Poverty-related bandwidth constraints reduce the value of consumption

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Poverty confers many costs on individuals, primarily through direct material deprivation. We hypothesize that these costs may be understated: poverty may also reduce human welfare by decreasing the experiential value of what little the poor are able to consume via reduced bandwidth (cognitive resources)—exerting a de facto "tax" on the value of consumption. We test this hypothesis using a randomized controlled trial in which we experimentally simulate key aspects of poverty that impair bandwidth via methods commonly used in laboratory studies (e.g., memorizing sequences) and via introducing stressors commonly associated with life in poverty (e.g., thinking about financial security and experiencing thirst). Participants then engaged in consumption activities and were asked to rate their enjoyment of these activities. Consistent with our hypothesis, the randomly assigned treatments designed to reduce bandwidth significantly and meaningfully reduced ratings of the consumption activities, with the strongest effects on the consumption of food. Our results shed additional light on how the consequences of poverty on human welfare may compound and motivate future work on the full scope of returns to poverty alleviation efforts.

poverty | bandwidth constraints | utility | consumption

Being born into poverty shapes future outcomes. A long-standing literature documents the negative effects of poverty on health and education (ref. 1 provides a review). These relationships may be even more insidious due to the existence of "poverty traps," self-reinforcing conditions in which the downstream consequences of poverty itself make it more difficult to escape poverty (2). Recent work has also begun to examine the psychological consequences of poverty, showing that the common financial and environmental stressors faced by the poor reduce cognitive "bandwidth," where bandwidth is shorthand for the mental energy available for making productive decisions, including both cognitive capacity and executive function (3–5).

However, the negative psychological consequences of poverty may not be limited to decision making and productivity. Economists have traditionally viewed the ultimate "cost" of being poor to be limited consumption—that is, the poor have lower utility and welfare because they are able to consume fewer goods and services. We hypothesize that poverty, through reducing the bandwidth available to engage in life's activities, may also reduce the enjoyment and satisfaction obtained from any given level of consumption.* For example, those who are consistently financially stressed or chronically deprived of sleep may receive less utility from entertainment, pleasurable meals, or participating in social functions simply because they are too distracted to enjoy them. This implies that poverty could levy a "double tax," where the poor not only consume less, but also have lower utility from a given unit of consumption when bandwidth is constrained. If true, this hypothesis would alter economists' views of the utility and the welfare costs of poverty and alter the cost–benefit calculations of policies to address poverty. However, evidence examining the link between poverty, bandwidth constraints, and the value of consumption is limited. To date, we are aware of only one small qualitative study related to this subject (6).†

We address this gap in the literature by conducting a randomized controlled laboratory experiment in urban India in which we assessed enjoyment from consumption of a variety of goods and activities after experimentally manipulating cognitive bandwidth via poverty-relevant treatments. In the first two treatments in our primary study, participants either memorized a series of patterns or discussed their financial worries, both of which have been shown to reduce cognitive bandwidth (3, 5, 7). In addition, we included an experimental treatment in which we increased the participant's thirst, a common sensation that we identified in our study population during piloting and one that correlates with water insecurity and the high temperatures of the tropics (8, 9). Collectively, this range of treatments was selected to capture the challenges—borne disproportionately among the poor—that impair bandwidth on a regular basis. The manipulations include both treatments that have been well validated in reducing cognitive bandwidth and additional treatments related to the everyday lives of the poor. This variation allows us to

Significance

Poverty confers many costs on individuals, primarily through constraining material resources. Poverty may also worsen welfare by reducing the utility (or enjoyment) individuals may get from whatever little they are able to consume by constraining cognitive resources—conferring a "double tax" on the wellbeing of the poor. However, the impacts of poverty on utility from consumption are not well known. We conducted a randomized experiment in India to investigate this question. We found that participants randomized to various features of poverty (e.g., thinking about a difficult financial situation) reported reduced enjoyment on a range of subsequent activities. The findings suggest that programs that alleviate the material deprivation of poverty may be even more valuable than assumed.

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*If these effects are taken broadly as a complementarity between available attention and consumption, they may not be limited to the poor. For example, the stress of an important meeting may also impact the value of consumption among the rich. However, we chose to focus on the poor given their frequent exposure to such taxes.

†The primary goal of this study was to explore the impact of malnutrition on basic physiology. However, the researchers also collected extensive qualitative data (n = 36) on changes in participants' mental status and focus and found that those who were calorie deprived suffered from a lack of engagement with everyday activities and enjoyment from consumption.

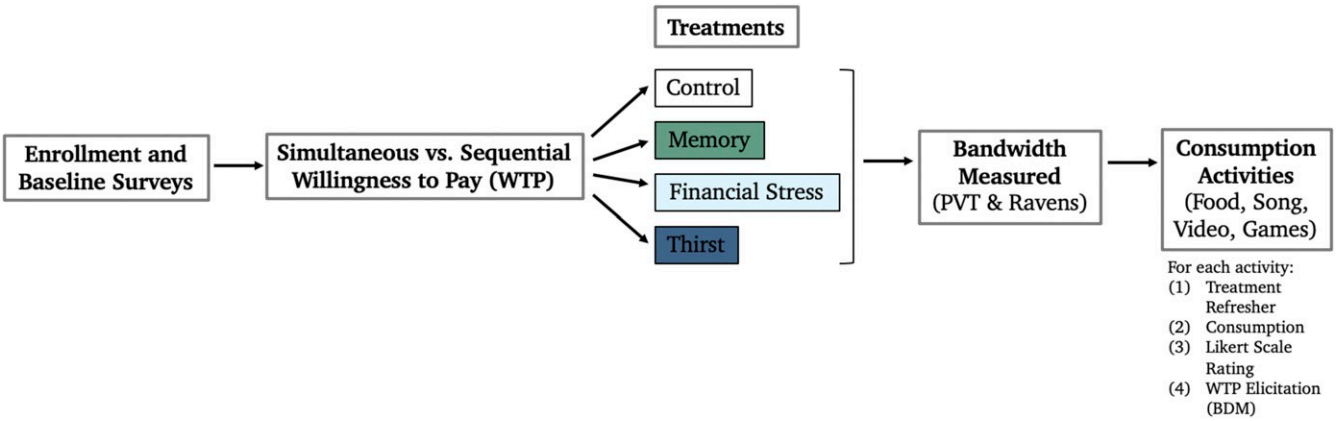

Fig. 1. Participant timeline. Shown are the activities completed by each participant.

capture the specific causal pathway underlying our hypothesis while also demonstrating the potential breadth of the impact of such constraints. After implementing the experimental interventions, we conducted standard assessments of cognitive bandwidth and, thereafter, all participants engaged in a variety of consumption activities and rated their enjoyment of these experiences on a validated scale commonly used in psychology.

Consistent with our hypothesis, each of the experimentally induced taxes on cognitive bandwidth significantly reduced the value of consumption as measured by the participants' rating of the experiences using a Likert scale. These effects were not only statistically significant, but also meaningful, with an average decline in value of 0.22 SD. The largest (standardized) impacts of bandwidth "taxes" on enjoyment were found for the consumption of food, a basic need whose (occasional) absence has long served as a cardinal sign of material deprivation. In addition to these substantive findings, we show that standard economic methods to elicit willingness to pay as a measure of utility may perform poorly relative to standard psychological measures like the Likert scale when cognitive bandwidth is constrained because these constraints directly impact how people make decisions and introduce cognitive biases (e.g., heuristic thinking).

Our findings, if replicated in other settings, would have important implications for our understanding of how poverty reduces welfare, as well as the returns to social welfare programs. In particular, programs that relieve the cognitive taxes of poverty may offer even larger returns than traditionally realized by enhancing the value of existing consumption.

Materials and Methods

This randomized trial was approved by the University of Pennsylvania Institutional Review Board (IRB) (Protocol 831716) in Philadelphia, PA, and the Institute for Financial Management and Research (IFMR) IRB in Chennai, India. All participants completed a thorough informed consent protocol with detailed comprehension questions prior to enrolling in the study. Participants were recruited in Chennai, India's fourth largest city. We specifically recruited low- and middle-income individuals (US dollars $1 to $5 per capita income per day) working in the informal labor market. Based on power calculations using extensive pilot data, we sought to enroll 500 participants. The timeline of study activities is displayed in Fig. 1.

The experiment was registered with the American Economic Association Randomized Controlled Trial (RCT) Registry (RCT ID 0005157). A detailed description of experimental methods and measures is available in *SI Appendix*.

In our primary study, we introduced bandwidth constraints both by using laboratory-based methods and by manipulating naturalistic features of life in poverty (3, 5, 7). Specifically, we randomized participants into the following groups:

1) Memorization. Participants memorized a sequence of visual stimuli, which imposes a cognitive burden that reduces bandwidth (7).
2) Financial Stress. Surveyors read participants a story narrating common financial concerns and then discussed participants' own financial concerns with them (3, 5).
3) Thirst. Participants ate dry salty crackers.
4) Control. Participants listened to a series of stories and engaged in a brief discussion about them. The stories were short and neutral to avoid effects on bandwidth or mood, and took a similar amount of time to complete as the experimental manipulations in the treatment arms.

To confirm that the experimental conditions indeed influenced bandwidth, participants completed two common experimental tasks used to measure bandwidth—the psychomotor vigilance test (PVT) (which measures attention) and Raven's progressive matrices (RPM) test (which measures fluid intelligence)—after undertaking the activities associated with their assigned experimental arm. Specifically, we regressed each of these measures against treatment dummies, both pooling the three experimental treatments and considering each experimental treatment separately. We hypothesized that individuals randomized to each experimental condition would perform more poorly on these tests of cognitive performance (bandwidth) than those randomized to the control group.

Thereafter, all participants engaged in each of four different types of consumption activities—eating a food item, listening to a song, watching a video, and playing a short game. The order of consumption activities was randomized. In an effort to better simulate what may occur in natural settings, participants were allowed to choose a specific good or experience within each type of consumption activity. This choice could attenuate experimental estimates of the impact of bandwidth constraints on enjoyment of consumption activities if, for example, participants were to choose, within each class of consumption activity, a good or experience that they may believe to be most distracting from a given experimental treatment. To examine this possibility, we assessed whether treatment assignment altered participants' choice of good or experience within each type of consumption activity.

Our primary, preregistered measure of utility from consumption comes from a visual analog representation of a 10-point Likert scale querying the degree of enjoyment from a given activity (10).[‡] We chose this approach to measurement given that these scales are easily understood, increasing the likelihood of consistent responses even when bandwidth is constrained (10, 11).[§] In our main models, we regressed consumption utility on experimental treatment, first obtaining the average effect on utility from any consumption good across all experiment treatments and then estimating effects disaggregated by each consumption activity and experimental treatment (in both cases, adjusting for Likert scores for participants' favorite food, assessed at baseline, to adjust for interindividual differences in interpreting the Likert scale). In an analysis that was not preregistered, we additionally assessed whether the effects of the financial stress treatment on utility from consumption were largest for low-socioeconomic status individuals (as ascertained by baseline employment, household income, education, and

[‡]The Likert scale nominally allowed for negative values if a participant disliked an experience; however, only 8 of 2,084 ratings were negative.

[§]In fact, Likert scales are one of the most commonly used scales among children, illustrating their simplicity and intuitive appeal (12).

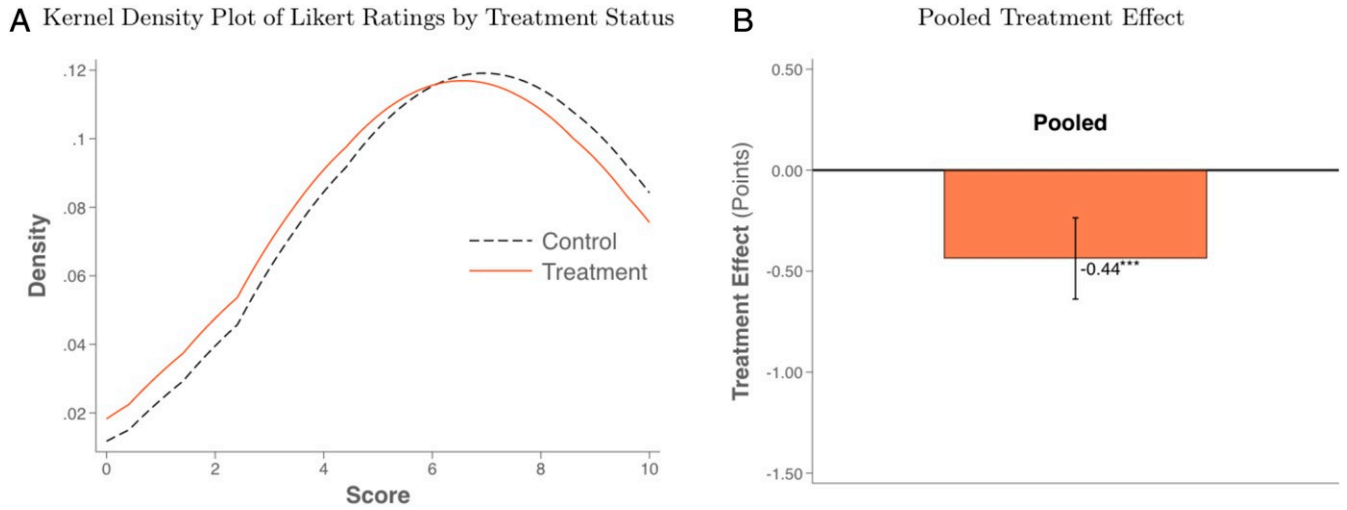

Fig. 2. Bandwidth constraints consistently reduce enjoyment. (*A*) Plot of the smoothed distribution of Likert scores across all consumption activities. The negative shift in scores among treated participants is relatively consistent throughout the distribution. (*B*) Plot of the pooled treatment effect coefficient that includes all treated participants and all consumption activities. For both *A* and *B*, n = 2,084: 521 participants scored four different consumption activities. Error bars are 95% confidence intervals. ***$P < 0.01$.

asset ownership), given prior evidence that impacts of financial stressors on bandwidth are largest among the poor (3).[¶]

We then contrasted findings from our primary Likert-based outcome to findings for a preregistered set of secondary outcomes, specifically measures of willingness to pay for each experience obtained using the Becker–DeGroot–Marshak (BDM) method (13).[#] However, BDM-based elicitation of the value of a good is substantially more complex than a simple Likert scale and therefore more likely to be directly affected by bandwidth constraints that could obscure the relationship between bandwidth and utility—for example, if bandwidth constraints result in heuristic thinking (14).[‖] We conducted two additional supplemental studies with the same participants on the same day (paired with an additional convenience sample) to examine these possibilities. In *SI Appendix*, Supplemental Study 1, we assessed whether the individuals exposed to the experimental treatments in the primary study were more likely to anchor on market prices when asked to report their willingness to pay for a chocolate bar (for which prices are well known). To undertake this study, the primary study participants' willingness to pay values were compared to the market prices reported by an independent convenience sample of 71 individuals. In *SI Appendix*, Supplemental Study 2, the same participants in the primary RCT study were also asked to report their willingness to pay for two sets of experiences of equal length: playing an enjoyable game for 5 min while listening to a high-pitched noise, followed by sitting quietly for 5 min, versus playing an enjoyable game for 5 min absent any noise, followed by listening to a high-pitched noise for 5 min (with order of elicitation randomized). *SI Appendix*, Supplemental Study 2, which was done in advance of the main experimental procedures in the primary study, was conducted to assess whether respondents (when not bandwidth taxed) valued the ability to engage in a pleasurable activity without exposure to a stressor that would limit bandwidth.

Results

We enrolled a total of 526 participants who were evenly distributed across the three treatments and control group.[**] Baseline characteristics are generally well balanced across treatment groups, with the exception of differences in reported average earnings (which range from Indian Rupees [Rs] 544 in the control group to Rs 675 in the memory treatment) (*SI Appendix*, Table S1). Focusing on the control group, the average participant was 38 y old and 45% were female. The majority of control group participants are married (84%) and employed (69%). A total of 84% are literate and the average participant completed nearly 8 y of schooling. The average participant earns Rs 544 (roughly $7.25)/d and reports a moderately high degree of financial stress (average of 6.8 on a 10-point Likert scale).

The experimental treatments were successful in reducing bandwidth. *SI Appendix*, Table S2 displays results evaluating the impacts of the treatment on our two measures of cognitive bandwidth, PVT and Raven's matrices scores (16, 17). We estimate models both pooling the three experimental treatments and considering each of these treatments separately, controlling for age, sex, literacy, and education. Relative to the control group, we found large and statistically significant declines in performance on these tasks, amounting to an 8% (0.21 SD) decline in earnings overall. Disaggregating by cognitive task, we found a 10% reduction in earnings (0.32 SD) relative to the control group mean on the PVT task and a 5% reduction (0.14 SD) on the Raven's matrices task, although Raven's matrices estimates were less precise. Similarly, the effects were well distributed across treatment arms as seen in *SI Appendix*, Table S2, column 4.

Although these changes may not appear large, they are measured in SDs of between-subject variation, which is typically much greater than within-subject differences over time. As points of comparison, a 10-dB increase in background noise decreases an index of bandwidth measures by 0.025 SD (18); being exposed to drought changes an index of cognitive performance by 0.04 SD (19), and going from pre- to postharvest increases cognitive performance by 0.67 SD (3). Hence, these effects are of a magnitude congruent with a variety of stressors commonly associated with poverty. These bandwidth effects are also congruent with direct self-reported measures of financial

[¶]We thank an anonymous referee for suggesting this additional analysis.

[#]In the standard BDM method, participants are provided with a series of increasing monetary values. They are asked whether they would be willing to pay that amount to undertake the consumption activity. One of the values is then randomly chosen. If the number chosen is less than the stated willingness to pay, the participant pays the selected value and consumes. If the number chosen is greater than the participant's willingness to pay, the participant pays nothing and does not consume. This procedure ensures that it is always in the participant's best interest to respond truthfully—i.e., it is incentive compatible—and hence is often preferred by economists.

[‖]In a recent working paper, ref. 15 also found large discrepancies between valuations for time based on wages and those elicited using BDM. A structural analysis suggests these gaps may also be due to behavioral biases in the elicitation method.

[**]Five participants dropped out of the study before completing it, primarily for unrelated reasons such as childcare emergencies. These individuals are omitted from the analysis.

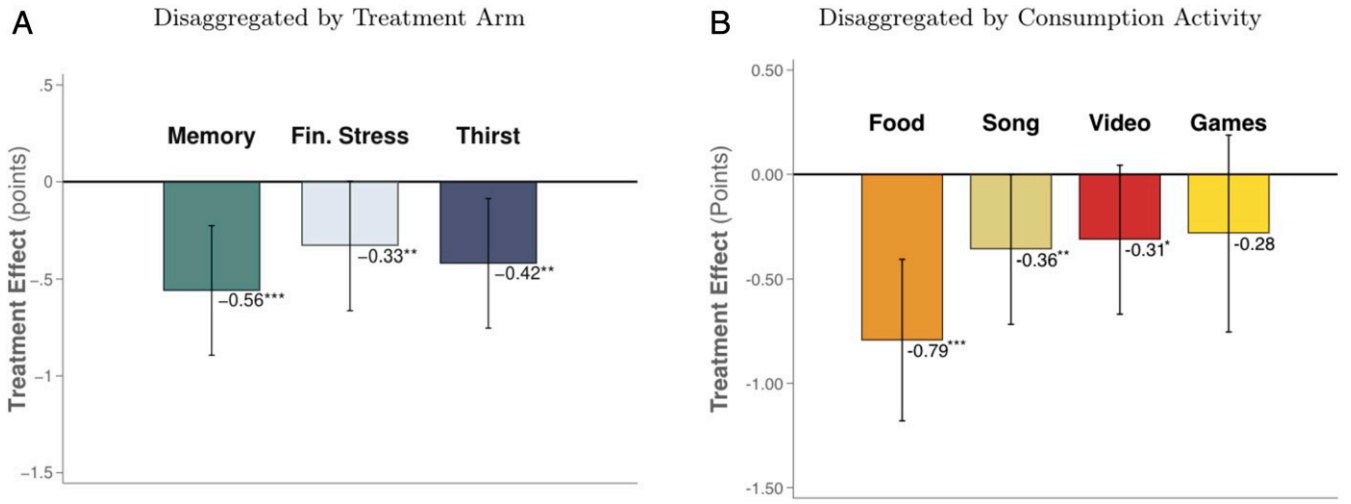

Fig. 3. Disaggregated treatment effects. (*A*) Plot of the treatment effect disaggregated by experimental arm. n = 2,084, 521 participants. (*B*) Plot of the treatment effect disaggregated by activity. n = 521 for each consumption activity. Error bars are 95% confidence intervals. *$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.

stress (the financial stress groups) and thirst (the thirst group) relative to controls (*SI Appendix*, Table S3).

Fig. 2 displays the main findings of the primary study (with corresponding regression results in *SI Appendix*, Table S4).

It plots the effects of the experimental treatments on our primary outcome of value of consumption, as elicited by Likert scales, adjusting only for a baseline Likert scale elicitation to improve precision. Pooling across all treatments and all types of consumption activities, participants in the bandwidth-constraining treatment groups reported lower Likert scores, indicating less enjoyment from consumption. The effect was precisely estimated and represented a 0.44-unit or 0.22-SD decline relative to the control group. We found similar treatment effects when disaggregating the analysis by treatment condition (Fig. 3*A* and *SI Appendix*, Table S4), suggesting that many stressors associated with poverty may generate deficits in the value of consumption.

Focusing specifically on the financial stress treatment, we found that the impacts on enjoyment from consumption were concentrated among low-socioeconomic status participants (Fig. 4 and *SI Appendix*, Table S5), which is consistent with prior work (3).

When we disaggregated by consumption activity (Fig. 3*B*), the largest effects were found for enjoyment of the consumption of food. The estimated decline in the average Likert-scale response is equivalent to a 0.4-SD decline in enjoyment of this activity. Estimates for each of the song, video, and game consumption activities were consistent in direction, but generally smaller in magnitude and less precisely estimated. Given that more "entertainment"-related consumption may be differentially immersive or distracting, we also jointly tested the pooled effect of the experimental treatments on these nonfood consumption activities and found a statistically significant 0.32-point (0.16-SD) decline in enjoyment of these activities (P value = 0.03).[††]

Additional analyses supported the main findings. We found little evidence that assignment to experimental treatment groups altered the choice of the specific song, video, or activity or game, although we found some evidence that participants randomized to the bandwidth-reducing treatment conditions were more likely to select chocolate over apple slices or samosas when asked to choose a specific food (*SI Appendix*, Fig. S1). In addition, we found that estimated treatment effects remained robust to including any baseline covariates that differed (at the 10% level of significance) between the experimental groups (*SI Appendix*, Table S6).

Consistent with our priors, estimates of treatment effects on utility from consumption using the secondary outcome willingness to pay measures elicited from the BDM method were smaller, statistically insignificant, and often wrong signed (*SI Appendix*, Table S7). Evidence from *SI Appendix*, Supplemental Studies 1 and 2 demonstrates that the divergence in findings relative to using our preferred, easily understood Likert-scale method is likely due to bandwidth constraints affecting engagement with the more complex BDM scale. *SI Appendix*, Supplemental Study 1 shows that individuals in the bandwidth-constraining treatment groups were more likely to rely on heuristics when answering willingness to pay questions, specifically by reporting a willingness to pay that corresponded to the mean and modal market price for these goods (*SI Appendix*, Fig. S2).[‡‡] The results from *SI Appendix*, Supplemental Study 2 show that participants—prior to being subject to the experimental treatments—were willing to pay less (0.07 SD, P = 0.05) for the simultaneous experiences of engaging in an enjoyable activity while experiencing annoying noises than when the two experiences were sequential (*SI Appendix*, Fig. S3). This finding suggests that, when facing lower bandwidth constraints, respondents were able to correctly anticipate that such constraints would reduce their experienced utility and correspondingly reduce their willingness to pay for that consumption.

Discussion

Poverty affects wellbeing in myriad ways. Our experiment uncovers a hitherto unexplored channel through which poverty may further reduce wellbeing and welfare. Our findings suggest that poverty can confer a double tax, reducing not only the level of consumption, but also the utility from a given unit of

[††]We thank an anonymous referee for suggesting this additional analysis, which was not preregistered.

[‡‡]The use of heuristics or types of "behavioral" decision making has the potential to create further welfare losses. Specifically, it may lead people to consume a bundle of goods, which would result in lower consumption utility than one based on true enjoyment of those goods.

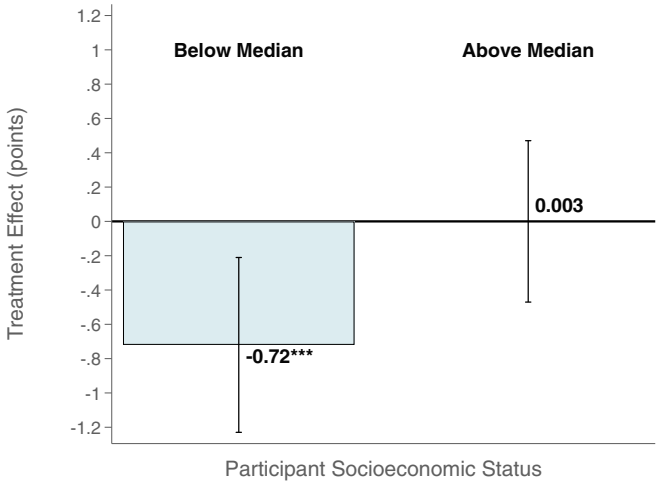

Fig. 4. Heterogeneous treatment effect by socioeconomic status. Shown is the treatment effect of the financial stress treatment on the enjoyment of the pooled activities (food, song, video, and game) separately for participants below and above median socioeconomic status. Socioeconomic status is measured by the Anderson index of four proxies: employment, income, education, and TV ownership. Additional details regarding the index are provided in legend of *SI Appendix*, Table S6. Participants rate their enjoyment of the activity on a Likert scale (0 to 10). There are 128 participants above median SES status, n = 512, and 134 participants below median SES status, n = 536. SEs are clustered at the participant level. ***$P < 0.01$.

consumption. We found that a range of different stressors commonly experienced by the poor reduced enjoyment in several types of activities. The most prominent effects were for the enjoyment derived from the consumption of a critical basic need—food.

Our findings contribute to an evolving scientific understanding of the negative consequences of poverty and to a number of active policy debates. Poverty alleviation efforts are often primarily motivated by the consequences of material deprivation on wellbeing over the life course. As a consequence, poverty reduction efforts have been judged on their ability to reduce financial constraints in the short run and improve downstream measures of wellbeing, such as health, investment in education, and the ability to eventually exit poverty.

These findings serve as a starting point for future work examining the impacts of poverty on utility. For example, future work should seek to replicate these findings in other study settings. It would be useful to more systematically assess the types of consumption that may be affected by experiences of poverty. For example, one explanation for why we found the largest impacts on food consumption may be that entertainment goods such as movies, songs, or games offer a more "immersive" means to deal with poverty-related stressors. As individuals have broader choice sets than are allowed in this experiment (i.e., choices can be made across categories as well as within them), these effects could be magnified if choices are suboptimal.

Our findings also suggest that poverty alleviation efforts may be undervalued if they do not account for follow-on effects on utility from consumption. For example, both conditional and unconditional cash transfers have become common in low-income countries and are increasingly being considered in high-income countries (e.g., universal basic income pilots in Canada and Finland) (20–24). Such programs can promote education and health as well as provide resources directly to low-income families. Our results suggest that such programs may generate utility not only via increased consumption on the margin, but also via gains in the value of consumption for all existing (inframarginal) consumption. Thus, they may significantly increase the overall welfare gains of the program, albeit in ways that researchers and policy makers do not currently measure.

Along these lines, our study may explain results from several recent studies that find cash transfer programs lead to substantial improvements in mental health and wellbeing, despite relatively modest gains in consumption (25, 26). Our experimental results suggest why this may be the case, given that diminished enjoyment from pleasurable activities represents one symptom of depression. For the same reasons, our findings may also help explain the persistent negative relationship between socioeconomic status and mental health observed worldwide (27).

Beyond cash transfer programs, our results suggest that social welfare programs that specifically mitigate taxes on cognitive bandwidth may also have a larger return than previously realized. Further, program designs that mitigate cognitive taxes (e.g., simplified forms or presumptive eligibility for public support programs) may enhance returns to those programs not only because they facilitate enrollment and program use, but also because they allow additional cognitive resources to be dedicated to either productive activities or the enjoyment of consumption, enhancing its value.

Data Availability. Anonymized data files and code have been deposited in the publicly accessible Harvard University Dataverse (https://doi.org/10.7910/DVN/K5AUV4).

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