Aerobic Exercise and Implicit Learning in Healthy Young Adults

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BACKGROUND

- Aerobic exercise is known to improve and maintain physical health, but it has also been shown to benefit cognitive functioning[1,4]
- Exercise exerts its salutary effects by changing structure and function of specific brain regions:
  - Increases volume of hippocampus[1,4], striatum[1], and regions in the frontal cortex[2]
  - Increases functional connectivity of prefrontal cortex[7]
- Many of the same brain regions known to be influenced by exercise are also known to underlie implicit learning[6]
  - Implicit learning is learning without awareness and is involved in acquiring and understanding languages, social intuition, and developing motor skills[5]
- However, most of the studies on exercise improvements in cognitive functions have focused on executive cognitive functions[1,4] and special populations with known cognitive and brain deficits[1]

AIM

- To investigate whether regular aerobic exercise is associated with implicit learning performance in a healthy young adult sample.

PARTICIPANTS

- Twenty-seven adults ages 18 to 23 ($M \pm SD$ = 20.8±1.92) were recruited from flyers around the campus of Georgetown University

Measure	Mean (SD)
Age	20.8 (1.92)
Education	14.8 (1.35)
EPAQ2	39.8 (46.2)
BDS	7.87 (3.0)
DSST	93.2 (15.2)
NAART	15.7 (3.9)

Note: EPAQ2 = EPIC-Norfolk Physical Activity, Questionnaire 2, BDS = Backwards Digit Span, DSST = Digit Symbol Substitution Test, NAART = North American Adult Reading Test.

METHODS

Tasks:

•**EPAQ2**: EPIC-Norfolk Physical Activity Questionnaire measures *vigorous activity levels*[8]
- Self-report of activity in different domains of life aimed at evaluating total energy expenditure

•**Flanker Task**: measure of *cognitive control*[3]
- Respond to the direction of the center arrow and ignore the surrounding flankers
  - Congruent trial: arrows pointing in the same direction as the center arrow
  - Incongruent trial: arrows pointing in the opposite direction of the center arrow
- Dependent Variable: *Interference score*
  - Mean reaction time (RT) incongruent minus congruent trials
  - Low interference scores signal good cognitive control

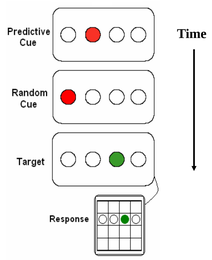
•**Triplet Learning Task (TLT)**: measure of *implicit learning*[5]
- View a horizontal row of four open circles
- Observe first two red cues and respond only to the green target
- Unbeknownst to participants, the first red cue predicts the location of the green target with 80% probability
  - Certain triplets of events (High Probability – HP) occur more often than others (Low Probability – LP)
- Dependent Variable: *Triplet-type effect*
  - Mean RT to LP triplets minus Mean RT to HP triplets
  - Greater triplet-type effect indicates more learning

Analysis:

•Correlated vigorous activity scores with interference score and triplet-type effect

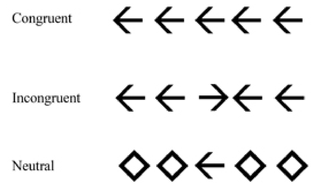
TASKS

Triplets Learning Task (TLT)



- Participants see a horizontal row of four open circles on the screen and are told to observe the first two red cues and to respond (via button press) only to the location of a green "target"
- Unbeknownst to them, the first red cue predicts the location of the green target with 80% probability, resulting in certain triplets of events occurring more often than others

Flanker Task



- Participants see a horizontal row of arrows on the screen and are told to respond to the direction of the center arrow with the corresponding key on the keyboard
- In a congruent trial all of the arrows are pointing in the same direction, in an incongruent trial the center arrow is pointing in the opposite direction of the flanker arrows, and in the neutral trial the center arrow is flanked by boxes

RESULTS

- **TLT Results; Figure 1**: Consistent with predictions
  - Significant positive relation between vigorous activity and triplet type effect (r = 0.486, p = 0.0177)
  - Figure suggests relationship may be driven by an outlier (x = 190, y = 35)
    - Without the outlier, correlation no longer significant (r = 0.313, p = 0.1577), but in same direction

- **Flanker Task Results; Figure 2**: Inconsistent with predictions
  - No significant relationship between vigorous activity and interference scores (r = 0.170, p = 0.4436)
  - Contrary to previous experiments that have found a significant negative relationship between vigorous activity and interference scores

Implicit Learning (Triplet Type Effect)

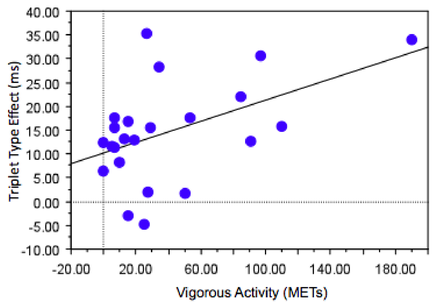


Figure 1. Scatterplot of vigorous activity versus Triplet Type Effect.

• Significant positive relationship (r = 0.486, p = 0.0177)

Lack of Cognitive Control (Interference)

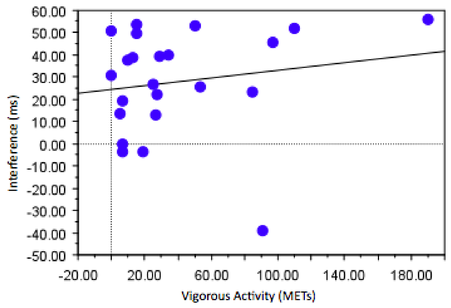


Figure 2. Scatterplot of vigorous activity versus interference scores.

• No significant relationship (r = 0.170, p = 0.4436)

THE EPAQ2

- A self-report questionnaire in which people indicate how often they did activities on average over the last 12 months, and the average length of time spent on each occasion
- A vigorous activity score was calculated for each participant based on answers

Sample:

Please complete EACH line

	Number of times you did the activity in the last 12 months								Average time per episode	
	None	Less than once a month	Once a month	2 to 3 times a month	Once a week	2 to 3 times a week	4 to 5 times a week	6 times a week or more	Hours	Mins
Swimming — competitive										
Swimming — leisurely										
Backpacking or mountain climbing										

SUMMARY & DISCUSSION

- Consistent with our prediction
  - Positive relationship between vigorous activity and the triplet-type effect from the TLT
  - Suggests that regular aerobic exercise benefits implicit learning
- Inconsistent with our prediction
  - No relationship between vigorous activity and interference scores from the Flanker Task
  - Contrary to previous literature, perhaps because of special characteristics of our sample
- These conclusions are also limited by the correlational nature of the study—we cannot infer cause
  - A training study would be optimal to address this question
- Our results highlight the need for future studies to examine the potential benefit of aerobic exercise and other interventions for implicit types of learning and memory

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