The effect of financial stress on inhibitory control and economic decisions

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A R T I C L E   I N F O

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A B S T R A C T

Financial scarcity, both real and imagined, is associated with impaired executive functions and present-focused economic decisions. What is the mechanism that connects the lack of financial resources to these cognitive and behavioral effects? The present work will test the hypothesis that the experience of financial stress contributes to these deficits by reducing executive functions related to self-control and causing present-focused, real-world economic decisions. In a preliminary experiment (N = 215), we found support for the hypothesis that financial stress (as compared to social stress) causes a reduction in inhibitory control performance. In the registered study, we recruited participants (N = 1014) from diverse socioeconomic backgrounds and assessed inhibitory control before and after a financial stress manipulation, and economic preferences. The results did not support the hypothesis that monetary financial stress reduces inhibitory control or alters time preference. However, chronic financial stress was associated with reduced inhibitory control and VWM, and real-world economic decisions. Several interactions between SES and the effect of conditions highlight the relevance of a person’s SES in the association between affective experiences and cognitive and behavioral responses. We discuss the implications of this work for future study of the association between SES, executive function, and economic decisions.

Poverty is a pernicious, all-encompassing environment for those at the bottom of the socioeconomic hierarchy. Defined by not having sufficient financial resources to meet basic needs, poverty is associated with atypical development (Aber, Bennett, Conley, & Li, 1997; Evans & English, 2002; Luby et al., 2013), negative health outcomes (Adler et al., 1994; Lago et al., 2018), and lower levels of well-being (Tan, Kraus, Carpenter, & Adler, 2020). In addition to these deleterious effects on important life outcomes, poverty is associated with impairments to executive functioning (Mani, Mullainathan, Shafir, & Zhao, 2013; Spears, 2011), a diminished capacity to exercise self-control (Bernheim, Ray, & Yeltekin, 2015), and present-focused economic decisions (Carvalho, Meier, & Wang, 2016; Haushofer & Fehr, 2014; Lawrance, 1991; Pepper & Nettle, 2017). These economic behaviors can be adaptive in a low resource environment (Reynolds & McCrea, 2019) but can also contribute to the perpetuation of poverty by creating additional barriers to accumulating financial resources (Bernheim et al., 2015; Farah & Hook, 2017).

Identifying the mechanism(s) by which poverty becomes self-perpetuating is an important step in developing interventions that help people move out of poverty. Haushofer and Fehr (2014) proposed that the subjective experience of poverty, specifically financial stress and negative affect, can explain the effects of poverty on economic behavior and self-control. However, previous work investigating the cognitive and behavioral effects of poverty has focused largely on financial scarcity, one objective attribute of poverty. There is less empirical work that considers how the subjective experience of poverty, in particular financial stress, might impact cognitive functioning and financial decisions. In the present work, we directly test the effect of chronic and acute financial stress on both inhibitory control (an executive function associated with self-control) and real-world economic behavior.

1. Poverty and cognitive function

One way poverty may self-perpetuate is by reducing an individual’s ability to exercise self-control through disruptions to associated cognitive functions, specifically executive functioning. Indeed, previous work has shown that both experimental manipulations, intended to elicit

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thoughts about personal finances, and naturally occurring times of financial scarcity impair executive function (Farbmacher, Kögel, & Spindler, 2019; Mani et al., 2013; Spears, 2011). For example, Mani et al. (2013) had participants recruited in a New Jersey Mall think about unexpected expenses, which caused impairments on tasks operationalizing fluid intelligence (Raven’s Progressive Matrices) and cognitive control (spatial incompatibility task), but only for the relatively low-income shoppers considering a large, unexpected expense. In a separate field study, the authors found similar reductions in fluid intelligence and cognitive control (via a numeric Stroop task) during preharvest times of scarcity, compared to post-harvest, for rural farmers in India (Mani et al., 2013). Spears (2011) found similar effects on both behavioral control (handgrip task) and cognitive control (numeric Stroop task) for poorer participants after they made an economic decision. Carvalho et al. (2016) reported being unable to replicate this effect on four measures of executive function (Flanker task, numerical Stroop, working memory, cognitive reflection task) in a sample of Americans before and after payday. However, a reanalysis of this data using a different analytic method showed an effect, but only for young or old individuals with very low income (Farbmacher et al., 2019). Across these studies, both real and imagined times of economic scarcity had deleterious effects on various measures of executive functioning but only for those with more limited financial resources.

Poverty can also self-perpetuate at the individual level when those with limited financial resources make present-focused (as opposed to future-focused) economic decisions, such as choosing to spend instead of saving or investing. Empirical work shows that poverty is associated with higher delay discounting rates, i.e., a greater preference for smaller rewards sooner over larger rewards later (Jachimowicz, Chakfi, Munrat, Prabhu, & Weber, 2017; Lawrance, 1991; Yusuf & Bluffstone, 2008). For example, Yusuf and Bluffstone (2008) showed that overall poor rural Ethiopian farmers had high discounting rates but that these rates reduced as a function of wealth, such that farmers who owned more land and oxen had lower discounting rates. Similar to the effects of financial scarcity on cognition, these findings showed a more pronounced effect on those with fewer financial resources, suggesting an individual’s subjective experience of the situation exacerbates these effects.

Efforts to understand the mechanism by which poverty impacts both executive functioning and delay discounting rates has focused primarily on attention (Shah, Mullainathan, & Shafir, 2012, 2019). Assuming the effects of financial scarcity are similar to the effects of other forms of scarcity, Shah et al. (2012, 2019) had participants play computerized children’s games and experimentally induced scarcity in the number of opportunities they received during the game or the amount of time they had to play. The results showed that non-financial scarcity causes individuals to focus more attention on the present task, ignoring the longer-term goals of the game. A self-replication study confirmed the effects on attention, but revealed that non-financial scarcity was not associated with a decrease in cognitive performance as measured by a Dots-Mixed task (Shah et al., 2019). Individuals experiencing scarcity in the context of games focused more on the present task (Shah et al., 2012) and ignored environmental contextual factors (Shah, Shafir, & Mullainathan, 2015) without exhibiting the cognitive impairment effect reported in the aforementioned studies on financial scarcity. Unlike financial scarcity, scarcity in other resources did not reduce executive functioning associated with self-control.

In addition, the proposition that scarcity-linked shifts in attention are the underlying cause of the cognitive impediments and present-focused economic behaviors thought to perpetuate poverty overlooks the primary psychological effect of poverty on subjective experience—financial stress (Baum, Garofalo, & Yali, 1999; Brunner, 1997; Haushofer & Fehr, 2014; Kristensen, Eriksen, Sluiter, Starke, & Ursin, 2004). In the real world, financial scarcity does not manifest as the number of turns afforded to players in a game or in the amount of time a person has to answer trivia questions or solve puzzles. Instead, scarcity of financial resources often means deciding between necessities, such as food and shelter. We propose that the impaired cognitive function, present-focused economic decisions, and financially sub-optimal behavior previously attributed to the financial scarcity attribute of poverty are caused at least in part by the subjective experience of financial stress. Though financial scarcity may be the root phenomenon, it is manifested psychologically as the immediate subjective experience of chronic and acute financial stress, caused by difficult everyday financial decisions and unexpected expenses, respectively. Importantly, if this is true, we should be able to observe the aforementioned cognitive impairments in individuals who are not objectively experiencing financial scarcity, but who perceive themselves to be.

2. Financial scarcity, financial stress, and inhibitory control

Many definitions of stress center on the subjective appraisal that demands exceed perceived resources (Lazarus & Folkman, 1984). Applying this definition to a financial context, financial stress results from the belief that financial demands exceeds one’s financial resources (Davis & Mantler, 2004). Characterized by fear, anxiety (Davis & Mantler, 2004), and both physical and mental strain (Garman et al., 2004), financial stress can be chronic for people living in poverty, whose day to day lives are filled with reminders that they lack adequate resources to meet their basic needs. Experiencing prolonged financial scarcity makes such mundane financial decisions as choosing what items to buy at the grocery store more stressful because they threaten to tip the balance of resources-to-demands toward the demand side. These everyday experiences therefore become more consequential and require more deliberate consideration (Shafir, 2017; Shah, Zhao, Mullainathan, & Shafir, 2018).

Financial scarcity is inexorably connected to financial stress — not having enough financial resources to meet needs causes individuals to experience financial stress. Indeed, the relationship between financial scarcity and stress has been shown across different contexts. Indicators of psychological stress are positively associated with both increases and decreases in financial scarcity (Chemin, de Laat, & Haushofer, 2013; Haushofer & Shapiro, 2014; Ong, Theseira, & Ng, 2019). For example, when financial scarcity increased for rural Kenyan farmers due to drought, they experienced increased psychological stress, as indexed by levels of the hormone cortisol, but non-farmers from the same area did not (Chemin et al., 2013). Other work has shown this effect in the opposite direction. Reductions in financial scarcity due to unconditional cash transfers decreased self-reported psychological stress and increased well-being (Haushofer & Shapiro, 2014).

Recent work suggests that financial stress may also be distinguishable from financial scarcity. Ong et al. (2019) tested the effect of different debt relief approaches on cognitive functioning and temporal preferences in a sample of chronically indebted people living in Singapore. The participants all received debt relief and showed improvements in cognitive functioning, reported reduced anxiety, and their decision making was less risk averse and present biased. Importantly, these effects were associated with the number of debts eliminated but not the total amount of debt paid off. The authors explained these results with the idea of “bandwidth taxes,” that more debts require additional cognitive resources. The effects of this debt relief were not directly attributed to scarcity per se, but instead are thought to be associated with the psychological experience of the debts.

These studies underscore the idea that, though financial scarcity and financial stress are correlated, the subjective psychological experience of financial stress might be uniquely related to cognitive and behavioral outcomes. Financial scarcity is also not the only route to experiencing financial stress. The subjective nature of the perception that demands exceed financial resources means that individuals can experience financial stress regardless of their income or any other objective indicator of their available resources. For instance, a number of recent popular press articles describe challenges living on a $100,000 a year salary (e.g., Bowman, 2017; Fay, 2022; McMunn, 2022). These stories...
3. The present research

The experience of subjective financial stress provides a parsimonious psychological explanation for the effects of poverty on cognition that have been previously attributed to the environmental description of scarcity (Shah et al., 2012; Shah et al., 2015), and a proximal explanation for the association between poverty and near-sighted financial behavior. It also provides a unifying framework from which to understand both the similarities and discrepancies in previous work. It can explain why, in the absence of financial scarcity, middle class shoppers in a New Jersey mall perform worse on measures of executive function than upper class ones (Mani et al., 2013); why lab manipulations of scarcity in non-financial contexts do not have cognitive effects (Shah et al., 2012; Shah et al., 2019); and why there are only cognitive impacts of paydays for individuals with the lowest income (Carvalho et al., 2016; Farbmacher et al., 2019). In addition, stress has been shown to impact executive function in circumstances when perceptions of need outweigh perceptions of resources (e.g., financial scarcity, overspending, stock market fluctuations, debt, large negative income shocks).

Finally, both chronic and acute stress outside of financial contexts have been shown to impact executive functioning (Mueller et al., 2010; Roos et al., 2017; Shields, Sazma, & Yonelinas, 2016). Using an eye-movement task, Mueller et al. (2010) showed that adolescents who experienced early-life stress, compared to those who had not, had deficits in inhibitory control, suggesting that chronic stress has long-term impacts on inhibitory control. Acute stress also reduces individual’s capacity to exercise self-control (Roos et al., 2017). Roos et al. (2017) asked participants to complete a measure of inhibitory control, the Stop Signal Task (SST; Verbruggen & Logan, 2008), before and after they completed either a Trier social stress task (Kirschbaum, Pirke, & Hellhammer, 1993) or a control task (reading a magazine for 15 min). After the social stress task, participants performed worse on the SST, indicating lower inhibitory control. These findings suggest that acute financial stressors, such as not having enough money to pay rent or buy food, will cause similar reductions in inhibitory control.

4. Preregistered preliminary study

The primary aims of the Preliminary Study were to demonstrate the feasibility of collecting the measure of inhibitory control, the Stop Signal Task (SST; Verbruggen & Logan, 2008) online and test the effectiveness of the stress manipulations. We also used the data from this sample to conduct a preliminary test of the following preregistered hypotheses: H1, a) financial stress will reduce inhibitory control to a greater degree than social stress, and b) this will be moderated by an individual’s SES, such that financial stress will cause a greater decrease in inhibitory control for lower SES individuals than for higher SES individuals; H2, chronic financial stress, as indicated by an individual’s SES, will be associated with lower baseline inhibitory control; and H3, the effects of financial stress on inhibitory control is dissociable from its effects on other executive functions.

4.1. Method

Both the preliminary study reported below and the registered report were approved by the University of Oregon’s Institutional Review Board (Protocol Number: 10192018.026). Measures of cognitive function and survey items were administered via the PsyToolkit platform (Stoet, 2010, 2017). Participants completed the tasks and survey in the same order in both conditions; the only difference between conditions was which stress manipulation was administered. The preregistration (https://osf.io/bufav/), data, and analysis code (https://osf.io/d24qa/) for the Preliminary Study are available on the Open Science Framework (OSF). We report all measures, manipulations, and exclusions in this study.

4.2. Procedure

After providing informed consent, participants completed a baseline stop-signal task (SST) followed by a baseline Corsi block task and then responded to items about their demographics and personality. Next, depending on condition, participants spent a minute recalling a time they experienced severe stress (financial or social). In the financial condition, participants were instructed to:

“Take the next minute to think back to a recent time in your life when you experienced severe financial stress. For example, this could be a time when you could not afford basic needs like food and shelter, you felt overwhelmed by credit card debt, you could not make your car payment or pay rent, or any other major financial event or circumstance that caused stress or anxiety. If you cannot think of a major financial stressor, you may also consider a specific time that you could not afford to go out with friends or buy a gift for someone important. Close your eyes and take a few moments to remember this time in detail: What was the specific event? Where were you? Who were you with? How did it make you feel?”

In the social condition, participants received the following instructions:

“Take a few minutes to think back to a recent time in your life when you experienced severe social stress. For example, this may be a time when you were embarrassed in front of family or friends, you felt socially excluded, had to speak in public, or any other major social stressor. Close your eyes and take a few moments to think about this time in detail: What was the specific event? Where were you? Who were you with? How did it make you feel? “

In both conditions, participants were then instructed to spend two minutes to write about the experience they recalled.

“Now, please use the next couple minutes to write down the details of this event and your feelings about it. Your response will be kept confidential, so please share as much detail as you can.”

Immediately after the two-minute writing period, participants completed a second SST and Corsi block task, and then indicated the amount of stress they experienced during the recall task.
4.3. Participants

A total of 316 participants were recruited and randomly assigned to either the financial stress (N = 158) or social stress condition (N = 158). Fifty-five participants were excluded for failing to complete either the pre or post SST and 35 additional participants were excluded based on a predefined outlier criteria for SST performance (see Congdon et al., 2012). In addition to the preregistered exclusions, we excluded 3 participants for indicating an age outside the expected range for undergraduates (<85) and 7 participants for an average score lower than a 3 on the Corsi block task, indicating inattentive responding. After exclusions, the data used for analysis included 215 participants (156 female; 151 white; age: 18–40 years, M = 20, SD = 2); 110 in the financial condition and 105 in the social condition.

No formal power analysis was conducted prior to data collection. Based on resource availability and the aim of collecting enough data to demonstrate feasibility of the procedure, we determined a minimum sample size of 250 participants would be adequate prior to data collection. After achieving this goal, we continued to collect data for the remainder of the academic term but no interim analyses were conducted on this data.

4.4. Measures

4.4.1. Cognitive measures

Stop-signal Task. The stop-signal task is a measure of inhibitory control that assesses a participant’s ability to inhibit a prepotent response (Verbruggen & Logan, 2008). The SST was programmed in and delivered via the PsyToolkit platform (Stoet, 2010, 2017). Participants completed one practice block, with 32 trials, followed by three experimental blocks, each with 64 trials. Seventy-five percent of the trials in each block were Go trials, in which participants were asked to press a key corresponding to the direction of a green arrow displayed on the screen, “Z” for left and “M” for right. The other 25% of trials were Stop trials, in which participants were shown a green arrow like in the Go trials, but after a variable delay (stop-signal delay; SSD) a red circle appeared around the arrow, which indicated they were not to push the button. We used a variable SSD so that for the initial Stop trial the SSD was 250 ms and increased 50 ms if the previous stop trial response was correct and decreased 50 ms for an incorrect response.

The dependent measure we used from the SST was the stop-signal response time (SSRT). We calculated the SSRT using the integration method (with replacement of go omissions; Verbruggen et al., 2019) with all available data from the experimental blocks. In this method, finishing time of the stop process corresponds to the nth reaction time (RT) for Go trials. To calculate the SSRT, errors in Go responses were replaced with maximum RT and then RTs were sorted in ascending order. The probability of a response given a stop-signal was then calculated by dividing the number of responses on No-Go trials by the number of No-Go trials. This probability was multiplied by the number of Go trials to determine the nth RT. The SSRT was then calculated by subtracting the mean SSD from the nth RT. The SSRT is expressed in milliseconds (ms) and reflects an estimate of the speed of the stopping process under a competitive stop-vs-go horserace model (Verbruggen 2017). In each trial, participants were shown a display of 9 randomly placed blocks (cubes) on the screen, which changed color when selected, and presented a series of block selections. The task was to replicate the pattern from memory using a computer mouse to select the blocks in the same order. In the initial trial, a pattern of two blocks was displayed and after each successful trial another block was added to the sequence. The task ended when the participant failed to correctly identify the blocks in the correct sequence in two consecutive trials. The Corsi-block score is the number of blocks correctly identified in the last trial. Participants completed three Corsi-block tasks and we averaged the three scores as our index of visual working memory.

4.4.2. Individual differences

Objective Socioeconomic Status (SES). Participants indicated parental levels of income and education. For income, participants were asked to indicate the household income of their immediate family using 16 bins, anchored at 1, “$9,999 or less”, with the next 14 bins increasing in $10,000 increments (e.g., “$10,000 to $19,999”, “$20,000 to $29,999”), and ending at 16, “$150,000 or more”.

For educational attainment, participants indicated the education of each of their parents using the following 6 choices: (1) No high school diploma or equivalent, (2) High school graduate, diploma or the equivalent (for example: GED), (3) Some college, (4) Associate’s degree (2 year degree), (5) Bachelor’s degree (4 year degree), (6) Master’s, Professional, or Doctorate degree.

Subjective SES. Participants responded to the one-item MacArthur Scale of Subjective Socioeconomic Status (Adler, Epel, Castellazzo, & Ickovics, 2000), providing an estimate of where they stand in the socioeconomic hierarchy of society on a 9-point scale. Subjective SES. Participants responded to the one-item MacArthur Scale of Subjective Socioeconomic Status (Adler et al., 2000), providing an estimate of where they stand in the socioeconomic hierarchy of society on a 9-point Likert scale. Participants also indicated their perceived childhood (α = .79) and current (α = .75) resource availability by responding to 6-items, 3 for each dimension, using a 7-point Likert scale anchored at 1, strongly disagree, and 7, strongly agree (Griskevicius, Delton, Robertson, & Tybur, 2011).

Planfulness (Ludwig, Srivastava, & Berkman, 2018). This 30-item scale measures individual differences in the tendency to employ effective cognitive strategies to attain goals. Respondents indicated agreement to the items using a 7-point scale anchored at 1—strongly disagree and 7—strongly agree. Scale scores were calculated by reverse scoring appropriate items and then averaging all of the items (α = .90).

BFI-2-XS, (Soto & John, 2017). The BFI-2-XS is a brief personality measure designed to capture an individual’s cross situation behavioral tendencies in the Big Five domains. Respondents indicated agreement to 3-items for each domain using a 5-point scale anchored at 1—strongly disagree and 5—strongly agree. Scale scores were calculated by reverse scoring appropriate items and then averaging all of the items (extra-version, α = .59; agreeableness, α = .66; conscientiousness, α = .61; neuroticism, α = .71; openness, α = .51).

Short-form Spielberger State-Trait Anxiety Inventory (Marteau & Bekker, 1992). This 6-item measure is designed to assess an individual’s current level of anxiety. Respondents indicated agreement to the items using a 4-point scale anchored at 1—not at all and 4—very much. The average of the items indicates the respondent’s current anxiety (α = .86).

Brief Self-Control Scale (BSCS; Tangney, Baumeister, & Boone, 2004). A 13-item measure of self-control. Respondents indicated agreement to items using a 5-point scale anchored at 1—not at all and 5—very much. Items were reverse scored as necessary and then averaged to indicate the respondent’s self-control (α = .89).

Stress during recall. A one-item measure of stress experienced during the recall task. Participants self-reported their level of experienced stress by responding to the question, “How much stress did recalling the financial (social) experience cause you?” using a 5-point scale anchored at 1—one great deal at 5—a great deal.

4.5. Results

All analyses were conducted in the R programming language (R Core Team, 2020). Descriptive statistics for SES indicators and cognitive task measures are reported in Table 1.
**H1: a)** To test the effect of acute financial stress on inhibitory control, we estimated a linear regression model regressing post-manipulation inhibitory control on condition and pre-manipulation inhibitory control. A sensitivity analysis conducted in G*Power (Faul et al., 2009) indicated this analysis (N = 215) had 80% power to detect an effect size of $\beta = .15$. The results supported H1a, showing that financial stress reduced inhibitory control more than social stress, $b = 16.30$, 95% CI [2.12, 30.47], $\beta = .15$, $p = .024$ (see Fig. 1). An exploratory follow-up analysis revealed that the difference in inhibitory control between conditions was driven by a reduction in inhibitory control in the financial stress condition, as indicated by an increase in stop signal reaction time (SSRT), from baseline ($SSRT_M = 218.21$, $SD = 61.74$) to post-manipulation ($SSRT_M = 243.63$, $SD = 52.86$), $b = 25.42$, 95% CI [10.15, 40.70], $\beta = .22$, $p = .001$. There was no change from baseline ($SSRT_M = 229.51$, $SD = 65.16$) to post-manipulation ($SSRT_M = 230.33$, $SD = 57.16$) in the social stress condition, $b = 0.82$, 95% CI [−15.86, 17.50], $\beta = .01$, $p = .923$.

**H1: b)** To test if the effect of financial stress on inhibitory control was stronger for those with lower SES, we estimated a set of 4 linear regression models. Each model added two predictors to the regression model in H1, an SES indicator and the interaction between the SES indicator and condition. A sensitivity analysis conducted in G*Power (Faul et al., 2009) indicated this analysis (N = 215) had 80% power to detect an effect size of $R^2 = .04$. The addition of the interaction term did not result in a significant change in the $R^2$ in any of the models: MacArthur ladder, $\Delta R^2 = .101$, F(2,210) = 1.17, $p = .312$; childhood perceived SES, $\Delta R^2 = .004$, F(2, 210) = 0.44, $p = .648$; current perceived SES, $\Delta R^2 = .002$, F(2, 210) = 0.239, $p = .788$; household income $\Delta R^2 = .003$, F(2,210) = 0.30, $p = .739$; father educational attainment, $\Delta R^2 = .002$, F(2, 208) = 0.26, $p = .774$; or, mother educational attainment, $\Delta R^2 = .009$, F(2,210) = 1.02, $p = .362$. This suggests that the effect of financial stress on inhibitory control is not moderated by SES, among college students.

**H2:** To test the association between chronic financial stress and baseline inhibitory control, we estimated 4 linear regression models each regressing baseline inhibitory control on one indicator of SES while controlling for state anxiety. A sensitivity analysis conducted in G*Power (Faul et al., 2009) indicated this analysis (N = 215) had 80% power to detect an effect size of $\beta = .04$. The results showed that college students do not differ in baseline inhibitory control as a function of SES.

<table>
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<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
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<th>4</th>
<th>5</th>
<th>6</th>
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<td>.29**</td>
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<td>4. Edu Father</td>
<td>4.17</td>
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<td>.43**</td>
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<td>6. Post-SSRT</td>
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<td>.01</td>
<td>.29**</td>
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<td>7. Pre-Corsi</td>
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<td>.02</td>
<td>.10</td>
<td>.17**</td>
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Note. M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. * indicates $p < .05$. ** indicates $p < .01$.

**Fig. 1.** Inhibitory Control (SSRT) and Visual Working Memory Scores (Corsi-block Task) by Time and Condition. Panel A depicts SSRT scores and shows a slowing in post-SSRT scores in the financial condition, indicating a decrease in inhibitory control. Panel B depicts Corsi-block scores and shows no differences between pre- and post-test scores in either condition. Error bars represent standard error.
as measured by the MacArthur ladder, $b = -0.44, 95\% \text{ CI} [-5.54, 4.66]$, $\beta = -0.1$, $p = .865$; childhood perceived SES, $b = 0.99, 95\% \text{ CI} [-4.91, 6.90]$, $\beta = 0.02$, $p = .740$; current perceived SES, $b = -0.02, 95\% \text{ CI} [-5.86, 5.82]$, $\beta = -0.00$, $p = .994$; household income, $b = 0.16, 95\% \text{ CI} [-1.59, 1.90]$, $\beta = 0.01$, $p = .858$; father educational attainment, $b = 1.83, 95\% \text{ CI} [-3.49, 7.15]$, $\beta = .05$, $p = .166$; or, mother educational attainment, $b = -2.35, 95\% \text{ CI} [-7.86, 3.17]$, $\beta = -.06$, $p = .209$. The Bonferroni corrected $p$-values for these analyses all equaled 1. Thus, chronic financial stress, as indicated by SES, does not impact inhibitory control among college students.

H3: To test if the effects of financial stress on inhibitory control are dissociable from its effects on other executive functions, we conducted a parallel set of analyses replacing inhibitory control scores with visual working memory (VWM) scores. A sensitivity analysis conducted in G*Power (Paul et al., 2009) indicated this analysis ($N = 215$) had 80% power to detect an effect size of $\beta = .15$. The results did not show an effect of financial stress on VWM, $b = -0.03, 95\% \text{ CI} [-0.26, 0.20]$, $\beta = -.02$, $p = .786$ (see Fig. 1), supporting the hypothesis that the effect of financial stress on inhibitory control is dissociable from its effects on other executive functions.

4.6. Exploratory analyses

Exploratory analyses that added demographic (age, gender, ethnicity) and individual differences (planfulness, conscientiousness, self-control) as covariates to the preregistered regression models did not moderate the effect of financial stress on inhibitory control (H1), or reveal significant or consistent associations with baseline inhibitory control or visual working memory (H2, H3). Full parameter estimates from these models are reported in the supplement (Tables S1-S6).

4.7. Discussion

The preliminary study accomplished its two primary aims. It demonstrated the SST can be administered online effectively and with adequate precision and also showed the effectiveness of the stress recall manipulation. The results also provide initial evidence supporting the primary hypothesis that the subjective experience of financial stress reduces an individual’s inhibitory control. Social stress did not impact inhibitory control and neither form of stress affected visual working memory. Together, this supports the claims that (a) financial stress reduces performance on measures of executive function related to self-control and (b) a manipulation involving the recall of financial stress has similar impact on measures of executive function to a Trier task.

The results did not support either hypothesis about individual differences in SES. Chronic stress, as indicated by SES, was not associated with inhibitory control. This measure was a sub-optimal indicator of chronic stress because it is a measure of objective scarcity rather than subjective stress per se. We resolve this conceptual limitation in the Registered Report by using a direct measure of chronic financial stress. Nonetheless, the question of the relation of SES to inhibitory control remains open. The undergraduate participants in this sample come from a restricted range of SES and the students have not yet established their own SES apart from their family. Both inaccurate reports of parental SES and the constrained SES of the sample could have attenuated an effect of SES or chronic stress on inhibitory control. It is also possible that for college undergraduates SES is not a reliable indicator of chronic financial stress. Living in a campus setting may reduce the impacts of SES by providing the majority of students stable living conditions, adequate food, and community support, which has been shown to reduce some impacts of SES (Jachimowicz et al., 2017).

Previous work has consistently shown that an individual’s position in the socioeconomic hierarchy moderates the impact of scarcity manipulations on both cognition (Mani et al., 2013; Spears, 2011) and time-preference (Yusuf & Bluffstone, 2008), such that the effects of scarcity are exacerbated or only found for those with relatively lower SES. The lack of support for this moderation effect in the present work could be attributed to the constrained SES of the sample but may also be due to the financial stress manipulation we administered. Past studies have used times of drought (Mani et al., 2013); economic decisions (Spears, 2011), and consideration of unexpected expenses (Mani et al., 2013) to elicit cognitive effects, at least for those with relatively lower SES. In each of these studies participants all received the same treatment. For example, both low and high SES shoppers were asked to consider the same unexpected expense. Because the scarcity manipulations were not calibrated to individual participants the effects of scarcity and financial stress are perfectly confounded; considering how to pay for an unexpected $1500 car repair causes more stress for someone with lower SES. Therefore, previous results showing that the same level of scarcity impacts the executive function of those with lower SES more severely are in line with the hypothesis that it is not scarcity per se that impacts cognition but the subjective experience of financial stress. Due to the restricted range of SES in the Preliminary Study sample we were not able to differentiate between these possibilities. A similar finding in a socioeconomically diverse sample would support a constant effect of financial stress on inhibitory control.

5. Registered report

The Preliminary Study provided initial support for the hypothesis that financial stress impedes inhibitory control. However, the restricted range of SES in the sample may have attenuated effects and limited the generalizability of the results. In this registered report we address these limitations by testing the same hypotheses in a socioeconomically diverse population. In addition, in order to connect these findings to previous work and test the effect of financial stress on time-preference and real-world economic behavior we include a Convex Time Budget Task (CTB; Andreoni et al., 2015) and will offer participants the opportunity to wait a week for payment to receive a 50% bonus in a one-shot delay discounting task.

This registered report will test the following hypotheses: H1, a) financial stress will reduce inhibitory control to a greater degree than a control condition or negative affect and b) this will be moderated by an individual’s SES, such that financial stress will cause a greater decrease in inhibitory control for lower SES individuals than for higher SES individuals; H2, a) financial stress will be associated with present-focused economic decisions to take less now versus more later and b) this will be moderated by an individual’s SES; H3, chronic stress will be positively associated with baseline inhibitory control; H4, the effects of financial stress on inhibitory control will be dissociable from its effects on other executive functions.

5.1. Method

This study was approved by the University of Oregon’s Institutional Review Board (Protocol Number: 10192018.026). Measures of cognitive function and survey items were administered via the Pavlovia platform. Participants completed the tasks and survey in the same order in all three conditions; the only difference between conditions was which stress manipulation was administered. The data, and analysis code for this study are available on OSF (https://osf.io/d24qa/?view_only=9322b28a2f034303940b36a3abc11145). We report all measures, manipulations, and exclusions in this study.

5.2. Procedure

The Registered Report followed the same basic procedure as the Preliminary Study with three notable differences: participants were assigned to one of three experimental conditions (financial stress, control, negative affect); we measured objective SES with an indicator more indicative of resource availability in the general population; and, to connect the effects of financial stress to real-world financial behavior we
administered a Convex Time Budget Task (CTB; Andreoni, Kuhn, & Sprenger, 2015) and a one-shot delay discounting task.

Participants were recruited from the Prolific online recruitment service. After agreeing to participate, they followed a link to the survey where they were randomly assigned to one of three experimental conditions (financial stress, negative affect, or control). Participants in all conditions first completed a baseline stop-signal task (SST) followed by a Corsi block task, then responded to items about their demographics and personality. Next, depending on condition, participants were instructed to spend one-minute recalling a time they experienced either financial stress, negative affect, or recall what they did yesterday afternoon (control). In the financial stress condition participants received the exact same prompt used in the Preliminary Study. In the control condition, participants were instructed to:

“Take the next minute to think back to what you were doing yesterday afternoon. Close your eyes and take a few moments to think about this time in detail: What were you doing? Where were you? Who were you with?”

In the negative affect condition, participants were instructed to:

“Take the next minute to think back to a recent time in your life when you felt disgusted. For example, this may be a time when you encountered something smelly and rotten in the garbage or observed someone else doing something you found disgusting, such as eating food you find revolting. Close your eyes and take a few moments to think about this time in detail: What was the specific event? Where were you? Who were you with? How did it make you feel?”

In all three conditions, after the one-minute recall period, participants received the same writing prompt as the Preliminary Study and spent two-minutes writing a description of the experience they just recalled.

Immediately following the recall task, participants completed a second SST, the CTB task, and a second Corsi block task. Finally, after reporting the amount of stress they experienced during the recall task participants were offered the opportunity to wait a week for an additional 50% compensation for their participation.

5.3. Measures

5.3.1. Cognitive measures

All cognitive measures were programmed in PsychoPy and delivered with Pavlovia. We used the same specifications for each task described in the Preliminary Study methods.

Stop-signal Task (Verbruggen & Logan, 2008).
Corsi Block-Tapping Task (Corsi, 1972; Kessels et al., 2000).

5.3.2. Behavioral measures

Convex Time Budget Task (CTB). This financial decision making task is designed to measure an individual’s temporal discounting rate, a preference for receiving smaller rewards now over larger ones in the future. Participants were asked to consider six economic reward options that vary the amount of reward across two time frames (one sooner and one later) and select one. They chose reward options for four different time frames. The time frames include both typical delay discounting tasks that ask if participants prefer smaller rewards now (e.g., today) versus larger rewards later (e.g., in 5 weeks), and ones that ask participants to decide between a reward that is delivered sooner (e.g., in 5 weeks) versus later (e.g., in 10 weeks). This benefit of using this task to measure temporal discounting is that the effect of delay is separated from the effect of immediacy.

One-shot Delay Discounting Task. Participants were given the choice to receive $10 upon completion of the study or to wait a week and receive $15. Previous work shows that a hypothetical one-shot delay discounting task correlates with lab-based procedures for estimating discount rates (Reimers, Maylor, Stewart, & Chater, 2009), supporting this as a valid approach to test time preference.

5.3.3. Individual differences

Socioeconomic Status (SES). We measured SES with the Income-to-Needs Ratio (INR). The INR uses household income and number of residents in the household to estimate access to resources, adjusted for household size and composition. Participants indicated household income of their immediate family using 16 bins, anchored at 1, "$9,999 or less" and 16, "$150,000 or more" with the intermediate bins increasing in $10,000 increments (e.g., "$10,000 to $19,999", "$20,000 to $29,999"). Number of people in the household was reported using a numerical scale from 1 to 20. To calculate an individual’s INR, we first adjusted household income to the center values of the bracket and then divided by the 2019 United States Census Bureau’s poverty threshold for a household of that size, for a person of that age.

Chronic Financial Stress. We used the 8-item InCharge Financial Distress/Financial Well-Being Scale (Prawitz et al., 2006) to measure chronic financial stress. The scale includes items that assess financial stress directly (e.g., “What do you feel is the level of your financial stress today?”) and ones that assess situations that may cause financial stress, such as the ability to pay bills (e.g., How often do you worry about being able to meet normal monthly living expenses?) or being able to afford small leisure’s (e.g., How often does this happen to you? You want to go out to eat, go to a movie or do something else and don’t go because you can’t afford to?). Participants responded to each item using a 10-point scale and the mean of the 8-items is their chronic financial stress score ($\alpha = .50$).

We used the same measures of subjective SES (Adler et al., 2000), Short-form Spielberger State-Trait Anxiety Inventory (Marteau & Bekker, 1992: $\alpha = .91$), and Stress during recall as in the Preliminary Study.

In addition, we had participants complete the same personality and demographic items as the Preliminary Study in between the pre- and post- cognitive tasks: Planfulness (Ludwig et al., 2018: $\alpha = .93$), BFI-2-XS (Soto & John, 2017; extraversion, $\alpha = .63$; agreeableness, $\alpha = .62$; conscientiousness, $\alpha = .72$; neuroticism, $\alpha = .84$; openness, $\alpha = .66$). Brief Self-Control Scale (Tangney et al., 2004; $\alpha = .89$). The primary purpose of collecting these measures was to provide temporal separation between the cognitive tasks. Based on the preliminary data, we had no confirmatory hypotheses for these measures but conducted planned exploratory analyses to test if individual differences moderated the effects of financial stress on cognitive control in a socioeconomically diverse population.

5.4. Sampling plan

We conducted a series of simulations using the paramtest package (Hughes, 2017) in the R programming language (R Core Team, 2020) to determine the sample size necessary to achieve 90% power or greater for each planned analysis. We used conservative estimates for both the main effects of interest and the interaction terms ($\beta = .125$) and simulated 5000 regression models, using data drawn form a normal distribution, for 6 sample size: 500 to 1000 by 100’s. The results indicated that 700 participants provide >90% power to detect both main effects of condition and the interaction effects between condition and SES. Based on this power analysis, we aimed to recruit a community sample of 750 adults (250 per experimental condition) from the Prolific online recruitment platform, stratified so that half had low SES (at or below the federal poverty line) and the other half had medium to high SES (>250% of the poverty line). Participants were compensated $10 or $15 dollars for participating, depending on their decision in the delay discounting task.

5.5. Exclusion criteria

Participants who failed to complete either the pre- or post-test SST were excluded from analyses with SSRT as the DV, and participants who
failed to complete either the pre- or post-test Corsi Block task were excluded from analyses with Corsi score as the DV. We excluded participants from all analyses if they provided the same answer to all items for two or more measures. For the SST, participants were also excluded based on the lenient outlier criteria (Congdon et al., 2012): a) percent inhibition on stop trials <25% or >75%; b) percent Go-Response <60%; c) percent Go-Errors >10%; d) SSRT estimate that is negative or <50 ms. Participants who scored <3 on the Corsi Block task were excluded from all preregistered analyses for inattentive responding.

5.6. Analysis plan

Inference Criteria. For all statistical tests we used an alpha level of .05.

H1a: Financial stress will reduce inhibitory control to a greater degree than negative affect, or the control condition, and b) this will be moderated by an individual’s SES, such that financial stress will cause a greater decrease in inhibitory control for lower SES individuals than for higher SES individuals. We tested H1a by regressing post-SSRT, on a dummy coded condition variable and pre-SSRT. We examined two contrasts for this hypothesis, comparing the effect of financial stress, to each of the other conditions (negative affect or control). The critical test of this hypothesis was the p-value associated with the regression parameter for the condition variable in each contrast. To test H1b, we estimated two additional linear regression models, each adding one SES indicator (INR, subjective SES) and the interaction between condition and the SES indicator to the linear regression model from H1a. The critical test of the hypothesis was the p-value associated with the parameter estimate for the interaction term.

H2: a) Financial stress will cause individuals to choose less money now, and b) this effect will be moderated by an individual’s SES. We tested H2a using both the CTB and one-shot delay discounting decision. To test if financial stress is associated with temporal discounting, in separate models we regressed each of the CTB parameters (beta, i.e., present bias; delta, i.e., patience) on a dummy coded condition variable and tested two contrasts, one comparing the effect of financial stress to the negative affect condition and one to the control condition. Similarly, to test the effect of financial stress on the decision made in the one-shot delay discounting task, we regressed the binary outcome on a dummy coded condition variable and test the same two contrasts. Following recent recommendations (Gemina, 2021), we used a general linear regression model for this analysis. To test if the effect of financial stress on financial decision making was moderated by the current experience of scarcity, we estimated two additional regression models for each model described above. In each, we added one indicator of SES (INR, subjective SES) and the interaction between that SES indicator and condition to the linear regression model from H2a. The critical test of hypothesis H2b was the p-value associated with the parameter estimate for the interaction term in each of the six regression models.

H3: Chronic financial stress is positively associated with baseline inhibitory control. We tested this hypothesis with a linear regression model, regressing baseline SSRT on chronic financial stress. We included state anxiety as a covariate in these analyses to control for any stress or anxiety that the participants experienced as a result of events that occurred prior to the study or as a result of their participation in the study. The critical test of this hypothesis was the p-value associated with the estimated regression parameter of the SES predictor.

H4: The effect of financial stress on inhibitory control is dissociable from effects on other executive functions. To differentiate these effects, we conducted the same analyses as in H1, H2, and H3, substituting Corsi-block scores (VWM) for inhibitory control. These analyses determined whether any observed effect of financial stress is specific to inhibitory control, as theory would predict, or if it generalizes to VWM.

In addition to the hypotheses outlined above, we tested for differences in the stress experienced during the recall task by regressing stress experienced during the task on condition and examined contrasts between the financial stress condition and each of the other two conditions. An effect of financial stress on inhibitory control and no difference in magnitude of stress experienced during the recall task, will indicate the effects are due to the type rather than the magnitude of stress. We explored significant differences in the amount of stress experienced by condition, with a linear regression model regressing post-SSRT, on condition, pre-SSRT, and the stress during recall score to determine if the magnitude of stress experienced during the task accounted for any observed differences in inhibitory control.

5.7. Results

5.7.1. Participants

We recruited 1135 participants on the Prolific online participant recruitment platform. We excluded 48 participants for not completing the study, and 46 responses submitted by participants who had already completed the study. Seventy-three participants who scored lower than three on the Corsi Block task were excluded for inattention. The remaining 1014 participants were randomly assigned to one of three conditions: financial stress (N = 325), negative affect (N = 336), and control (N = 343). Participants reported the following demographics: age in years: M = 39, SD = 13; gender: 518 women, 448 men, 38 people indicated another gender, and 10 did not respond; race/ethnicity: Black = 146, Asian = 51, Latino/Latina = 69, Native American = 6, White = 646, other, or multiple categories = 87, and 9 people did not respond. Descriptive statistics for SES indicators and the VWM measure are reported in Table 2.

For analyses with the SSRT, we excluded and additional 350 participants for failing to meet the lenient SST exclusion criteria (Congdon et al., 2012). After SST exclusions, the remaining 664 participants were assigned to the following conditions: financial stress (N = 212), negative affect (N = 233), and control (N = 219). Participants reported the following demographics: age in years, M = 37, SD = 12; gender: 333 women, 295 men, 33 non-binary, and 3 people did not respond; race/ethnicity: Black = 83, Asian = 36, Latino/Latina = 51, Native American = 2, White = 425, other, or multiple categories = 64, and 3 people did not respond.

Table 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Income-to-Needs Ratio</td>
<td>3.46</td>
<td>2.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Subjective SES</td>
<td>4.51</td>
<td>1.89</td>
<td>.59**</td>
<td>[0.55, 0.63]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Chronic Financial Stress</td>
<td>5.70</td>
<td>1.46</td>
<td>-.42**</td>
<td>[-.47, -.37]</td>
<td>-.52**</td>
<td>[-.57, -.48]</td>
</tr>
<tr>
<td>4. Pre VWM</td>
<td>5.96</td>
<td>0.97</td>
<td>-.01</td>
<td>-.01</td>
<td>-.06</td>
<td></td>
</tr>
<tr>
<td>5. Post VWM</td>
<td>6.02</td>
<td>1.03</td>
<td>-.03</td>
<td>-.02</td>
<td>-.07*</td>
<td>.62**</td>
</tr>
</tbody>
</table>

Note. 95% confidence intervals are reported below the correlation coefficients.

* p < .05, ** p < .01.
not respond. The samples sizes for the analyses with the SSRT did not meet the goal for each group \((N = 250)\). Descriptive statistics for SES indicators and inhibitory control measure are reported in Table 3.

To test our hypothesis for inhibitory control with higher statistical power, we also conducted the registered analyses in larger samples by using different exclusion criteria. One data set included participants who met the SSRT criteria but failed to achieve a 3 in the Corsi Block task. Several participants reported experiencing technical difficulties with the Corsi Block task but were excluded for inattention based on the registered exclusion rule. Including these participants resulted in a sample of \(705\) participants, with \(>90\%\) power to detect the effect of condition. The two other data sets were one with alternative, more lenient SST exclusion criteria \((<20\%\) go-errors instead of \(10\%\)), and one that excluded participants based on extreme SSRT scores \((< 100 \text{ or } > 600)\). These analyses are reported in the supplemental material.

All analyses were conducted in the R programming language (R Core Team, 2023). Some participants did not respond to all of the measures, so the sample sizes for each analysis may differ slightly.

**H1a:** We did not detect a main effect of condition on inhibitory control in either of the planned contrasts: financial stress and the control condition, \(b = 3.46, 95\% \text{ CI } [-4.52, 11.44], \beta = .03, t(660) = 0.85, p = .395; \) or financial stress and negative affect, \(b = 4.31, 95\% \text{ CI } [-3.57, 12.20], \beta = .03, t(660) = 1.07, p = .283\) (Fig. 2). Analysis with data that included participants excluded for poor Corsi Block performance showed similar results: financial stress and the control condition, \(b = 2.80, 95\% \text{ CI } [-5.02, 10.62], \beta = .02, t(701) = 0.70, p = .482; \) financial stress and negative affect, \(b = 3.99, 95\% \text{ CI } [-3.75, 11.72], \beta = .03, t(701) = 1.01, p = .312. \) The hypothesis that financial stress would reduce inhibitory control more than negative affect or the control condition was not supported. Results from exploratory analyses with the alternative exclusion criteria (described above) were in line with those from the registered analysis (see Table S10). A sensitivity power analysis conducted in G*Power (Faul et al., 2009) indicated this analysis \((N = 664)\) had \(80\%\) power to detect an effect size of \(f = .11\), a small effect, between conditions, with a correlation between the pre and post-test scores of \(r = .71\).

**H1b:** To test if SES moderated the effect of condition on inhibitory control we added one SES indicator (INR or subjective SES) and its interaction with condition to the linear regression model from H1. The registered analyses did not reveal significant interactions between participants’ SES and the effect of financial stress compared to negative affect (Table S11). These effects suggest that experiencing financial stress decreased inhibitory control more for people with higher SES compared to people with lower SES, which is in the opposite effect hypothesized for H1b. The experience of disgust had the opposite effect; it decreased inhibitory control more for people with lower SES compared to people with higher SES. Fig. 3, generated with the
Fig. 3. The effect of condition on inhibitory control by SES.

Fig. 4. The effect of condition on payment decisions by SES.

Note. The pay later variable on the y-axis is a binary outcome. Participants either chose to get paid now (0) or to be paid later (1).
registered exclusions does not show significant interactions, but does show a similar interaction pattern.

**H2a.** We tested if financial stress was associated with present-focused economic decisions using two delay discounting measures. First we examined whether financial stress influenced the components of the CTB (present bias, patience). We estimated the present bias and patience components for each participant with mixed-effects models (see Ludwig, Flournoy, & Berkman, 2019). A sizable number of participants \((N = 167)\) had no variance in their responses; they either chose to receive more money later or less money now in every trial. The mixed-effects models for these participants did not converge so we excluded them from analyses with the CTB components as outcomes.

The results showed no effect of condition on present bias or patience in either contrast: financial stress and control, present bias, \(b = 0.01, 95\% CI [-0.01, 0.03], \beta = 0.03, t(844) = 0.77, p = .443\), or patience, \(b = 0.00, 95\% CI [-0.00, 0.00], \beta = 0.02, t(844) = 0.49, p = .627\); financial stress and negative affect, present bias, \(b = 0.01, 95\% CI [-0.01, 0.03], \beta = 0.03, t(844) = 0.71, p = .481\), or patience, \(b = 0.00, 95\% CI [-0.00, 0.00], \beta = 0.04, t(844) = 1.05, p = .292\).

There was also no effect of financial stress on the real-world economic decision participants made to either get paid $10 now or $15 in a week, when compared to the control condition, \(b = 0.06, 95\% CI [-0.00, 0.12], \beta = 0.07, t(1011) = 1.85, p = .064\); or negative affect, \(b = 0.03, 95\% CI [-0.03, 0.09], \beta = 0.03, t(1011) = 0.94, p = .350\).

**H2b.** We examined if the effects of financial stress on time-preference was moderated by SES by adding one SES indicator and its interaction with condition as predictors to the regression models from H2a. The analyses with the present bias and patience components of the CTB as outcomes did not have any significant effects.

However, adding the SES predictors to the real-world decision models revealed both a main effect of SES: INR, \(b = 0.03, 95\% CI [0.01, 0.04], \beta = .19, t(1000) = 3.63, p < .001\), and subjective SES, \(b = 0.03, 95\% CI [0.01, 0.06], \beta = .15, t(1008) = 2.65, p = .008\), on payment choice. People with lower SES, compared to those with higher SES, were more likely to choose to be paid less now over being paid more later across conditions. The model with INR, but not subjective SES, showed an interaction between SES and the effect of condition, financial stress compared to negative affect, \(b = -0.03, 95\% CI [-0.05, -0.00], \beta = -.10, t(1000) = -2.39, p = .017\). Experiencing financial stress causes people with higher SES to choose more money later and those with lower SES to choose more money now, whereas experiencing disgust has a more consistent effect across SES (Fig. 4). The interactions in the model with subjective SES were not significant but show a similar pattern.

**H3.** We tested the association between chronic financial stress and baseline inhibitory control with a linear regression model. People who reported experiencing greater chronic financial stress had lower baseline inhibitory control (i.e., a higher SSRT score), controlling for state anxiety, \(b = 4.63, 95\% CI [0.78, 8.48], \beta = .010, t(661) = 2.36, p = .019\). Exploratory analyses with the different SST exclusion criteria samples showed the same effect (see Table S12).

There was no association between baseline inhibitory control and chronic financial stress and either indicator of SES: INR, \(b = 0.35, 95\% CI [-2.23, 2.92], \beta = .01, t(993) = 0.27, p = .790\); subjective SES, \(b = 2.29, 95\% CI [-1.78, 6.36], \beta = .04, t(1001) = 1.10, p = .270\), replicating the preliminary study. There was also no association in the exploratory analyses conducted with the alternative exclusion criteria data sets. The experience of chronic financial stress was associated with reduced inhibitory control but an individual’s SES was not. We conducted exploratory analysis to examine interactions between SES and chronic financial stress on inhibitory control, but found no statistically significant results – chronic financial stress was associated with reduced inhibitory control for all people across SES.

**H4.** To investigate if the effects of financial stress on inhibitory control were dissociable from its effects on other executive functions we conducted all of the same analyses above substituting visual working memory (VWM) for inhibitory control. Similar to inhibitory control, there was no main effect of financial stress on VWM compared to control, \(b = -0.42, 95\% CI [-0.16, 0.08], \beta = -.02, t(1010) = -.67, p = .503\); or negative affect, \(b = 0.03, 95\% CI [-0.09, 0.16], \beta = .02, t(1010) = 0.55, p = .585\) (Fig. 2).

![Fig. 5. The effect of condition on visual working memory by SES.](image-url)
However, there was an interaction between INR and the effect of financial stress compared to negative affect on VWM, $b = 0.21$, 95% CI [0.03, 0.39], $\beta = .10$, $p = .024$. Financial stress was associated with reduced VWM for people with lower INR, and increased VVM for those with higher INR. Results did not reveal a statistically significant interaction with subjective SES but show a similar pattern between the effect of condition and SES (see Fig. 5).

There was also a main effect of chronic financial stress on VWM, $b = -0.05$, 95% CI $[-0.09, -0.00]$, $\beta = -.07$, $p = .040$. People who experience greater chronic financial stress have lower VWM. Like inhibitory control, neither SES indicator was associated with baseline VWM.

5.8. The experience of stress by condition

Participants reported experiencing more stress from the financial stress manipulation than they did in either the control condition, $b = -0.97$, 95% CI $[-1.14, -0.81]$, $\beta = -.39$, $t(1011) = -11.39, p < .001$, or the negative affect condition, $b = -0.50$, 95% CI $[-0.67, -0.33]$, $\beta = -.20$, $t(1011) = -5.83, p < .001$. Adding SES to the models showed a main effects for both INR, $b = -0.07$, 95% CI $[-0.11, -0.03]$, $\beta = -.18$, $t(1000), p < .001$, and subjective SES, $b = -0.17$, 95% CI $[-0.23, -0.11]$, $\beta = -.27$, $t(1008) = -5.28, p < .001$. People overall experienced greater stress in the financial stress condition, while people with lower SES experienced more stress in all three conditions as compared with those of higher SES. In addition, for subjective SES there was an interaction between conditions, such that people with lower subjective SES experienced a greater amount of stress in the financial stress condition but people with higher SES experienced about the same amount of stress in the three conditions (Fig. 6). The amount of stress did not explain variability in inhibitory control or VWM across conditions.

5.9. Exploratory analyses

Exploratory analyses conducted with the alternative exclusion criteria data was consistent in the models testing H1 (Table S10). However, analyses with these alternative data sets revealed a significant interaction between SES and the effect of financial stress compared to negative affect in five out of six models (Table S11). These interactions suggest that momentary financial stress increases inhibitory control for people with lower SES and decreases it for people with higher SES; whereas disgust has the opposite effect, decreasing inhibitory control for people with lower SES and increasing for those with higher SES (Fig. S1). The results for financial stress are in the opposite direction than predicted by previous work. More research is needed to disentangle the differential effects of financial stress and disgust and determine how SES moderates these effects.

The association between chronic financial stress and baseline inhibitory control was consistent across the different exclusion criteria (Table S12), and there were no main effects or interactions with the demographic (age, gender, ethnicity) or individual difference (planfulness, conscientiousness, self-control) variables (H1a: Table S13; Table S14). The same was true for H2a (Table S15; Table S16). For the H3 exploratory analysis, there was a significant interaction between age and chronic financial stress on baseline inhibitory control (Table S17), suggesting that for older people the experience of chronic financial stress is associated with increased inhibitory control (lower SSRT), whereas for younger people the experience of chronic financial stress is associated with decreased inhibitory control (higher SSRT). There were no interactions between the individual difference variables and the effect of chronic financial stress on baseline inhibitory control.

5.10. Discussion

The main finding from the preliminary study was not replicated in the registered report. In a larger and more socioeconomically diverse sample, financial stress did not reduce inhibitory control more than negative affect or a control condition. In addition, the results did not support the hypothesis that the effect of financial stress on inhibitory control was dependent on SES. However, exploratory analyses with alternative exclusion criteria that included more participants revealed a
consistent statistically significant interaction between SES and the effect of financial stress on inhibitory control as compared to the negative affect condition. Interestingly, these interactions showed an opposite effect from what has been reported in previous work. Financial stress reduced inhibitory control more for people with higher SES than those with lower SES, compared to the effects of disgust.

The results did not support the hypothesis that the experience of financial stress affects time preference. The experience of financial stress was not associated with either component of the CTB (present bias, patience), nor did it affect economic decisions about payment. However, there was an association between SES and real-world economic decisions such that people with lower SES were more likely to choose to be paid $10 now and people with higher SES were more likely to choose to be paid $15 in a week. This finding supports a general association between SES and time-preference (Ishii, Eisen, & Hitokoto, 2017; Ludwig et al., 2019; Peretti-Watel, L’haridon, & Seror, 2013), but did not replicate the association between SES and the CTB component of present bias found in previous work (Ludwig et al., 2019).

In addition to the main effect of SES on payment decisions, there was an interaction between an individual’s SES and the effect of financial stress, compared to negative affect, on economic decisions. The interaction showed that financial stress exacerbated the association between SES and payment decision; people with higher SES were more likely to choose to get paid more later and people with lower SES to choose to get paid less today. The experience of financial stress had a different effect on the economic decisions of people with high and low SES.

An important aim of this registered report was testing the association between chronic financial stress and both inhibitory control and VWM with a better, more direct indicator of chronic financial stress. However, there was an association between SES and real-world economic decisions such that people with lower SES were more likely to choose to be paid $10 now and people with higher SES were more likely to choose to be paid $15 in a week. This finding supports a general association between SES and time-preference (Ishii, Eisen, & Hitokoto, 2017; Ludwig et al., 2019; Peretti-Watel, L’haridon, & Seror, 2013), but did not replicate the association between SES and the CTB component of present bias found in previous work (Ludwig et al., 2019).

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6. General discussion

Previous work on scarcity conclude that poverty is self-perpetuating because it impedes cognition and causes counter-productive economic decision making (Mani et al., 2013; Spears, 2011). In other words, being poor has cognitive and behavioral effects which cause people in poverty to make economic decisions, such as taking out payday loans, that keep them poor (Mani et al., 2013; Shah et al., 2012). It is a compelling theory because it provides a cognitive mechanism for seemingly irrational economic behavior that is understandable if not strictly rational: during times of scarcity, executive function associated with self-control decreases, which suggests that some of the challenges people with low SES face with spending and saving can be attributed to the cognitive effects of having lower SES (Shah et al., 2012). There has been some difficulty replicating these effects (O’Donnell et al., 2021), which we proposed could be caused by focusing on scarcity rather than the psychological effects of scarcity, financial stress.

We conducted two studies to examine if the experience of financial stress could explain the effect of scarcity on cognition. The preliminary study supported the hypothesis that financial stress reduces inhibitory control but the registered report, with a larger, more socioeconomically diverse sample, did not. The findings do not provide clear support for or against the hypothesis that momentary financial stress is the mechanism through which financial scarcity influences or impedes cognition. One potential explanation for the discrepancy between the results is the restricted range of SES among participants in the preliminary study, who were undergraduates. A sample drawn from the higher end of SES is equivalent to zooming in on the right side of Figs. 4 or 5, which would lead to different results and conclusions.

We also found that the experience of momentary financial stress did not influence time-preference or economic decisions. However, chronic financial stress was associated with lower inhibitory control, VWM, and present-focused economic decisions, supporting the proposed link between financial stress, cognitive function, and economic decisions, but on a longer time-frame than hypothesized in the present work.

6.1. Different effects for different SES

The results did not replicate findings that stress (Roos et al., 2017) or disgust (Xu et al., 2015) reduce inhibitory control or influenced economic decisions. However, SES moderated the effects of each on inhibitory control, VWM, and economic decisions in a relatively consistent pattern, highlighting the relevance of a person’s SES level in the relation between affective experiences and cognitive and behavioral responses. Financial stress reduced inhibitory control more for people with higher SES than people with lower SES, contradicting previous work, whereas disgust increased inhibitory control more for people with higher SES than people with lower SES. The interactions were driven by small effects in the opposite direction than what was expected, so we interpret them with caution.

Considering the different needs of people with higher and lower SES, the interactions generally support the inference that people from both ends of the SES respond adaptively to the environment and their situation. It is sensible that a person lacking adequate resources would respond to financial stress by exerting additional control, whereas a person with ample resources would respond to the same stress by reducing control of spending or other activities that could regulate the affective experience of financial stress. The opposite effect of disgust on inhibitory control also appears adaptive. For someone with lower SES, a reduction in inhibitory control as response to disgust could help overcome a natural disgust reaction to available food. The opposite effect among people with higher SES could also be construed as adaptive: in a resource rich environment, increased control when experiencing disgust could promote survival by avoiding toxic food.

We observed a larger interaction effect between financial stress and SES on real-world economic decisions. Financial stress caused people with lower SES to choose to be paid less now but it caused people with higher SES to choose to be paid more later. Financial stress makes economic scarcity more salient among individuals with low SES individuals, but by choosing (less) money now they can potentially relieve some current financial stress. In contrast, financial stress might invoke thoughts about lack of savings for the future among high SES individuals, who can reduce concerns about their financial future by waiting for more money later.

6.2. Momentary versus chronic financial stress

We examined the effects of both momentary (e.g., considering how to pay for an unexpected expense) and chronic financial stress (e.g., not enough income to cover monthly expenses). We anticipated that both would be associated with more present-focused economic decisions and decreases in inhibitory control but not in VWM. Instead, we found that the experience of momentary financial stress, induced by recalling a recent episode of financial stress, was not associated with changes in either inhibitory control or VWM. However, the experience of chronic financial stress was associated with both lower inhibitory control and VWM. The specificity of the effects to chronic as opposed to momentary stress provides a potential explanation for the association between scarcity and cognitive control: people in poverty typically experience chronic financial stress, which lowers cognitive control.

A person’s SES was not associated with differences in inhibitory control or time-preference, but was specifically associated with
economic decisions. This pattern of findings provides an important insight with respect to previous findings of an association between scarcity and executive functions. The lack of a correlation between SES and cognition shows that individual differences in inhibitory control (and other forms of executive function) are not the cause of poverty—people are not poor because they have less self-control than others. Instead, the experience of poverty, and more specifically the experience of chronic financial stress, appears to erode executive function. This aligns with work published during data collection that shows financial stress mediates the association between scarcity and self-reported executive function measures (O’Neill, Cameron, Leone, & Orom, 2021).

The present results combined with recent empirical work and replication efforts (O’Donnell et al., 2021; Shah et al., 2019) lead to two important conclusions. First, the effects of financial scarcity on executive function and time-preference can at least partially be attributed to the experience of chronic financial stress. It remains a possibility that severe financial stress may reduce cognitive control in a similar manner to acute social stress (Ross et al., 2017). Second, in-line with the findings from the empirical audit, the effects of financial stress are more prominent in economic decisions than they are in measures of executive function (O’Donnell et al., 2021), leading us to the same conclusion: future work in this area should focus on economic behavior rather than executive function.

6.3. Limitations and future directions

A central conclusion from this work was that it is challenging to accurately measure executive function online or time-preference with the CTR. Despite efforts to assess the feasibility of collecting executive function measures online in the preliminary study, doing so in a socio-economically diverse community sample proved more challenging. A larger proportion of the community participants (31%), compared to the undergraduates (11%), were unable to complete the SST within the constraints of the lenient exclusion criteria. The cause of this discrepancy is unknown but there are a couple of potential explanations. First, undergraduates might have been better at following instructions to complete the survey in a quiet environment free from outside distractions. A larger proportion of the community sample could have taken the SST while distracted, by a smartphone, TV, or other people. Without real-time monitoring of participants it is impossible to know if they participated undistracted. Second, we used different software to deliver the SST that we anticipated would increase precision of inhibitory control measurement. We created an identical SST but recognize the possibility that unrelated features of the software might have reduced participant’s comprehension of instructions or level of engagement. How these distractions or the exclusion of a large number of participants influenced the results is unclear, but it is likely that excluded participants share some characteristics. It is also possible that had we been able to measure the inhibitory control of the excluded participants the results could have been different. Future work with a diverse sample in a controlled environment will be needed to disentangle the effect of the SST exclusions.

We also excluded a sizable number of participants from the analysis with the CTR time-preference components due to a lack of variability in their responses. Despite having more choices than previous delay discounting measures, a meaningful number of participants still chose to either take the least amount of money now or chose the most amount of money later for each decision. It is possible that a wider range of timeframes or larger differences in money would make it possible to estimate patience and present bias for these participants. However, for the present work, it remains unclear how excluding participants who responded in these systematic ways affected the results.

A fruitful direction for future work will be to better understand the association between chronic financial stress and economic decision making. For example, does chronic financial stress impact a broader range of economic decision making, such as everyday spending or strategies for saving, or just the kinds of narrow measures of economic decision making under examination here? Future work can also examine if chronic financial stress is associated with general cognitive impairments. The present work shows it impedes both inhibitory control and VWM, suggesting it might impact cognitive functioning write large.

7. Conclusion

The principal narrative in the study of financial scarcity and economic decision making is that poverty is associated with behavior that perpetuates poverty, which is often attributed to deficits in self-control-related executive function. The present work tested the hypothesis that the psychological effect of scarcity (i.e., financial stress) was the mechanism through which scarcity reduced cognitive control and influenced economic decisions. The results did not support the financial stress hypothesis consistently. However, they do establish an important association between financial stress, SES, and both cognitive and behavioral outcomes. Additional research is needed to better understand these associations.

Chronic financial stress was associated with both executive function and economic behavior but an individual’s SES was not. This combination of results supports an important takeaway: associations between scarcity, cognition, and behavior are driven by the psychological effects of SES, rather than scarcity itself. People with lower SES do not necessarily have less self-control or make worse economic decisions than those with higher SES. Instead, the consequences of scarcity include psychological effects (i.e., chronic financial stress) that help explain these associations.

Author note

The preregistration, data, and analysis code for Preliminary Study, and the data, and analysis code for the Registered Report Study are available on OSF: https://osf.io/d24qa/

Code availability

All analysis code is available on OSF: https://osf.io/d24qa/

CRediT authorship contribution statement

Bradley T. Hughes: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. Rita M. Ludwig: Investigation, Visualization, Writing – review & editing. Kelly E. Robles: Data curation, Formal analysis, Investigation, Software, Writing – review & editing. Elliot T. Berkman: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – review & editing.

Declaration of competing interest

None of the authors has any competing interest.

Data availability

Data from both the preliminary study and registered report are available on OSF:https://osf.io/d24qa/

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