Available online at www.sciencedirect.com
ScienceDirect
Biological Psychology 73 (2006) 227–234
BIOLOGICAL PSYCHOLOGY
www.elsevier.com/locate/biopsycho

Lower blood pressure correlates with poorer performance on visuospatial attention tasks in younger individuals

Whitney Wharton [a,*], Elliot Hirshman [a], Paul Merritt [b], Bethany Stangl [a], Kathleen Scanlin [a], Lauren Krieger [a]

[a] Department of Psychology, The George Washington University, 2125 G Street, Washington, DC 20005, United States
[b] Department of Psychology, Texas A&M University Corpus Christi, 6300 Ocean Drive, Corpus Christi, TX 78412, United States

Received 19 September 2005; accepted 7 April 2006
Available online 15 May 2006

Abstract

The relationship between low blood pressure and cognitive function among younger individuals is not fully understood. While a number of studies have examined hypertensive and hypotensive individuals, particularly in older populations, little attention has been devoted to healthy, young populations. We tested 105 healthy young individuals whose blood pressure levels naturally fell in the below normal-to-normal range. Our primary finding was a positive relation between blood pressure and cognition, as measured by two visuospatial attention tasks. This relation appears to be specific to visuospatial skills, as no relationship was observed between recognition memory and blood pressure. We discuss possible explanations for this positive relationship, such as structural neural mechanisms, and how they apply to the overall blood pressure–cognition relationship.

Keywords: Blood pressure; Cognition; Hypertension; Hypotension; Visuospatial; Recognition memory

1. Introduction

Numerous studies have demonstrated a negative relationship between blood pressure and cognitive performance (Andre-Petersson et al., 2001; Elias et al., 2003; Waldstein, 2003; Zelinski et al., 1998; cf. Glynn et al., 1999). This relationship has been demonstrated in cross-sectional designs in which participants with hypertension (high blood pressure) perform more poorly than normotensive, control participants (e.g., Andre-Petersson et al., 2001) and in longitudinal/prospective designs in which participants with hypertension demonstrate greater declines in cognitive performance over time (e.g., Cervilla et al., 2000) than normotensive, control participants. Studies have generally been conducted on older adults because of the high incidence of hypertension in this population. The negative relationship between blood pressure and cognition may be explained by examining neural imaging studies.

Brain imaging studies have suggested plausible neural mechanisms for blood pressure's relation to cognition (Raz et al., 2003; Schmidt et al., 1995; Strassburger et al., 1997). Raz et al. (2003) demonstrated that hypertensive patients had a reduced volume of brain tissue in the pre frontal cortex (PFC) and its associated white matter. Strassburger et al. (1997) demonstrated that hypertensive patients had smaller volumes of thalamic nuclei and larger volumes of cerebrospinal fluid in the cerebellum and temporal lobes.

Importantly, there is also isolated evidence that there can be a positive relation between blood pressure and cognition when the performance of hypotensive and normotensive participants is compared (Costa et al., 1998; Morris et al., 2002; Weisz et al., 2002). Weisz et al. (2002) demonstrated that normotensive control participants performed better than hypotensive patients on one subtest of the attentional and cognitive efficiency (ACE) battery. This subtest measured participants' reaction time (RT) when switching from a routine to a controlled response (quantifying attentional flexibility). Weisz et al. (2002) also demonstrated a significant positive correlation between systolic blood pressure and the amplitude component of the contingent negative variation evoked potential (see also Costa et al., 1998). Similarly, Morris et al. (2002) demonstrated that normotensive control participants performed better than hypotensive participants on memory and arithmetic tasks.

* Corresponding author. Tel.: +1 512 585 2327.
E-mail address: whitw@gwu.edu (W. Wharton).

0301-0511/$ – see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.biopsycho.2006.04.002

The current study explores whether there is a positive relation between blood pressure and cognitive performance on two visuospatial attention tasks and an episodic memory task. The visuospatial attention tasks were the spatial orienting task (Posner, 1980) and the visual search task (Tresiman and Gelade, 1980). The episodic memory task was recognition memory (Russeler et al., 2003). Demonstrating a relation between blood pressure and performance on these tasks may help refine our understanding of the overall relation between blood pressure and cognition.

We chose to examine performance in healthy, young participants (in contrast to the older, hypertensive population traditionally studied) to inspect the positive relation between blood pressure and cognition. Specifically, blood pressure is more likely to be in the below normal-to-normal range in this population (Fu and Hao, 2002) and prior empirical work (e.g., Weisz et al., 2002) has demonstrated positive relations between blood pressure and cognitive performance in this range. Moreover, any negative effects associated with chronic levels of higher blood pressure (i.e., stroke, ischemic white-matter lesions, cardio-vascular disorders, and vascular dementia, Skoog, 2003) are likely to be minimized in a healthy, young population.

We used visuospatial attention tasks because prior studies have demonstrated relations between blood pressure and visual search, with hypertensive participants being more likely than normotensive participants to make errors and aging effects being more pronounced for hypertensive participants (Madden and Blumenthal, 1998). Moreover, neuro-imaging studies have shown that variation in blood pressure is associated with changes in the pre-frontal cortex (Raz et al., 2003), an area known to mediate performance in visuospatial attention tasks (de Fockert et al., 2004; Greenlee et al., 2000).

We used the recognition memory task to provide evidence on the generality of any observed relations between blood pressure and performance on the visuospatial attention tasks. Given that distinct processes influence the recognition memory and visuospatial attention tasks (Conroy et al., 2005), comparing the relationship between blood pressure and performance on these tasks may help identify the neural mechanism involved in any observed relationships.

The cognitive tasks were designed to replicate traditional results. In the spatial orienting task, we manipulated cue validity (valid versus control versus invalid) and stimulus onset asynchrony (SOA) between the cue and target (150 ms versus 250 ms versus 500 ms versus 1000 ms). Prior studies have demonstrated faster latencies for valid than invalid cues and that latencies decrease as SOAs increase (Posner et al., 1980). Prior studies have also demonstrated an interaction in which the difference between performance on valid and invalid cues (hereafter, the validity effect) is an inverted function of SOA, increasing up to 500 ms and decreasing thereafter (Filoteo et al., 1997).

In the visual search task, we manipulated type of search (color versus letter versus conjunctive) and target status (target present versus target absent). Prior studies have demonstrated that latencies for correct responses are greater for the conjunctive search condition and that latencies for correct responses are greater in the target absent condition (Tresiman and Gelade, 1980). In the recognition memory task, we manipulated presentation duration during study (800 ms versus 4 s). Prior studies have demonstrated better recognition memory performance with longer presentation durations (Hirshman and Hostetter, 2000).

Last, we also measured participant's body fat and post-exercise heart rate. These variables are correlated with blood pressure (Skinner et al., 2003; Nelson et al., 1999) and are known to be related to cognition (Barnes et al., 2003; Kramer et al., 2000). Regression analyses were used to examine whether observed relations between blood pressure and cognition are independent of the effects of these correlated variables.

2. Methods

2.1. Participants

There were 105 participants (45 males) from the Department of Psychology at The George Washington University who participated for course credit. Potential participants were excluded if they self-reported: (1) use of medications that might influence cognition (e.g., medications for attention deficit disorders, anti-depressant medications); (2) a history of drug or alcohol abuse; (3) diagnosis of a learning disability (e.g., attention-deficit hyperactivity disorder, dyslexia); (4) a serious mental illness (e.g., schizophrenia, depression); (5) being pregnant; (6) any significant physical illness including, but not limited to, personal or familial hypertension or hypotension, anorexia and related eating disorders, cancer, cardio-vascular disease, head trauma or neuro-degenerative disorders (e.g., Parkinson's disease), impaired vision, sleep disorders, stroke, and surgical treatment for weight loss or any other surgical procedure requiring general anesthesia within the prior 2 years. The purpose of these extensive exclusions was to prevent the occurrence of spurious influences on cognitive performance.

Demographic characteristics of the sample indicates that our participants are relatively young ($M = 19.25$ years, S.D. = 1.13) and well-educated ($M = 13.32$ years, S.D. = 1.15). Data from the Beck Depression Inventory-II (BDI-II, Steer et al., 1999) indicated that, per our selection criteria, our participants do not suffer from depression ($M = 7.47$, S.D. = 5.32). BDI-II scores below 10 do not generally motivate further clinical inquiries and mean BDI-II scores in samples of depressed patients are substantially higher (e.g., >40, Beck et al., 1996). Scores on the morningness–eveningness questionnaire (MEQ, Duffy et al., 2001) indicated that our participants are slightly more active in the evening than the morning ($M = 40.93$, S.D. = 8.26), a common finding for this age group (Blagrove and Akehurst, 2000). All participants had given informed consent prior to participating and the experimental protocol was approved by the Human Subjects Research Committee of the George Washington University.

2.2. Cognitive tasks

2.2.1. Apparatus for cognitive tasks

All stimuli were presented using a Dell Optilex GX1p personal computer. Participants were seated approximately 55 cm from the computer monitor. RT data was collected via a PST-Net Serial Response Box. Stimuli were presented and data collected using the E-Prime software following the suggested RT data protocols (Schneider et al., 2002).

2.2.2. Experimental design for cognitive tasks

The visual search task used a 3×2 within participant design, manipulating type of search (color versus letter versus conjunctive) and target status (target present versus target absent). The spatial orienting task used a 3×4 within