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Cognitive load and strategic sophistication☆

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ABSTRACT

We study the relationship between the cognitive load manipulation and strategic sophistication. The cognitive load manipulation is designed to reduce the subject's cognitive resources that are available for deliberation on a choice. In our experiment, subjects are placed under a high cognitive load (given a difficult number to remember) or a low cognitive load (given a number that is not difficult to remember). Subsequently, the subjects play a one-shot game then they are asked to recall the number. This procedure is repeated for various games. We find that the relationship between cognitive load and strategic sophistication is not persistent across classes of games. This lack of persistence is consistent with recent findings in the literature. We also find that the relationship between cognitive load and actions is different from the relationship between cognitive load and beliefs. This suggests that actions and beliefs may not be as closely related as standard game theory would predict.

1. Introduction

Models of strategic sophistication have greatly improved our understanding of play in games.[1] These models posit that subjects exhibit heterogenous sophistication in their thinking of the game. An open question relates to the origin of these strategic levels and whether they arise from a specific trait of the subjects. A natural candidate for the source of the strategic levels is the measured cognitive ability of the subject. This has prompted researchers to investigate the relationship between measured cognitive ability and strategic sophistication.[2]

However, one difficulty in employing measures of cognitive ability is that subjects with different cognitive ability are possibly also different in other ways. As such, it might not be possible to distinguish between an alternate hypothesis that

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[1] For instance, Stahl and Wilson (1994, 1995), Nagel (1995), Costa-Gomes et al. (2001), Costa-Gomes and Crawford (2006), and Camerer et al. (2004). See Crawford et al. (2013) for an updated overview of the field.

[2] For instance, see Bayer and Renou (2012), Burnham et al. (2009), Brañas-Garza et al. (2011), Carpenter et al. (2013), Devetag and Warglien (2003), Georganas et al. (2015), and Gill and Prowse (2015).

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an unobserved characteristic is responsible for the level of strategic sophistication, and cognitive ability is merely correlated with this characteristic. Here, rather than measure cognitive ability, we manipulate the cognitive resources available to the subject via cognitive load. Cognitive load experiments often direct subjects to make a decision in one domain while simultaneously manipulating the cognitive resources available to reflect on the decision.

The cognitive load manipulation is designed to occupy a portion of the working memory capacity of the subject. Working memory can be conceptualized as the cognitive resources available to temporarily store information so that it can be used in decision making. Therefore, working memory is instrumental in the execution of deliberative thought.[3] Several studies have found that measures of cognitive ability are positively related to measures of working memory capacity.[4] Further, reducing the available working memory of a subject via cognitive load, reduces the cognitive resources available for deliberation, and can be regarded as similar to the condition of having a diminished cognitive ability. Additionally, given the within-subject design of our experiment, we are able to observe the behavior of each of the subjects in different cognitive load treatments. As a consequence, our results are not possibly driven by unobserved characteristics that are only related to cognitive ability.[5]

We tested whether the cognitive load manipulation would produce uniformly less strategically sophisticated behavior. However, we find that the relationship between cognitive load and strategic sophistication is not persistent across classes of games. In our experiment, we directed subjects to play various one-shot games while under a cognitive load. In particular, they played ten 3 × 3 games, a variation of the 11–20 game (Arad and Rubinstein, 2012), and a variation of the beauty contest game (Nagel, 1995). We note that our version of the 11–20 game is relatively simple, the beauty contest is relatively complicated, and the 3 × 3 games have various levels of complexity.

The subjects played these games under either a low or a high cognitive load. Subjects in the low load were directed to commit a three digit binary number to memory and subjects under a high load were directed to commit a nine digit binary number to memory. Subsequently, the subjects were asked to recall the number. Further, in some treatments subjects were also informed about the load of their opponent.

The cognitive load manipulation is consistent with two effects. First, subjects under a high cognitive load can have difficulty making the computations associated with optimal play. Second, subjects under a high load are aware of the first effect and can decide to devote additional cognitive effort in order to mitigate this disadvantage. We find that the net result of these two opposing effects depends on the strategic setting and is not persistent across different classes of games.

The first effect dominates the second effect when, in the relatively complicated beauty contest game, the subjects under a high load selected less strategic actions. We also find that in relatively simple 3 × 3 games, subjects under a high load were less likely to play their Nash equilibrium action than were subjects under a low load. These results identify settings in which subjects under a high load were less strategically sophisticated than subjects under a low load.

On the other hand, the second effect dominates the first effect, where subjects under a high load selected a more strategic response in the relatively uncomplicated 11–20 game. Additionally, in the beauty contest game, when subjects under a high load were reminded of the distribution of the cognitive load of their opponents they were more sophisticated than subjects under a high load who were not reminded. However, subjects under a low load were not affected by the reminder. These results identify settings in which subjects under a high load were more strategically sophisticated than subjects under a low load.

Overall, we find a relationship between available cognitive resources and strategic sophistication that is not persistent across different classes of games. In order to better understand this lack of persistence, we also analyze beliefs in the 3 × 3 games. We find that the relationship between cognitive load and strategic actions is different from the relationship between cognitive load and strategic beliefs. This suggests that actions and beliefs are less closely related than predicted by standard game theory.

This lack of the persistence is also consistent with the recent findings of Georganas et al. (2015). These authors find evidence that strategic sophistication can be largely persistent within a class of games but is not persistent across classes of games. Our findings compliment this result in that we observe that the implications of available cognitive resources on strategic behavior are not persistent across classes of games.

1.1. Related literature

The economics literature increasingly regards the brain as an object worthy of study in that, subject to its limitations and heterogeneity across subjects, it is the source of economic behavior. This line of inquiry has investigated topics ranging from the effects of sleep on strategic behavior (Dickinson and McElroy, 2010, 2012), to optimal search patterns (Sanjurjo, 2014, 2015), to neurological studies of the brain during choice (Coricelli and Nagel, 2009, 2012), to novel elicitation methods designed to measure the reasoning of subjects (Agranov et al., 2015; Burchardi and Penczynski, 2014; Chen et al., 2013b;

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[3] See Alloway and Alloway (2013).

[4] For instance, see Conway et al. (2003), Kane et al. (2005), Oberauer et al. (2005), and Süßet al. (2002). See Burgess et al. (2011) and Cole et al. (2012) for recent advances in understanding the neurological basis of this relationship.

[5] We note that research finds that the cognitive load manipulation is more effective on subjects with a higher measure of cognitive ability (Carpenter et al., 2013). However we do not find evidence of this in our setting. In every regression involving our measure of cognitive ability (self-reported grade point average) we also run unreported specifications where we also include the interaction with the grade point average and the cognitive load. In only a single specification do we find a significant interaction.