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Journal of Acupuncture and Meridian Studies

journal homepage: www.jams-kpi.com

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■ RESEARCH ARTICLE ■

The Effect of Acupuncture on Working Memory and Anxiety ☆

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Abstract
Objective: The purpose of this study was to investigate whether acupuncture can improve memory and reduce anxiety.
Design, Setting and Subjects: A two-group, randomized, single-blind study involving 90 undergraduate university students was conducted from January to December of 2011.
Interventions: Subjects completed the State-Trait Anxiety Inventory (STAI) form Y-1 (State Anxiety, SA) and Y-2 (Trait Anxiety, TA). Then, each subject lay on a treatment table for 20 minutes. The acupuncture group had needles inserted into select acupoints; control subjects did not. Subjects then completed the STAI form Y-1 again, after which they completed the Automated Operation Span Task (AOSPAN) - a computerized test of working memory.
Main Outcome Measures: Performance on the AOSPAN and the STAI scores were the main measures of the outcomes.
Results: The acupuncture group scored 9.5% higher than the control group on the AOSPAN Total Correct Score (65.39 vs. 59.9, p=0.0134), and committed 36% fewer math errors (2.68 vs. 4.22, p=0.0153). Acupuncture subjects also reported lower SA after intervention than control subjects (26.14 vs. 29.63, p=0.0146).

1. Introduction

Working memory (WM) was originally described by Baddeley and Hitch [1] to account for deficiencies of a model that conceptualized memory as having only long-term and short-term components. WM is short-term memory plus attentional control. It is understood as consisting of three constituent systems: a central executive which is in charge of allocating mental resources and attention; a phonologic

loop and a visual sketchpad where audio or visual data are kept in short-term memory, respectively [2].

Operation span tasks have been developed to measure WM and have been associated with predicting such diverse capabilities as reading comprehension [3], arithmetic calculation [4], note taking [5], language comprehension [6], learning a computer language [7], learning to spell [8], following directions [9], building vocabulary [10], writing [11], complex learning [12], and reasoning ability [13]. Working memory capacity is correlated with success in many areas.

Anxiety has been shown to impair performance in math [4,14], reading [15], and operation span task measures of working memory [16]. Anxiety impairs test performance. According to the American Test Anxiety Association, "About 16—20% of students have high test anxiety, making this the most prevalent scholastic impairment in our schools today. Another 18% are troubled by moderately-high test anxiety" [17]. This means that up to 38% of students have performance impaired by anxiety. Students with high test anxiety score approximately 12 percentage points lower than their peers on school examinations [18]. Reducing anxiety should help improve test performance.

When performed by a trained practitioner, acupuncture is a safe procedure [19], and has been shown to reduce anxiety. Studies have shown that acupuncture can reduce generalized anxiety, depressive anxiety, and preoperative anxiety. See Pilkington et al [20] for a review of the literature regarding acupuncture and anxiety.

If anxiety impairs memory and acupuncture can reduce anxiety, can acupuncture improve memory? Research has been conducted with cognitively-impaired animals that shows that acupuncture protects and restores cognitive function [21—24]. Some research has also shown that acupuncture can help cognitively-impaired humans [25—27]. To date, however, no study has examined whether acupuncture can improve memory in healthy human individuals. The purpose of this study was to investigate the effect of acupuncture on WM and anxiety in healthy subjects.

2. Material and methods

Full approval for the study was granted by the Institutional Review Board of the National University of Health Sciences. All study protocols adhered to the NIH Guidelines for Protecting Human Research Participants and the Declaration of Helsinki.

2.1. Participants

Ninety students of varied ethnicity were recruited from local universities. Clinical Trial Registry: Clinicaltrial.gov ID = NCT01492738.

Inclusion criteria were that all participants must: be undergraduate university students aged 18—30 years; be willing to receive acupuncture; have not received acupuncture in the three months prior to the testing; be free of any serious medical problems; not be taking any psychoactive medication; not be pregnant; not be breastfeeding; and be fluent in English language. Participants received US$20 financial compensation for their participation at the conclusion of the study.

2.2. Setting

The study was conducted at two private acupuncture clinics: A Center for Oriental Medicine in Wilmette, IL USA, and the Tiffani Kim Institute in Chicago, IL, USA. Consent and demographic questionnaires were filled out in the waiting room. The remaining procedures were performed in a 2.4 m × 3.0 m private room with a treatment table, a desk with a laptop computer, and one chair.

2.3. Instruments and measures

The state-trait anxiety inventory (STAI) is a self-report anxiety instrument comprised of two separate 20-item subscales that measure state (situational, SA) and trait (baseline, TA) anxiety. The STAI has shown test-retest reliability and external validity [28]. It is one of the most widely-used anxiety measurement instruments in the world [29].

The automated operation span task (AOSPAN) by Unsworth et al is a computerized test of WM that has shown good internal reliability and external validity [30]. Participants are presented with a math problem to perform in their head and then are shown a letter to remember after answering the math problem. Afterwards, they are presented with another math problem followed by another letter. After a set of between three and seven of these math-letter pairs, participants are shown a recall screen and are asked to recall all the letters they were shown in the correct order. The math-letter sets and recall screens are presented consecutively with a total number of 75 letters and math problems each. The AOSPAN absolute score and the total correct score both reflect the recall of the letters. The total correct score counts all correct responses. The absolute score only gives credit for letters recalled correctly when the entire set is recalled correctly. For example, if there is a set of seven math problems and letters and a participant correctly recalls six of the letters, the absolute score would be zero and the Total Correct Score would be six. The AOSPAN also tracks performance on the math problems. It provides a score for the total number of math errors; and breaks that number down into accuracy errors and speed errors (failure to answer in the allotted time) [30]. The AOSPAN can be thought of as testing how well participants can keep information in the back of their minds while processing tasks in the front of their minds and *vice versa*.

2.4. Independent variable

The independent variable was whether or not the participant received acupuncture for 20 minutes while they lay on a massage table for 20 minutes.

2.5. Dependent variables

The dependent variables analyzed were: initial SA (SA1), SA after the variable period (SA2), TA, change from SA1 to SA2 (ΔSA), AOSPAN total correct score, AOSPAN absolute score, AOSPAN math total errors, AOSPAN math speed errors, and AOSPAN math accuracy errors.