering advice. Thank you to the participants, guardians of participants, and dance teachers that gave up their class time to be involved in this study. Thank you to my friends, housemates, and loving partner that listened to my ideas and problems throughout this project and never stopped cheering me on. Lastly, I thank my parents and brother who have supported me in all my endeavors, big and small.

REFERENCES

Aguiñaga, S., Kaushal, N., Balbim, G. M., Wilson, R. S., Wilbur, J. E., Hughes, S., Buchner, D. M., Berbaum, M., McAuley, E., Vásquez, P. M., Marques, I. G., Wang, T., & Marquez, D. X. (2022). Latin Dance and Working Memory: The Mediating Effects of Physical Activity Among Middle-Aged and Older Latinos. *Frontiers in Aging Neuroscience*, *14*. https://doi.org/10.3389/fnagi.2022.755154

Digit Span Task (Backwards only) | Science Of Behavior Change. (n.d.). Retrieved May 23, 2023, from https://scienceofbehaviorchange.org/measures/digit-span-task-backwards-only/#:~:text=The%20Digit%20Span%20Task%20%28Backwards-Only%20Child%20Version%29%20measures

McMorris, T. (2016). History of Research into the Acute Exercise–Cognition Interaction: A Cognitive Psychology Approach. *Exercise-Cognition Interaction*, 1-28. https://doi.org/10.1016/B978-0-12-800778-5.00001-3

Rehfeld, K., Müller, P., Aye, N., Schmicker, M., Dordevic, M., Kaufmann, J., Hökelmann, A., & Müller, N. G. (2017). Dancing or Fitness Sport? The Effects of Two Training Programs on Hippocampal Plasticity and Balance Abilities in Healthy Seniors. *Frontiers in Human Neuroscience*, *11*. https://doi.org/10.3389/fnhum.2017.00305

Rehfeld, K., Lüders, A., Hökelmann, A., Lessmann, V., Kaufmann, J., Brigadski, T., Müller, P., & Müller, N. G. (2018). Dance training is superior to repetitive physical exercise in inducing brain plasticity in the elderly. *PLOS ONE*, *13*(7), e0196636. https://doi.org/10.1371/journal.pone.0196636

Scarpina, F., & Tagini, S. (2017). The Stroop Color and Word Test. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.00557

Stroop Test. (n.d.). https://teach.genetics.utah.edu/content/memory/Stroop-test.pdf

Teixeira-Machado, L., Arida, R. M., & de Jesus Mari, J. (2019). Dance for neuroplasticity: A descriptive systematic review. *Neuroscience & Biobehavioral Reviews*, *96*, 232-240. https://doi.org/10.1016/j.neubiorev.2018.12.010

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of personality and social psychology, 54(6), 1063.

Wechsler, D. (1987). Manual for the Wechsler memory scale-revised. San Antonio, TX: Psychological Corporation.