European Economic Review 78 (2015) 97–119

Contents lists available at ScienceDirect

European Economic Review

journal homepage: www.elsevier.com/locate/eer

# The effect of cognitive load on economic decision making: A survey and new experiments

Cary Deck[a,b], Salar Jahedi[c,*]

[a] Department of Economics, Sam M. Walton College of Business, Business Building 402, Fayetteville, AR 72701-1201, USA
[b] Chapman University, USA
[c] RAND Corporation, 1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138, USA

ARTICLE INFO

*Article history:*
Received 8 January 2014
Accepted 22 May 2015
Available online 9 June 2015

*JEL classification:*
D03
C91
D81

*Keywords:*
Cognitive load
Risk preferences
Impatience
Anchoring
Unhealthy food choice
Experiments

ABSTRACT

Psychologists and economists have examined the effect of cognitive load in a variety of situations from risk taking to snack choice. We review previous experiments that have directly manipulated cognitive load and summarize their findings. We report the results of two new experiments where participants engage in a digit-memorization task while simultaneously performing a variety of economic tasks including: (1) choices involving risk, (2) choices involving intertemporal substitution, (3) choices with anchoring effects, (4) choices over healthy and unhealthy snacks, and (5) math problems. We find that higher cognitive load reduces numeracy as measured by performance in math problems. Moreover, within-subject analysis indicates that cognitive load leads to more risk-averse behavior, more impatience over money, and (nominally) more likelihood to anchor. We do not find any evidence that cognitive load increases impatience over consumption goods or unhealthy snack choices. Exploiting the panel nature of our data set, we find that those individuals who are most sensitive to cognitive load, as measured by a large drop in their own math performance across 1- and 8-digit memorization treatments, are driving much of the effect.



## 1. Introduction

Identifying how individuals make decisions under uncertainty, how they make intertemporal trade-offs, and the extent to which their judgments are influenced by context are core components of understanding economic decisionmaking. Increasingly it has been demonstrated that individuals deviate systematically from classic assumptions; namely, they exhibit too much risk-aversion, they are overly impatient in the short-run, and they use non-informative cues in making decisions. Such deviations are often modeled by researchers as behavioral preferences (Köszegi and Rabin, 2006; Laibson, 1997; Tversky and Simonson, 1993), with the implicit notion that these preferences are stable within the individual. However, there is a large body of research suggesting that the expression of such preferences depend critically on the cognitive resources available to the decision maker. For example, people of high cognitive ability, as measured by their IQ score, are found to be more risk-tolerant, more patient, and less prone to anchoring effects than those with lower cognitive ability (Frederick, 2005; Burks et al., 2009; Dohmen et al., 2010; Benjamin et al., 2013; Bergman et al., 2010).

* Corresponding author.
*E-mail addresses:* cdeck@walton.uark.edu (C. Deck), sjahedi@rand.org (S. Jahedi).

http://dx.doi.org/10.1016/j.euroecorev.2015.05.004
0014-2921/

Cross-sectional studies typically encounter difficulties in pinning down the causal relationship between cognitive resources and decisions. Experimental research can shed light on this causal link by exogenously impairing cognitive resources in the lab. Researchers have employed several techniques to generate cognitive load; the most common method is to have subjects hold a 6-or-more-digit number in their memory while simultaneously making choices. The survey section of this paper reviews evidence of how performance across a variety of economic tasks is affected in experimental settings that directly manipulate cognitive load. Across studies, it appears that increasing cognitive load leads to poorer reasoning and math performance, more risk-aversion, and more impatient choices, although the evidence is mixed for each of these. Most experimental studies examining cognitive load focus on a single type of task and often have small samples and hypothetical stakes. A notable exception is the paper by Benjamin et al. (2013) which utilizes a series of hand-run experiments to test whether 7-digit number memorization affects performance on risk, patience, selfishness, and analytical tasks using a between-subjects design. While they are unable to definitively show that their number-memorization task was successful at impacting cognitive load (performance in the analytical task did not vary by treatment), their findings do indicate that subjects in the 7-digit treatment are more risk-averse than subjects with no memorization task.

Dual-system theories (Kahneman, 2002, 2011) offer a mechanism by which cognitive load can impact behavior. In this framework, people have an impulsive "intuitive" system and a cool "reasoning" system. When required to make a decision, the intuitive system quickly reaches a decision that the reasoning system can override for a cost. Insofar as risk-averse or impatient behavior is impulsive and undesirable *and* cognitive resources are abundant, the reasoning system can repress those preferences from being exhibited. Placing a person under cognitive load increases the workload of the reasoning system and hinders its ability to regulate choice, leading to less reasoned behavior. A number of models have operationalized these predictions (Fudenberg and Levine, 2006; Mukherjee, 2010).

Our paper reports the results of two experiments in which subjects are placed under cognitive load and asked a series of questions spanning multiple tasks. We improve on Benjamin et al. (2013) by using a larger sample size, exposing subjects to a different memorization problem for each question, and successfully manipulating cognitive ability, as measured by a drop in performance in a math task. The major contribution of our study, however, is that we employ a within-subjects design to test whether cognitive load has a systematic effect on individuals across multiple tasks. That is, we ask whether the same individuals whose arithmetic performance suffers most under cognitive load are the same individuals whose performances suffer in other tasks as well.

Our Experiment 1 reports on a computerized experiment that tests the causal effect that increased cognitive load has on (1) an incentivized arithmetic question, (2) an incentivized binary choice between a safe option and a risky gamble, (3) a *hypothetical* binary choice between two monetary sums paid at different times, and (4) an incentivized counting task with an uninformative anchor. In our first experiment, participants are given either a 1-digit or an 8-digit number to memorize and are incentivized to keep that number in their memory while completing a randomly determined task. The data show that an individual is more likely to make arithmetic mistakes, act risk-averse, and be susceptible to anchoring in the 8-digit treatment as compared to the 1-digit treatment. The results are driven mainly by those individuals who are most sensitive to cognitive load – defined as individuals whose math performance in the 8-digit treatment diminished the greatest when compared to their own math performance in the 1-digit treatment. Our findings for these incentivized tasks generally corroborate the existing literature, but the hypothetical intertemporal decision task does not. There we find that people become *more* patient when memorizing an 8-digit number. Furthermore, the result is mainly driven by those individuals least sensitive to cognitive load.

To explore why we find the puzzling results regarding patience, we conduct Experiment 2 using *real* stakes. Because this study involves intertemporal decisions, the subjects are required to sign up for two sessions exactly one week apart.[1] We used the same general format as Experiment 1, where participants are incentivized to memorize a number, then complete a task, and then recall the number. Four tasks were included in the second experiment: (1) a money impatience task, (2) a consumption impatience task, (3) an immediate snack choice task, and (4) a delayed snack choice task. In both of the impatience tasks, subjects had to make an incentivized binary choice between a small amount of money/snack today vs. a larger amount of money/snack in one week. In both of the snack choice tasks, subjects had to make an incentivized binary choice between a healthy or unhealthy snack that is awarded either immediately or in one week. The latter tasks are an attempt to replicate and extend Shiv and Fedorikhin's (1999) study, which found that cognitive load led to more unhealthy food choice. Selecting the unhealthy snack can be interpreted as being impatient since the subject is trading off immediate gratification against longer term health. Because Shiv and Fedorikhin had suggested physical proximity to the food is important, this study was hand-run. In one treatment subjects were shown the actual food which would be received during the session. In the other, subjects were shown pictures of food which would be received in one week.[2] The results of the second experiment reverse the results from the hypothetical task in Experiment 1: people under higher cognitive load acted more impatiently for real money. However we found no evidence that cognitive load affected choices in any of the food

[1] One downside of using real stakes is that there is uncertainty from receiving future payoffs and this uncertainty can make impatience difficult to differentiate from risk-aversion. Experiment 1 uses hypothetical stakes to equalize uncertainty regarding payments. In Experiment 2 we attempt to minimize the uncertainty of future payoffs by requiring that everybody return in one week to collect the bulk of their show-up fee.

[2] The first experiment consisted of 1-digit and 8-digit treatment groups. The second experiment consisted of three within subject treatments: no memorization, 2-digit memorization and 8-digit memorization. These changes were due to a desire to be compatible with previous studies on food choice and to allow for the possibility that any number memorization constituted some cognitive load.