



# Cognitive and Physical Activity Attenuate Age and Education Differences in Executive Functioning

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## Abstract

There is robust evidence for aging-related declines in cognitive functioning especially for the domains of working memory, processing speed, and attention switching. Nevertheless, there is wide variability in the patterns and rates of change. We examined whether those who have low education but engage in cognitively stimulating activities would show benefits for their executive functioning. Using the Middle in the United States (MIDUS) survey, we investigated the role of both physical and cognitive activity in relation to performance on an attention switching task, the Stop and Go Switch Task (SGST), and a broad composite measure of cognitive mechanics, the Brief Test of Adult Cognition by Telephone (BTACT). The sample included 2,876 adults (54.5% women) ranging from 32 to 84 with average education of 14.42 years. We assessed cognitively stimulating activity by asking participants how often they read, did word games, played cards or other games, attended lectures, wrote, and used the computer using a 6-point scale ranging from 'Never' to 'Daily'. Physical activity was operationalized as the frequency of vigorous or moderate physical exercise, either on the job, at home, or for leisure in winter and summer months, using a 6-point scale ranging from 'Never' to 'Several times a week.' As predicted, cognitive functioning was negatively related to age and positively related to educational level, and to frequency of engaging in vigorous physical exercise and cognitively stimulating activities. Using multiple regressions, with health and sex as covariates, we entered age, education, physical activity, cognitive activity, and all interactions among the predictors. We found significant interactions showing evidence for moderation of age and education effects. Physical exercise was not related to latencies for attentional switching for young adults, but among middle-aged and older adults those who engaged more frequently in vigorous exercise showed faster reaction times. A three way interaction of physical exercise, cognitive activity, and education showed those with low education levels who also frequently engaged in cognitive activity showed faster switch latencies similar to those with high education. The quickest reaction times were found for those with high education, high cognitive activity, and high physical activity. For the composite measure of cognitive mechanics, the effects of age, education, and activity were significant, but there were no significant interactions. Thus, the benefits of physical exercise and cognitively challenging activities were consistent across all age and education levels. This research has implications for understanding the role of modifiable behavioral factors for enhancing cognitive aging and reducing educational disparities.

## Background

There is wide variability in the age patterns and rates of change for cognition. Moreover, there are differences in cognition tied to educational experiences, but little is known about the mechanisms that account for such variations. Our research goal is to examine behavioral factors that are associated with differences in cognitive performance.

- Although past research has found physical exercise to improve cognitive functioning, the differential effects of exercise have not been considered across the adult lifespan or in relation to educational level.
- There is also controversy about the role of cognitive activities for cognitive functioning. It is unclear to what extent these cognitive activities reduce or delay the effects of cognitive aging, or whether those who are more educated and have better cognitive functioning are more likely to engage in such activities.

## Research Questions & Hypotheses

- We investigated the role of both physical and cognitive activity in relation to performance on:
  - An attention switching task, the Stop and Go Switch Task (SGST)
  - A broad composite measure of cognitive mechanics
- We examined whether those who have less education but engage in cognitive and physical activities would show benefits for their cognitive functioning.

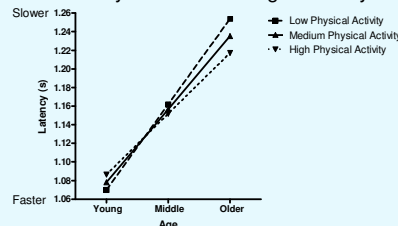
## Method & Participants

- Midlife in the United States (MIDUS) survey
- The sample included 2,876 adults (54.5% women) ranging from 32 to 84 with average education of 14.42 years.
  - **Frequency of cognitive activity:** how often they read, did word games, played cards or other games, attended lectures, wrote, and used the computer
    - 6-point scale ranging from 'Never' to 'Daily.'
    - Summary score was computed by taking the average of the six items
  - **Physical activity:** the frequency of vigorous or moderate physical exercise on the job, at home, or for leisure in winter and summer months
    - 6-point scale ranging from 'Never' to 'Several times a week'
    - Frequencies were averaged across seasons and the maximum frequency of the three domains for either vigorous or moderate activity was computed.
  - **Cognitive measures** were assessed over the telephone using the Brief Test of Adult Cognition by Telephone (BTACT; Lachman & Tun, 2008) and the SGST (Tun & Lachman, 2006; Tun & Lachman, in press)
    - Latencies for Attention Switching (SGST): Latencies were recorded for responses to the word 'red' with 'stop' and 'green' with 'go' in the congruent (normal) condition; the incongruent (reverse) condition reversed the required responses. Participants alternated between the two conditions following 'switch' cues that were given at random intervals of 2 to 6 trials. We assessed response latencies for the trial following a switch to the normal or reverse condition.
    - BTACT Cognitive Composite: Included measures of episodic memory with immediate and delayed recall of word lists, speed of counting backwards, backward digit span, inductive reasoning with letter series, and verbal fluency.

## Analyses & Results

- Significant correlations with Cognitive Composite: Age (-); Ed (+); Physical Exercise (+); Frequency of Cognitive Activity (+)
- Significant correlations with Switch Latency: Age (+); Ed (-); Physical Exercise (-); Frequency of Cognitive Activity (-)
- Using multiple regressions, with health and sex as covariates, we entered age, education, physical activity, cognitive activity, and all interactions involving predictors. Findings are summarized below:

Figure 1: Two-way Interaction of Age and Physical Activity for Switch Latency



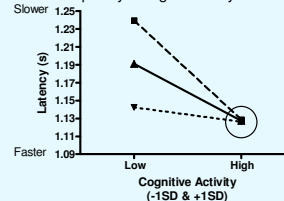
Including age, education, physical activity, with all interactions and covarying sex and health.

- There was a significant age by physical activity interaction for switch latency.
- Physical exercise was not related to latencies for attentional switching for young adults, but older adults those who engaged more frequently in vigorous or moderate exercise showed faster switch reaction times (see Figure 1).

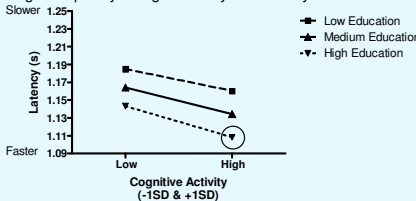
Figure 2: Three-way Interaction of Education, Cognitive Activity, and Physical Activity for Switch Latency

- A three way interaction of physical exercise, cognitive activity, and education showed among those who do not engage in frequent physical activity, high frequency of cognitive activity is associated with faster switch latencies and education effects are reduced (see Figure 2a).
- The quickest reaction times were found for those with high education, high cognitive activity, and high physical activity (see Figure 2b).

2a. Low Frequency of Vigorous Physical Activity

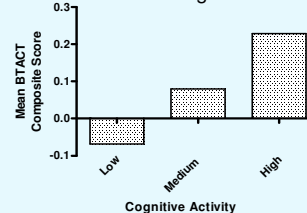


2b. High Frequency of Vigorous Physical Activity



Including age, education, physical activity, with all interactions and covarying sex and health.

Figure 3: Main Effect of Cognitive Activity on BTACT Composite



Including age, education, physical activity, with all interactions and covarying sex and health.

- For the composite measure of cognitive mechanics, the effects of age, education, health and cognitive activity were significant in the expected directions, but there were no significant interactions.
- A greater frequency of cognitive activity was associated with a better cognitive composite score (see Figure 3).

## Conclusions

- For cognitive mechanics, the positive relationship with frequent cognitive activity was uniform across age, sex, and education.
- For switch latency, the effects of frequent cognitive activity were more pronounced for those who do not engage in regular physical activity.
- The combination of high education and frequent cognitive and physical activity was associated with the fastest speed.
- The compensatory effects of physical exercise were seen primarily for older adults' speed of attentional switching.
- This research has implications for understanding the role of modifiable behavioral factors for enhancing cognitive aging and reducing educational disparities.