

Measuring “Schmeduling”

ALEX REES-JONES

Cornell University and NBER

and

DMITRY TAUBINSKY

University of California, Berkeley and NBER

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What mental models do individuals use to approximate their tax schedule? Using incentivized forecasts of the U.S. Federal income tax schedule, we estimate the prevalence of the “schmeduling” heuristics for constructing mental representations of nonlinear incentive schemes. We find evidence of widespread reliance on the “ironing” heuristic, which linearizes the tax schedule using one’s average tax rate. In our preferred specification, 43% of the population irons. We find no evidence of reliance on the “spotlighting” heuristic, which linearizes the tax schedule using one’s marginal tax rate. We show that the presence of ironing rationalizes a number of empirical patterns in individuals’ perceptions of tax liability across the income distribution. Furthermore, while our empirical framework accommodates a rich class of other misperceptions, we find that a simple model including only ironers and correct forecasters accurately predicts average underestimation of marginal tax rates. We replicate our finding of prevalent ironing, and a lack of other systematic misperceptions, in a controlled experiment that studies real-stakes decisions across exogenously varied tax schedules. To illustrate the policy relevance of the ironing heuristic, we show that it augments the benefits of progressive taxation in a standard model of earnings choice. We quantify these benefits in a calibrated model of the U.S. tax system.

Key words: Income taxation, Tax misperception, Heuristics, Ironing, Spotlighting

JEL Codes: D03, H20, H30

1. INTRODUCTION

Financial incentives often feature nonlinearities, leading to complex decision environments. Economic models of fully optimizing and fully informed decision makers offer a rationale for this complexity: in the presence of information asymmetries, standard results in mechanism design show that the optimal incentive scheme is often nonlinear. In practice, however, understanding these incentives appears to be difficult for many decision-makers. For example, the challenges of optimizing with nonlinear incentive schemes are starkly apparent in insurance plan choice (Bhargava *et al.*, 2017), cell-phone usage (Grubb and Osborne, 2015), and water and energy consumption (Carter and Milon, 2005; Ito, 2014). In the context of taxation, a growing literature documents behaviour inconsistent with full optimization with respect to tax credits (Chetty and Saez, 2013; Chetty *et al.*, 2013; Miller and Mumford, 2015; Feldman *et al.*, 2016),

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and surveys of taxpayers document misunderstanding of features of the income tax schedule (reviewed in Section 2.2).¹

As recently shown by [Farhi and Gabaix \(2018\)](#) and others,² the canonical mechanism-design frameworks for optimal taxation can be modified to account for these types of mistakes, with the modifications leading to new and quantitatively important implications for public policy. However, a reasonably precise understanding of the mistakes, and how they vary with policy parameters, is necessary to implement the “behavioural sufficient statistics” approach of these frameworks. From an empirical and practical standpoint, this necessarily complicates policy analysis because suboptimal responses can arise from many widely varied heuristics. However, in cases where it can be established that people rely on a small set of parsimoniously modelled heuristics, it is possible to measure and integrate them into standard mechanism design.

In this article, we undertake this task for two potentially focal approaches to simplifying a nonlinear incentive schedule: the models of “ironing” and “spotlighting” discussed and popularized in [Liebman and Zeckhauser’s “Schmeduling” \(2004\)](#).³ These models capture individuals’ tendency to approximate complex, non-linear schedules with less complex linear ones. When applying the spotlighting heuristic, the individual assumes that the slope of the linearized schedule is equal to his marginal incentive. When applying the ironing heuristic, the individual assumes that the slope of the linearized schedule is equal to his average incentive. These heuristics—and in particular ironing—capture the pervasive difficulty of “thinking on the margin.”⁴ Due in part to their intuitive appeal, the schmeduling heuristics are often suggested as potential mechanisms underlying misoptimized responses to tax incentives (see, *e.g.*, [Chetty *et al.*, 2009](#); [Congdon *et al.*, 2009](#); [Finkelstein, 2009](#); [Miller and Mumford, 2015](#); [Rees-Jones and Taubinsky, 2018](#)). But despite the frequent discussion of these heuristics in the behavioural public economics literature, little existing evidence informs their importance as an account of tax misperceptions.

We report on two complementary experimental studies that we designed to identify individuals’ propensity to rely on the schmeduling heuristics. Study 1 relies on detailed survey elicitation of individuals’ perceptions of the U.S. Federal income tax schedule. The key innovation of the approach in this study arises from the observation that direct elicitation of individuals’ perceptions of broader regions of the tax schedule is extremely useful for separately identifying the schmeduling heuristics from closely related candidate forms of misunderstanding. Such elicitation makes it possible to study how variation in respondents’ average and marginal tax rates relates to their tax forecasts for a given level of income. In Study 2, individuals make incentivized choices between receiving additional taxable or non-taxable income, and face randomly assigned tax schedules. This design allows us to infer tax perceptions from choice behaviour, and to study how tax perceptions respond to exogenous variation in average and marginal tax rates.

In Section 2, we derive a series of distinguishing predictions for schmedulers’ beliefs about different regions of the tax schedule. These predictions describe the biases that arise when forecasting one’s own marginal tax rate, the steepness of the tax schedule over a broader region of incomes, the tax liabilities of the relatively rich and the relatively poor and, importantly, how all of these forecasts evolve with the respondent’s own income. For example, the ironing heuristic

1. Supporting the notion that understanding the tax schedule is challenging, a recent literature documents large cognitive costs from complex tax filing (see, *e.g.*, [Aghion *et al.*, 2017](#); [Benzarti, 2017](#)).

2. See, *e.g.*, [Gerritsen \(2016\)](#), [Blomquist and Micheletto \(2006\)](#), [Kanbur *et al.* \(2008\)](#), [Kanbur *et al.* \(2006\)](#), as well as [Bernheim and Taubinsky \(2018\)](#) for a review.

3. See also [Sobel \(1984\)](#) for an early formulation of ironing by consumers facing nonlinear price schedules.

4. The difficulty of thinking on the margin should be apparent to anyone who has taught undergraduate microeconomics classes. Beyond such anecdotes, this difficulty has been documented in high-stakes managerial decisions about product pricing (see, *e.g.*, [Altomonte *et al.*, 2015](#)).

leads individuals to overestimate the taxes paid by low-income earners and underestimate the taxes paid by high-income earners, though the overall perception of the tax burden on both the poor and the rich is increasing in individuals' incomes. Conversely, the spotlighting heuristic leads to average underestimation of all tax burdens, with perceptions of the taxes paid by the poor decreasing in respondents' incomes. We show that measurements of these kinds of perceptions allow the relative propensity of each schmeduling heuristic to be separately identified from a rich class of other candidate misunderstandings.

In Section 3, we describe the design and results of Study 1. We deployed an incentivized tax-forecasting task to an approximately representative sample of 4,197 U.S. taxpayers. Respondents forecast the tax due by an example taxpayer who faces an income different from their own, but who is otherwise constructed to be very similar to themselves on tax-relevant dimensions. Forecasts are repeatedly elicited for different potential income amounts for the example taxpayer, facilitating inference on the structure of the schedule that the respondents believe is in place.

Using these data, we examine the basic structure of perceptions of the U.S. income tax schedule. Consistent with prior work, we find that taxpayers underestimate the marginal tax rates that apply in their own tax brackets. Examining perceptions beyond the respondent's own bracket, we find a systematic tendency to overestimate the taxes paid by the comparatively poor, to a degree that becomes more severe as respondents' own income increases. Conversely, we find a systematic tendency to underestimate the taxes paid by the comparatively rich, to a degree that becomes less severe as respondents' own income increases. Taken together, these results are largely consistent with the predictions of ironing, are inconsistent with the predictions of spotlighting, and are inconsistent with models in which misperceptions are invariant to respondents' incomes.

Motivated by these reduced-form results, we estimate a structural model of tax perceptions that embeds populations of ironers, spotlighters, correct forecasters, and a rich class of other candidate mistakes. We find that tax perceptions are best explained by a model with approximately 43% of filers adopting the ironing heuristic and no filers adopting the spotlighting heuristic. The remaining filers appear to overestimate taxes on most of the population by a relatively constant amount, and underestimate taxes applicable to the top 5% of the population. On average, these remaining filers have perceptions of marginal tax rates not far off from the truth. These results are qualitatively unchanged in robustness checks that consider various sample restrictions or possible misunderstandings of the survey prompt.

Despite the many different ways in which taxpayers could misperceive taxes, we find that a model accounting for only our estimated rate of ironing is able to precisely explain the systematic underestimation of marginal tax rates in one's own tax bracket. This result holds not only when ironing propensity is estimated using our full sample of elicited perceptions, but also in an out-of-sample fit assessment that estimates schmeduling propensity while excluding forecasts from the respondent's own bracket. This validates our use of individuals' perceptions of broader regions of the tax schedule to help estimate the heuristic processes that govern more local perceptions. Furthermore, this suggests that a parsimonious two-type model of ironers and correct forecasters provides a satisfactory account of systematic marginal tax rate misperceptions.

Of course, predicting field behaviours based on our survey study requires caution (see [Bernheim and Taubinsky \(2018\)](#) for a critical discussion of the use of belief elicitations in behavioural welfare analyses). Individuals may not necessarily act on the beliefs that they state, or they may be more prone to think about marginal tax rates when considering an incremental increase in taxable income.⁵ Furthermore, misperceptions could be endogenous to the tax

5. A survey study eliciting marginal tax rates could potentially mitigate this concern, but would face other severe challenges to identification. See the discussion in Section 2.3.

schedule; for example, individuals might be less likely to rely on the ironing heuristic if the tax schedule were simplified.

To explore these issues, and to examine the robustness of our results beyond our particular elicitation context, we conducted an incentivized online experiment that reveals the rate of ironing through individuals' choices. In Study 2, we presented 3,130 participants with a choice between an incremental contribution to a taxable account or an incremental contribution to an untaxed account. Participants were randomized into one of 54 possible tax schedules, which generated exogenous variation in both marginal and average tax rates. The tax schedules also varied in complexity: half of the participants were assigned to tax schedules with two tax brackets, while half were assigned to tax schedules with five tax brackets. Our design closely relates to work by [de Bartolome \(1995\)](#), which uses a single tax schedule and shows that individuals underreact to its marginal tax rates. In contrast, we exploit exogenous variation in both average and marginal tax rates to quantify how much of that underreaction may be attributed to ironing.

We report the results of Study 2 in Section 4. Similar to Study 1, we find substantial reliance on the ironing heuristic: our primary estimates show that 9% of respondents correctly use the marginal tax rate, 35% of respondents incorrectly use their average tax rate as if it were their marginal tax rate, and the remainder are unresponsive to variation in either the average or marginal tax rate. This pattern of results is consistent with a substantial fraction of respondents failing to attend to taxes (a now-common finding in line with the work of [Chetty *et al.*, 2009](#)), but with widespread use of the ironing heuristic among those who do attend to the tax. We find no evidence of other systematic misperceptions: a simple three-type model in which individuals either ignore variation in tax schedules, iron, or react correctly explains over 87.5% of the variation in tax perceptions arising from variation in schedules.

We report two other findings that are relevant for assessing the psychological mechanisms driving ironing. First, we find no evidence that the propensity to rely on the ironing heuristic is endogenous to the complexity of the tax schedule. This casts some doubt on the possibility that use of the ironing heuristic is a deliberate choice that depends on the tax system in place. Second, we find that only 46% of participants choose to costlessly examine marginal tax rates while making their decision. This suggests either that individuals are confident that information beyond the average tax rate is not necessary for their decision, or that ironing is an automatic and habitual way of representing the world—a “mental gap” ([Handel and Schwartzstein, 2018](#)).

In Section 5, we illustrate the implications of our findings for tax policy. We embed a population of ironers in an otherwise standard model of income taxation building on, *e.g.*, [Mirrlees \(1971\)](#) and [Saez \(2001\)](#). In this model, ironing increases the welfare attained under a convex tax schedule because reliance on this heuristic generates revenue in a progressive fashion. For the U.S. income tax system, our preferred estimates imply that the presence of ironing increases welfare by an amount equivalent to a 2.3% windfall in available government revenue—a quantitatively large effect both in absolute and relative terms.⁶ Moving to analysis of policy reform, we find that ironing increases the welfare costs of moving toward a flat tax. Because ironers do not underestimate marginal tax rates in a flat tax system, moving to this system generates the additional cost of eliminating the welfare-enhancing mistakes created by ironing. Our preferred estimates suggest that ironing increases the welfare costs of moving from the U.S. tax schedule to a revenue-equivalent flat tax by 14%. Moving to analyses in the tradition of [Saez \(2001\)](#) (and their behavioural extensions in [Farhi and Gabaix, 2018](#)), we find that our estimated prevalence of ironing substantially increases the optimal top marginal tax rate.

6. To illustrate, 2.3% of individual income tax return revenue in our year of study amounts to 32 billion dollars—approximately half of the cost of programs such as the Earned Income Tax Credit (\$68 billion in 2014) or the child tax credit (\$57 billion in 2014); for details and other useful benchmarks, see Congressional Budget Office (2013).

In Section 6, we conclude by highlighting what we view as the primary considerations of external validity when evaluating the implications of our results for policy analysis. We highlight the elements of our analysis that we view as most, and least, susceptible to external validity concerns, summarize the generalizable lessons for tax policy, and highlight productive paths for further research.

While economists traditionally favour revealed-preference analysis, recent works have argued that direct belief elicitation serves a key function in economics: reported beliefs can often discriminate between models that are indistinguishable from observed behaviour alone (Manski, 2004; Gennaioli *et al.*, 2015). This logic is particularly relevant when studying misperceptions of income tax systems. Existing quasi-experimental studies (*e.g.*, Feldman *et al.*, 2016) are qualitatively consistent with the presence of ironing, but cannot identify ironing and spotlighting propensities or establish the degree to which these heuristics offer a complete characterization of systematic misperceptions.

We contribute to two distinct lines of research applying survey methods to questions in public economics. First, our article contributes to the existing literature on direct elicitation of tax perceptions. Surveys of tax knowledge (*e.g.*, Lewis, 1978; Fujii and Hawley, 1988) suggest that a key prediction of ironing—underestimation of marginal tax rates—is common. We directly improve on this literature by providing better powered estimates of marginal tax rate underestimation using improved elicitation methods. But more importantly, we leverage elicited perceptions of taxes on incomes outside of one’s bracket to identify the mechanisms driving tax rate misunderstanding. Tests of tax understanding at different regions of the tax schedule, as in Blaufus *et al.* (2015) and Gideon (2017), move in the direction of our empirical design, and suggest misperceptions of taxes on the comparatively rich and poor that could arise from ironing. Yet as we show in Section 2, none of the existing survey evidence is able to firmly distinguish ironing from other candidate models (and indeed, this was not the goal of this previous work).

Additionally, we relate to a recent literature that elicits individual beliefs about, and preferences over, inequality (see, *e.g.*, Cruces *et al.*, 2013; Weinzierl, 2014; Kuziemko *et al.*, 2015; Weinzierl, 2017; Alesina *et al.*, 2018). This literature studies individuals’ preferences for redistribution and their determinants. In contrast, we study individuals’ understanding of the economic incentives generated by the tax systems in place—a necessary component for the integration of misperceptions into optimal tax policy analysis.⁷ To the extent that beliefs about the taxes paid by others are of direct interest (as they pertain to questions of policy support and political economy), our study provides an unusually comprehensive study of the beliefs held by U.S. taxpayers.

2. “SCHMEDULING” AND ITS PREDICTIONS

2.1. *Definitions*

Liebman and Zeckhauser (2004) propose two compelling heuristics for decision-making with a non-linear incentive schedule like the income tax. In summarizing these heuristics, we denote perceived income tax schedules by $\tilde{T}(z|z^*)$, and the true income tax schedules by $T(z)$. These report the tax due as a function of income (z), given the individual’s chosen income (z^*).

Definition 1 *The ironing heuristic arises when an individual uses the average price at the point where he consumes to forecast prices at other consumption levels. In the tax context, this*

7. Kuziemko *et al.* (2015) have one question pertaining to perceptions of tax rates: whether the top income tax rates today are higher or lower than what they were in the 1950s and 1960s.

corresponds to an individual knowing his average tax rate and applying that rate to any amount of income. Formally, $\tilde{T}_I(z|z^*) = \frac{T(z^*)}{z^*} \cdot z$.

As illustrated in Figure 1, use of the ironing heuristic corresponds to approximating the non-linear tax schedule with a secant line drawn through one's own position on the schedule and the origin. As noted in Liebman and Zeckhauser, the reliance on this heuristic can be rationalized given the manner in which tax information is often conveyed to taxpayers. Paystubs typically present one's gross earnings and the subtracted tax withholdings, making the average tax salient and leaving the marginal tax rate unknown. Furthermore, at the time of completion of annual tax returns, filers must calculate both their total annual taxable income as well as the total annual tax due, again inviting assessment of the average tax rate. Taxpayers who find these numbers more accessible could conceivably adopt this forecasting rule as a time-saving heuristic, allowing them to approximate their own position on the schedule while accessing only a single, salient number. Despite its convenience, reliance on this heuristic would result in misoptimized labour supply choices on the intensive margin.

Definition 2 *The spotlighting heuristic arises when an individual uses the local slope of his price schedule to forecast prices at non-local levels. In the tax context, this corresponds to an individual acting as if his own tax bracket extends to other regions of the tax schedule. Formally, $\tilde{T}_S(z|z^*) = T(z^*) + T'(z^*) \cdot (z - z^*)$.*

As illustrated in Figure 1, use of the spotlighting heuristic corresponds to approximating the non-linear tax schedule with a tangent line drawn through one's own position on the schedule. Use of this heuristic can be rationalized by noticing that some individuals might take the time to learn their own local region of the tax schedule—for example, by noting their past-years' tax burden and by looking up their statutory marginal tax rate—but might mistakenly forecast these local parameters beyond the narrow region to which they apply. Compared to the ironing heuristic, the usage of the spotlighting heuristic is somewhat more cognitively demanding, as it requires knowledge of two idiosyncratic parameters (one's tax burden and marginal tax rate) rather than just one (the average tax rate, in the case of ironing). Although this heuristic leads to (approximately) optimized labour supply choices on the intensive margin, it would lead to incorrect labour supply choices on the extensive margin.⁸

Additionally, if taken literally, the use of this heuristic can result in the extreme prediction that tax burdens on very low incomes are negative, whereas the ironing heuristic results in weakly positive tax forecasts. An alternative model of this heuristic would replace negative tax forecasts with forecasts of zero tax. As we will discuss in Section 3.3.2, using this alternative definition has minimal impact on our results.

Several possible psychological frameworks could underlie these heuristics. One is the psychological literature that likens human judgments to those of a “naive intuitive statistician” (Fiedler and Juslin, 2006). This literature argues that decision makers are often able to form reasonably accurate forecasts of simple sample properties, such as frequencies or averages (for early examples, see Spencer, 1961, 1963). However, they often fail to account for sampling biases or constraints in such judgments. As summarized in Juslin *et al.* (2007), “people tend spontaneously to assume that the samples they encounter are representative of the relevant populations.” Both scheduling heuristics may be considered specific examples of this general decision error. The decision-maker correctly assess the average tax rate over either all dollars

8. See, *e.g.*, Saez (2002) for a theory and quantification of the importance of extensive margin elasticities.

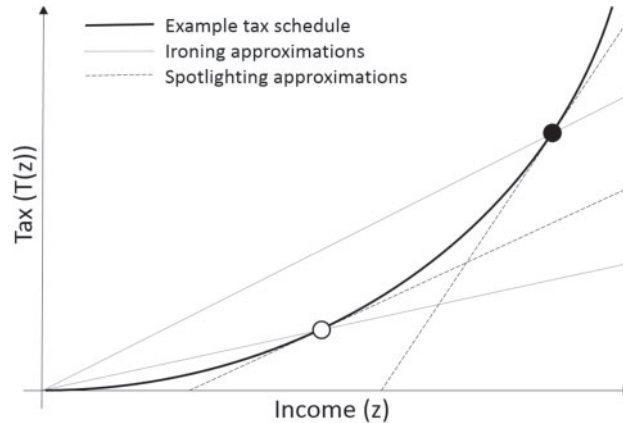


FIGURE 1

Ironing and spotlighting heuristics

Notes: This figure presents an illustration of the ironing and spotlighting heuristics applied to a convex tax schedule. Taxpayers applying these heuristics approximate the schedule with linear forecasts that depend on their own position. We present two example positions, one with high income (the black dot) and one with comparatively low income (the white dot). Under the ironing heuristic, the taxpayer forecasts by applying his average tax rate at all points, resulting in the observed secant lines. Under the spotlighting heuristic, the taxpayer forecasts by applying his marginal tax rate to the change in income that would occur, resulting in the observed tangent lines.

earned that year (in the case of ironing) or over small changes to his own income (in the case of spotlighting), but then incorrectly applies this average as the range is changed in a manner rendering their previously considered sample non-representative.⁹

Another possible foundation for these heuristics is the cognitive economy of linear approximations. Linearization is a common computational technique in economics and other disciplines; it is possible that non-academics use similar techniques more heuristically and less deliberately in their day-to-day decisions. Other possible manifestations of this psychology include exponential growth bias (Stango and Zinman, 2009; Levy and Tasoff, 2016). The bounded rationality model of Gabaix (2014) features some of this psychology by assuming the individuals linearize the marginal benefits of information acquisition or attention allocation; extensions of the model could potentially be used to formalize linearization as a cognitive shortcut more generally.

In general, we note that ironing and spotlighting are unlikely to be “primitive biases.” Consequently, until the details of the underlying cognitive processes are fully understood, an analyst must consider that reliance on these heuristic may be endogenous to features of the tax system. We will directly test for this possibility in Study 2.

2.2. Predictions of schmeduling

We now formalize a series of predictions aimed at illustrating the features of tax perceptions that do, or do not, distinguish between these heuristics. In principle, the use of these heuristics can be examined at the individual level (related analyses will be presented in Section 3.3.4). However, in practice, common imperfections in survey responses—such as measurement error or rounding heuristics—can substantially confound individual-level analyses. These issues lead us to formulate our predictions with respect to the average tax schedule perceived by a population of heuristic forecasters.

9. A potentially related psychology is narrow-bracketing, which is the tendency of people to treat different dimensions of a decision separately, without considering how they interact with each other.

We first analyse predictions about the levels of misperceptions and then analyse predictions about the slope of the misperceptions. We document these predictions for the empirically relevant case of progressive—*i.e.*, convex—tax schedules. We also note that in addition to the predictions spelled out here, both models make the assumption that the forecasted tax schedule is linear and intersects the true one at the forecaster’s own income. We examine these assumptions in Section 3.3.4.

Prediction 1 *Perceptions of taxes on low- and high-income filers.*

- 1-I: Ironers overestimate the taxes paid by low-income filers and underestimate the taxes paid by high-income filers.
- 1-S: Spotlighters underestimate the taxes paid by both low- and high-income filers.

The reasoning behind Prediction 1 is apparent in Figure 1. At the individual-level, ironers overestimate the taxes due for individuals with lower earnings than their own and underestimate the taxes due for individuals with higher earnings than their own. When averaging the perceived schedules of a population of ironers, this results in Prediction 1-I, with low- and high-income evaluated relative to an appropriately weighted average of the incomes of the tax forecasters. In contrast, the forecast corresponding to the spotlighting prediction is always below the true taxes due at the individual level, resulting in Prediction 1-S.

Prediction 2 *Perceptions of taxes on low- and high-income filers, by own income.*

- 2-I: Higher-income ironers exhibit more overestimation of the taxes paid by low-income filers and less underestimation of taxes paid by high-income filers.
- 2-S: Higher-income spotlighters exhibit more underestimation of the taxes paid by low-income filers and less underestimation of taxes paid by high-income filers.

The reasoning behind Prediction 2 is again apparent in Figure 1. As the ironer’s income is increased, the slope of the secant line increases, directly leading to Prediction 2-I. As the spotlihter’s income is increased, the tangent line rotates upward, leading to Prediction 2-S.

We now consider how the scheduling heuristics influence perceptions of the steepness of the tax schedule, both locally and more globally.

Prediction 3 *Perceptions of marginal tax rates (MTRs).*

- 3-I: Ironers underestimate their own MTR.
- 3-S: Spotlighters correctly estimate their own MTR.

Claim 3-S follows immediately from the definition of spotlighting: by assumption, spotlighters know and apply their MTR. Turning to Prediction 3-I, we note that the definition of ironing does not fundamentally require underestimation of MTRs, but that this underestimation arises for progressive tax schedules, in which average tax rates (ATRs) are always lower than MTRs.

As a means of characterizing perceptions of the “steepness” of a broader region of the tax schedule, it is convenient to define the *perceived slope* over income range $[z_1, z_2]$ to be $\frac{\hat{T}(z_2|z^*) - \hat{T}(z_1|z^*)}{z_2 - z_1}$, and the *actual slope* to be $\frac{T(z_2) - T(z_1)}{z_2 - z_1}$.

Prediction 4 *Perceived slope of tax schedule.*

- 4-I: Consider income range $Z = [\underline{z}, \bar{z}]$ which satisfies $z_i^* \in Z$ for all individuals i . Evaluated over Z , ironers’ perceived slope underestimates the actual slope.
- 4-S: Consider income range $Z = [\underline{z}, \bar{z}]$ which satisfies $z_i^* \in Z$ for all individuals i . There exists a threshold $z^\dagger \in Z$ such that spotlighters earning $z_i^* \leq z^\dagger$ underestimate the actual slope over Z , whereas spotlighters earning $z_i^* > z^\dagger$ overestimate the actual slope.

As illustrated in Figure 1, the use of the ironing heuristic results in a linear approximation to the schedule that ultimately is shallower than the schedule itself. Since the schedule is convex, treating one’s average tax rate as the relevant slope for higher income values will result in an approximate schedule that underestimates the highest taxes due, and concurrently is “flatter” than the true schedule. In contrast, spotlighters’ perceptions of the average slope of the full tax schedule depend more critically on their own income. For lower-income individuals, one’s own marginal tax rate can be lower than the average slope of the entire schedule. However, for sufficiently high-income individuals, this effect reverses, leading spotlighters to overestimate the average slope. This contrast is displayed in the two examples of Figure 1.

Moreover, because both marginal and average tax rates are rising with one’s own income in a progressive tax system, the perceived slope over an income range will be increasing in the scheduler’s income:

Prediction 5 *Perceived slope of tax schedule, by own income.*

- 5-I: Ironers’ perceived slope over income range Z is increasing in their earnings, z^* .
- 5-S: Spotlighters’ perceived slope over income range Z is increasing in their earnings, z^* .

While Prediction 5 does not distinguish between the use of the two heuristics, it does clearly differentiate their use from correct forecasting, or from forecasting based on misperceptions of the schedule that are not tied to one’s earnings.

2.2.1. Summary of existing survey evidence. Perceptions of the income tax have long been of interest in public finance, with a literature on the survey measurement of these perceptions extending back at least to the 1960s.¹⁰ While this literature has asked questions in some ways related to our own, the different objectives of these papers lead them to collect data of limited use in identifying the scheduling heuristics. For example, early papers in this literature (Enrick, 1963, 1964; Wagstaff, 1965) assess if taxpayers know the size of their own tax bill—a feature of tax perceptions for which ironing, spotlighting, and correct forecasting all make the same prediction.¹¹ Later papers became more interested in assessing taxpayers’ understanding of their marginal tax rate, which permits an assessment of Prediction 3. The early works of Gensemer *et al.* (1965) and Brown (1969) document substantial misperceptions of marginal tax rates, with Brown documenting a tendency towards marginal tax rate overestimation. Subsequent studies with substantially larger samples have found average underestimation (Lewis, 1978; Fujii and Hawley, 1988), consistent with Prediction 3-I and rejecting Prediction 3-S.¹² However, viewed in isolation, such findings do not clearly establish ironing as the mechanism driving this underestimation.

10. Supplementary Appendix Table A1 provides a summary of the most relevant survey literature and indicates the scheduling predictions that these papers inform.

11. For recent work further examining perceptions of average tax rates, see Ballard and Gupta (2018).

12. In more nuanced recent work, Gideon (2017) examines the accuracy of marginal tax rate perceptions across the income distribution. He finds average underestimation of marginal tax rates for respondents with gross income exceeding \$50,000, and average overestimation for those of lower income.

Fewer results are available to assist in assessing Predictions 1, 2, 4, or 5. Blaufus *et al.* (2015) ask a panel of German respondents about their perceptions of the taxes paid by those earning 10,000, 40,000, 300,000, or 2 million euros a year. They find evidence that the tax burden is overestimated at the bottom of the scale and underestimated at the top of the scale, consistent with Prediction I-1. Gideon (2017) finds that survey respondents tend to underestimate the top marginal tax rate, a feature that could lead to underestimation of taxes paid by the rich (as in 1-I) and could arise from an underestimation of slope of the full tax schedule (as in 4-I). Beyond results such as these, this literature's focus on perceptions of taxes at a smaller number of very specific, typically local points results in a general inability to test the nuanced predictions that firmly separate the scheduling heuristics from other potential mechanisms. This motivates the design of our experiment, eliciting the key class of data absent from this work: perceptions of taxes over a broader variety of incomes, sampled with continuous support.

2.3. Identifying scheduling propensities

Formally, we characterize the average perceived tax schedule as a mixture model of forecasting types, given by

$$E[\tilde{T}(z|z^*)|z, z^*] = \gamma_I \tilde{T}_I(z|z^*) + \gamma_S \tilde{T}_S(z|z^*) + \sum_k \omega_k \tilde{T}_k(z) + (1 - \gamma_I - \gamma_S - \sum_k \omega_k) T(z). \quad (2.1)$$

In this model, γ_I denotes the fraction of individuals using the ironing heuristic and γ_S denotes the fraction of individuals using the spotlighting heuristic. Non-scheduling taxpayers may hold alternative perceptions of the schedule (captured by the term $\sum_k \omega_k \tilde{T}_k(z)$), with the remainder of taxpayers adopting the correct tax schedule.

We aim to make minimal assumptions about the structure of the alternative misperceptions beyond explicitly specifying that they are not a function of earnings choice, and thus are not a function of either the individual's average or marginal tax rate. Misperceptions of this sort could correspond to, *e.g.*, average overestimation of the tax burden or a general tendency to underestimate marginal tax rates. For example, \tilde{T}_k could correspond to underestimation of all MTRs by 50%; that is, $\tilde{T}_k = t_0 + \frac{1}{2}T$, for some constant $t_0 \in \mathbb{R}$. Note that although we think it most psychologically natural to consider γ_I and γ_S as probabilities of pure ironing or spotlighting types, we could instead interpret these parameters as weights in a representative agent model of partial ironing and spotlighting.

To obtain intuition for the data requirements for identifying equation (2.1), consider first a dataset in which only perceptions of respondents' own MTR under a fixed schedule are measured (*i.e.* $\frac{d}{dz} E[\tilde{T}(z|z^*)|z, z^*]|_{z=z^*}$). Such observations are plainly insufficient to separately identify γ_I , γ_S , and $\sum_k \omega_k \tilde{T}_k(z)$. To illustrate, note that correct average perceptions of MTRs could arise from correct tax forecasting, or from spotlighting, or from some individuals underestimating their own MTRs due to ironing while others over-estimate MTRs in a perfectly offsetting manner. As another example, consider a group of individuals facing an average tax rate of 10% and an MTR of 20%, but perceiving their MTR to be 15%. Such perceptions could be rationalized by a 50–50 mixture of correct forecasters and ironers. However, they could also be rationalized by a 50–50 mixture of correct forecasters and individuals who simply underestimate *all* MTRs by half; or by a 3:1 mixture of correct forecasters and individuals who underestimate *all* MTRs by 75%.

The “ideal” variation for identifying γ_I and γ_S is exogenous variation in the marginal and average tax rates at z^* . This would generate exogenous variation in $\tilde{T}_I(z|z^*)$ and $\tilde{T}(z|z^*)$, which would lead to clear identification of γ_I and γ_S . We employ this kind of exogenous variation in Study 2.

In Study 1, we work with the fixed U.S. income tax schedule, and thus cannot utilize this ideal variation. Instead, we utilize variation in marginal and average tax rates that is obtained from respondents’ own earned income z^* . Under the assumption that residual misperceptions ($\sum_k \omega_k \tilde{T}_k(z)$) do not covary with z^* , the variation in z^* provides the needed variation in average and marginal tax rates.

Formally, we elicit beliefs about $\tilde{T}(z|z^*)$ across a joint distribution of (z, z^*) spanning the relevant range of each variable’s support. With such data, the analyst has access to the empirical moments $\frac{d}{dz^*} E[\tilde{T}(z|z^*)|z, z^*]$. Both models of schmeduling offer different, full accounts of the structure of this derivative. For example, predictions 1 and 2 show that the models predict different *signs* for this derivative for $z < z^*$. Moreover, since either correct forecasting or our position-independent alternatives require that this derivative be zero at all points, this is sufficient to identify both γ_I and γ_S . Conditional on such estimates, the average of all other perceived schedules is identified by the “residual” structure of $E[\tilde{T}(z|z^*)|z, z^*]$ unexplained by the estimated schmeduling propensity. This illustrates the identifying power of tax perceptions elicited over a broader support of (z, z^*) , and motivates our design of an experiment capturing such perceptions.

Focusing on forecasts of absolute tax paid, rather than on forecasts of marginal tax rates, is an important feature of our empirical strategy. Note that a dataset that elicits perceptions of marginal tax rates at different points on the tax schedule would primarily be identified through the heuristics’ differing predictions about $\frac{d^2}{dzdz^*} E[\tilde{T}(z|z^*)|z, z^*]$. As shown in prediction 5, both models predict that perceptions of MTRs increase with z^* , resulting in greater colinearity of predictors since ATR is an increasing function of the MTR in progressive tax schedules. Such an empirical framework would be less well-powered to differentiate between the two heuristics of interest, and would also be less robust to assumptions about functional form.¹³ These concerns guided our decision to collect a different class of data than has been pursued in many prior works.

3. STUDY 1: PERCEPTIONS OF THE U.S. FEDERAL INCOME TAX

3.1. *Experimental design*

We administered Study 1 during the tax season of 2015. From 15 March through 17 May, respondents were recruited for a brief¹⁴ web survey hosted on the Qualtrics platform, with recruitment targeting similar sample sizes in all weeks of this sampling window. Subject recruitment was managed by ClearVoice Research, a market research company that maintains a large, national population of respondents willing to take brief online surveys.¹⁵ Respondents were recruited based on demographic data previously provided to ClearVoice, allowing us to generate a sample with demographics that approximate the national age, income, and gender distribution found in the U.S. census records (for tabulations of demographics in our sample and the census, see [Supplementary Appendix Table A2](#)).

3.1.1. Experimental protocol. The Qualtrics survey featured four modules. Screenshots of the full experiment are available in the Supplementary Survey Appendix; we summarize the contents here.

13. For example, consider nonlinear transformations of the schmeduling predictions, as in the alternative definition of spotlighting that we discuss in Section 2.1.

14. Median completion time: 16 min. Interquartile range: 11–25 min.

15. For other economic research making use of the ClearVoice panel, see [Benjamin et al. \(2014\)](#) or [Taubinsky and Rees-Jones \(2018\)](#).

Introductory module: The first module elicited basic information about respondents' tax filing behaviour, allowing us to construct a similar hypothetical tax filer in the forecasting module. Respondents were asked if they had already filed their tax return; who completed (or would complete) that tax return; their filing status; their exemptions claimed; if they claimed the standard or itemized deduction; their total income; if they filed each of schedule B through F; if they used TurboTax or similar software; if they or their spouse were born before 2 January 1950; and if they claimed the Earned Income Tax Credit.¹⁶ Additionally, respondents were asked their degree of confidence in the key parameters determining their tax: their filing status, their exemptions, their deduction status, and their income. Confidence in these parameters was high. Given ratings options of "very confident," "somewhat confident," and "not confident at all," 96% of respondents were "very confident" in their filing status; 89% of respondents were "very confident" in their number of exemptions; 90% of respondents were "very confident" in their deduction status; 71% of respondents were "very confident" that their total income reported was within \$1,000 of being correct.

Forecasting module: The key questions for our empirical analysis were contained in the forecasting module. Respondents were presented with a variant of the following prompt, describing a hypothetical taxpayer whose filing behaviour was very similar to their own:¹⁷

This next group of questions is about Fred, a hypothetical taxpayer who is very similar to you. Fred is your age, and has a lifestyle similar to yours. Fred filed his 2014 Federal Tax Return claiming [own exemptions] exemption(s) and [own status] filing status, like you did. Fred also claimed the standard deduction, like you did.¹⁸ However, Fred's tax computation is particularly simple, since all of his taxable income comes from his annual salary. He has no other sources of taxable income, and is not claiming additional credits or deductions.

For the following questions, we will ask you to estimate the total federal income tax Fred would have to pay for different levels of total income. To help motivate careful thought about these questions, we are providing a monetary reward for correct answers. At the end of the survey, one of these questions will be chosen at random. If your answer to that question is within \$100 of the correct answer, \$1 will be added to your survey compensation.

Following this preamble, respondents made 16 forecasts of taxes due under different amounts of income, given the following prompt:

If Fred's total income for the year were \$[X], the total federal income tax that he has to pay would be:

The amounts of income substituted into the prompt above were drawn according to three sampling schemes. Ten forecasts were drawn from the "mid-range sampling distribution." This is a range of income values spanning all but the top of the national income distribution, sampling uniformly

16. Respondents who claimed the Earned Income Tax Credit completed an additional brief battery of questions regarding their understanding of this tax provision.

17. For respondents who had not yet completed their tax return, the verb tense was changed from past to future as appropriate.

18. For filers not claiming the standard deduction, this sentence read: "Unlike you, Fred claimed the standard deduction."

from \$0 up to a point partially through the fourth tax bracket. This sampling pattern differs by filing status, leading us to present estimates separately by filing status in some of our analysis. Four forecasts were drawn uniformly from the “high-income sampling distribution,” starting from the top of the mid-range income distribution and ranging to approximately \$500,000. We call the sample of all 14 points the “full sampling distribution.” Finally, two draws were included that guarantee the presence of some forecasts “close” to the respondent’s own income. One draw substituted the respondent’s own reported income for X above, while the second applied that income plus a random perturbation taking a value between 0 and 1,000.¹⁹ When assessing respondents’ knowledge of the tax schedule local to their own income, we will restrict data to the “local distribution” consisting of these two forecasts as well as any of the random forecasts that happen to fall in the respondent’s own tax bracket. However, when we are not assessing questions about local tax perceptions, we exclude these two forecasts to preserve a random sampling structure.

Miscellaneous questions: After the forecasting task, respondents faced a brief battery of miscellaneous questions. These included an elicitation of the salience of their income tax, assessments of their health and savings behaviours, an elicitation of their elasticity of charitable giving, the “big three” financial literacy questions of [Lusardi and Mitchell \(2014\)](#), and a test of knowledge of their sales tax rate. These also included an attention check, in which the text of the question instructed the respondent not to selected any of the multiple-choice options below the text. This assists in screening out respondents providing random answers without reading instructions.²⁰

Incentives: On the final screen, one of the respondent’s 16 tax forecasts was randomly selected for incentivization. They were told the correct answer, reminded of their own answer, and awarded the bonus payment if their response was within \$100 of the truth.

3.2. *Sample for analysis and dataset preparation*

Over the course of our sampling period, 4,828 individuals completed the full survey. We exclude respondents according to several criteria. First, we exclude 5 respondents with missing data on one or more of the tax forecasts. Second, we exclude 73 respondents forecasting either 0 tax or 100% tax for all forecasts, as we believe this reporting pattern indicates either misunderstanding of the prompt or represents an attempt to quickly click through the survey without meaningfully responding to questions. Third, we restrict our sample to respondents reporting income ranging from zero to \$250,000, excluding 117 respondents whose self-reported incomes are outside the typical range of the panel. Finally, we exclude 436 respondents who failed the attention check included in the miscellaneous questions module. To limit the influence of extreme tax forecasts, we conduct a rolling Winsorization of tax forecasts to the 1st and 99th percentile values in each \$10,000 income bin.

This set of restrictions results in a final sample of 4,197 respondents, and a total of 58,758 forecasts of tax liability for randomly drawn incomes. In Section 3.3.4, we discuss the robustness of our empirical results to these dataset construction decisions.

19. This value fell within the respondent’s own tax bracket for all but 89 respondents.

20. The text of the attention check was as follows: “Sometimes participants who take online surveys don’t read all of the instructions and click through the questions more quickly than they should. We want to make sure that participants taking this survey are paying attention to the instructions. On this screen, your instructions are simply to click on the continue button at the bottom of the screen, and not to fill in any of the answer below. Please click continue now.” Below this prompt, multiple choice options ranging from “Always” to “Never” were present. These were meant to appear like standard Likert-scale responses to a respondent who had not read instructions.

3.3. *An empirical assessment of tax misperceptions*

3.3.1. Reduced-form tests of schmeduling. Systematic over- and under-estimation (Schmeduling Predictions 1 and 2): To present an initial, non-parametric summary of income tax perceptions, Figure 2 plots a kernel-smoothed estimate of average perceived tax schedules. Since schedules are filing-status specific, we present estimates separately for the two largest filing-status groups: single and married filing jointly. The top panels present estimates restricted to the data from the ten income draws of the mid-range sampling distribution. The lower plots extend the support to include the four income draws from the high-income sampling distribution.

The top two panels illustrate two important features of perceived tax schedules. First, on average, the perceived tax schedule is qualitatively similar to the true tax schedule, though it displays some systematic error. For example, over the mid-range sampling distribution, respondents overestimate the tax burden by \$679 (clustered s.e.: \$185) on average, or 3.2 percentage points (clustered s.e.: 0.003pp) in effective tax rates. Standard errors are clustered at the respondent level.

Second, and perhaps more importantly, these plots also demonstrate that the sign of the average misperception depends on the amount of income that is being taxed. In both plots, the average perceived tax schedule appears more linear than the true schedule, with a tendency towards overestimation of the tax burden for low amounts of income and underestimation of the tax burden for high amounts of income. In the lower two plots of Figure 2, which present analyses including the high-income sampling distribution, this underestimation of taxes on high incomes becomes even more pronounced. This pattern indicates a general underappreciation of the degree of progressivity in the current U.S. tax code. The qualitative patterns of these results provide a test of Prediction 1, formally rejecting the predictions made by the spotlighting model (1-S) while remaining consistent with the predictions made by the ironing model (1-I).

Turning to Prediction 2, we next explore the differences in perceived schedules as a function of respondents' own income. Figure 3 summarizes the average bias in forecasts as a function of the true tax due, and plots this bias conditional on respondent's own income quartile. We present fitted values from the regression model:

$$(\tilde{T} - T)_{i,f} = \sum_{b,q} \alpha_{b,q} * I(\text{income}_f \in \text{bin}_b) * I(\text{income}_i \in \text{quartile}_q) + \epsilon_{i,f}.$$

In this regression, we predict the difference between the perceived tax (\tilde{T}) and the true tax (T) for person i 's assessment of Fred scenario f . We estimate the average of this forecast error in \$5,000 bins (denoted b), estimated separately by the income quartile of the respondent (denoted q).²¹ As seen in this figure, the primary pattern described above—overestimation of low tax burdens and underestimation of high tax burdens—persists across all four income groups. Despite this consistent pattern, tax perceptions are significantly different across income quartiles. Wald tests reject joint equality in all pairwise comparisons of the income-quartile-specific estimates of α (all p -values < 0.014). An important feature revealed in the plots is that the “crossing point” where overestimation turns to underestimation occurs at higher income values for higher income respondents. These patterns are consistent with the predictions of ironing (2-I), and are broadly inconsistent with the predictions of spotlighting (2-S).

Perceived slope of tax schedules (Schmeduling Predictions 3–5): Figures 2 and 3 suggest underestimation of the slope of the tax schedule. This is visually apparent in the “flattening” of the estimated schedules in Figure 2, and in the negative slope of the bias functions in Figure 3.

21. Note that the estimation sample is restricted to cases with tax burdens in the range [0,55000).

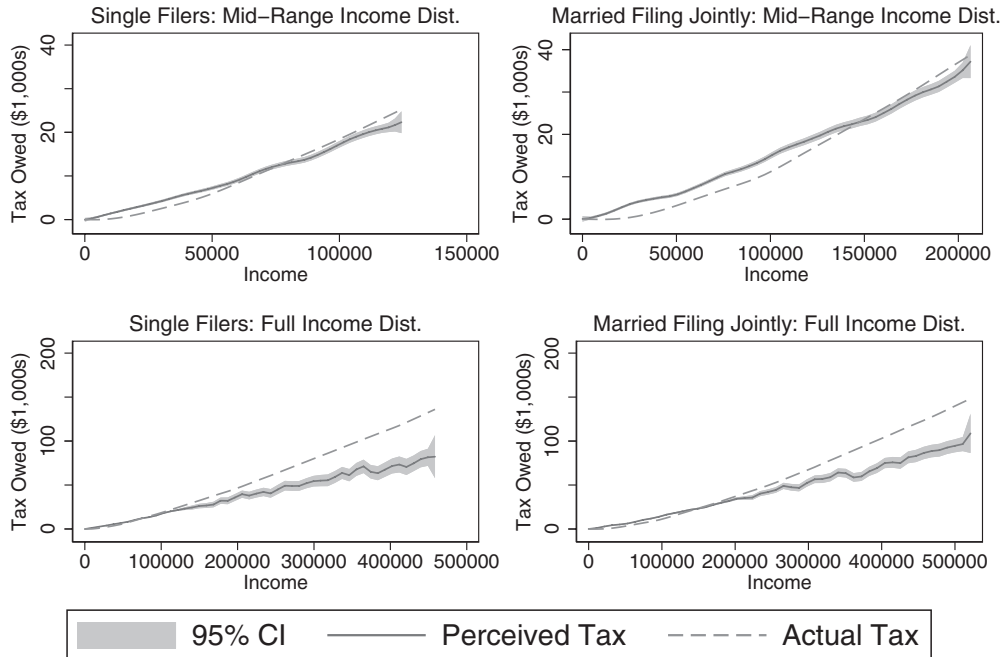


FIGURE 2

Local-polynomial approximations of the perceived tax schedule

Notes: This figure presents local-polynomial approximations of the perceived relationship between the income earned and taxes owed. Results are plotted separately for single and married-filing-jointly tax filers, as incomes considered in the forecasting task were drawn from filing-status-specific distributions. The first row of figures presents estimates derived from only mid-range forecasts, while the second row presents estimates derived from the full sampling distribution. The shaded regions illustrate the 95% confidence intervals of the local-polynomial estimates. Bandwidth: 10,000. Degree of polynomial: 2. Kernel: Epanechnikov.

We now turn to a statistical assessment of this underestimation, and use our results to assess Predictions 3–5.

To formally test for underestimation of the slope of the tax schedule, we estimate fixed-effect OLS regression models of the form $\tilde{T}_{i,f} = \beta T_{i,f} + v_i + \epsilon_{i,f}$. The object of interest in this analysis is β , which measures the scaling of the tax schedule implicit in the respondents' forecasts. By including respondent-specific fixed effects (v_i), we identify β from the effective slope of the tax schedule reported within-subject. We test the null hypothesis of $\beta = 1$, the value that would be estimated if respondents indicated a rate-of-increase of taxes consistent with the true tax schedule. An estimated value over 1 would indicate an implicit steepening of the schedule, and an estimated value under 1 would indicate an implicit flattening. Results of this analysis are presented in Table 1.

In the first panel of Table 1, we restrict the estimation sample to the “local distribution,” consisting only of the two locally sampled income draws and any of the randomly sampled income values that happen to fall in the respondent's own tax bracket. Beliefs in this region of the tax schedule directly reveal whether taxpayers correctly perceive the marginal tax rates that they face, and thus allow the assessment of Prediction 3. We find that our respondents underestimate the marginal tax rates in their own tax bracket ($\beta = 0.81$, clustered s.e. = 0.043), consistent with the prediction of ironing (3-I) and inconsistent with the prediction of spotlighting (3-S). The 2nd–5th columns of the table provide estimates of this same parameter when the sample is restricted to respondents in each of the four income quartiles. Across these estimates, we find that underestimation remains statistically detectable for respondents in the top two income quartiles.

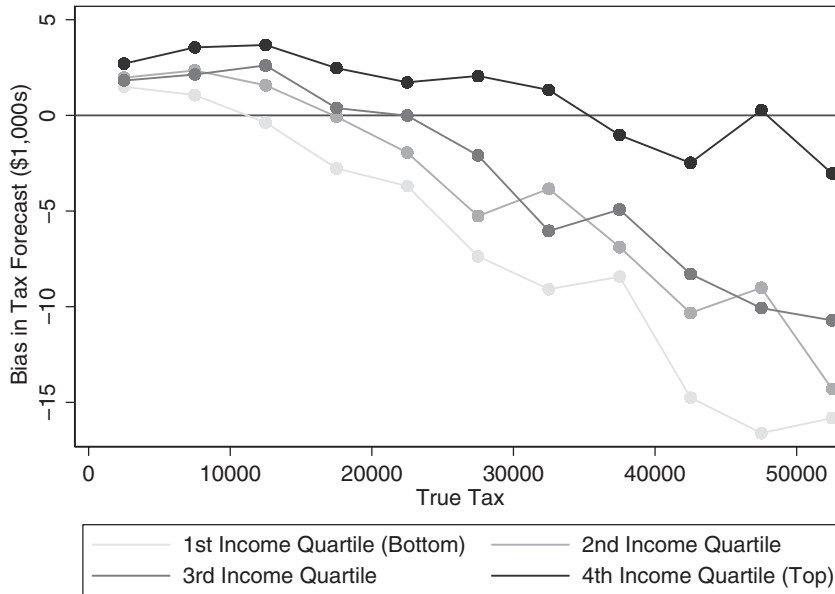


FIGURE 3

Bias in tax perceptions, by respondents' income quartile

Notes: This figure plots the average bias in tax forecasts as a function of the true tax owed by the hypothetical tax payer. To explore how misperceptions of the tax schedule vary depending on the forecasters' own income, we plot this relationship separately by the income quartile of the respondent. Presented are the estimated coefficients from the regression $(T - T)_{i,f} = \sum_{b,q} \alpha_{b,q} * I(\text{income}_f \in \text{bin}_b) * I(\text{income}_i \in \text{quartile}_q) + \epsilon_{i,f}$, predicting average bias conditional on income quartile and the true tax owed, rounded into \$5,000 bins.

For respondents in the bottom two income quartiles the standard errors of these estimates are sufficiently large that we can reject neither correct perception nor substantial underestimation or overestimation of their MTRs.

The second panel of Table 1 presents estimates of β derived from the 10 random draws of the mid-range sampling distributions. As in the local analysis, we find substantial and statistically significant underestimation of the steepness of the tax schedule ($\beta = 0.82$, clustered s.e. = 0.013). In contrast to the local analysis, we find that this underestimation persists among all four income quartiles, with the null hypothesis of $\beta = 1$ rejected at at least the 1% level for each estimate. The degree of underestimation is most severe among the lowest-income respondents: estimates range from 0.70 (clustered s.e. = 0.029) for the lowest-income respondents to 0.94 (clustered s.e. = 0.023) for the highest-income respondents. These results provide an investigation of Predictions 4 and 5, and again refute the predictions of the spotlighting model while supporting the predictions of the ironing model.

The third panel estimates β using data from the full sampling distribution. Results are congruent with those generated from only the mid-range sampling distribution. Underestimation of the slope of the tax schedule persists, and indeed is more severe ($\beta = 0.62$, clustered s.e. = 0.010). As in the second panel, we find that all four income quartiles underestimate the average slope of the tax schedule, with the difference again increasing in the respondent's own income.

Summary: Assessing the five predictions articulated in Section 2, we find no support for the predictions of the spotlighting model and consistent support for the predictions of the ironing model.

TABLE 1
Testing for “Flattening” of the tax schedule

	All incomes pooled	1	2	3	4
Estimation sample: local draws					
Scale of slope (β)	0.81*** (0.043)	1.01*** (0.205)	1.07*** (0.113)	0.83*** (0.058)	0.78*** (0.054)
p -Value of $H_0: \beta = 1$	0.000	0.975	0.552	0.003	0.000
Respondents	4,197	1,050	1,062	1,040	1,045
Forecasts	17,937	3,143	4,074	5,293	5,427
Estimation sample: mid-range sampling distribution					
Scale of slope (β)	0.82*** (0.013)	0.70*** (0.029)	0.78*** (0.030)	0.80*** (0.026)	0.94*** (0.023)
p -Value of $H_0: \beta = 1$	0.000	0.000	0.000	0.000	0.005
Respondents	4,197	1,050	1,062	1,040	1,045
Forecasts	41,970	10,500	10,620	10,400	10,450
Estimation sample: full sampling distribution					
Scale of slope (β)	0.62*** (0.010)	0.53*** (0.020)	0.56*** (0.021)	0.61*** (0.019)	0.76*** (0.017)
p -Value of $H_0: \beta = 1$	0.000	0.000	0.000	0.000	0.000
Respondents	4,197	1,050	1,062	1,040	1,045
Forecasts	58,758	14,700	14,868	14,560	14,630

Notes: Standard errors, clustered by respondent, in parentheses. Presented are coefficients from OLS fixed-effect regressions of the form $\tilde{T}_{i,f} = \beta * T_{i,f} + v_i + \epsilon_{i,f}$. The coefficient β can be interpreted as a scaling of the slope induced by the true tax schedule, where estimated values less than 1 indicate a “flattening” of the tax schedule. Two-sided Wald-test p -values, testing the hypothesis that $\beta = 1$, are presented below each regression. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.3.2. Disentangling heuristic use. While the reduced-form results support the presence of ironing and provide little evidence of spotlighting, these analyses do not address three questions of primary interest. First, how much of the apparent under-appreciation of progressivity can be attributed to ironing? Second, even if they are not prevalent, are there any spotlighters in the population? Third, are there features of average tax perceptions that schmeduling fails to capture? We address these questions with a mixture-model approach to estimating the propensity of each heuristic.

Estimating heuristic propensity: To provide quantitative estimates of the propensity of heuristic use, we estimate the structural model in equation (2.1). We present results from two estimating equations:

$$\tilde{T}_{f,i} = (1 - \gamma_I - \gamma_S)T(z_{f,i}) + \gamma_I \tilde{T}_I(z_{f,i}|z_i^*) + \gamma_S \tilde{T}_S(z_{f,i}|z_i^*) + \epsilon_{f,i} \quad (3.2)$$

$$\tilde{T}_{f,i} = (1 - \gamma_I - \gamma_S)(T(z_{f,i}) + r(T(z_{f,i}))) + \gamma_I \tilde{T}_I(z_{f,i}|z_i^*) + \gamma_S \tilde{T}_S(z_{f,i}|z_i^*) + \epsilon_{f,i} \quad (3.3)$$

In these equations, $\tilde{T}_{f,i}$ denotes the forecasts of the taxes due by the hypothetical taxpayer. Individual respondents are indexed by i , and iterations of the hypothetical taxpayer question are indexed by f . We model tax forecasts as a convex combination of three possible models of tax perceptions. We include the ironing and spotlighting forecasts as defined in Section 2.1. We generate the ironing forecast ($\tilde{T}_I(z_{f,i}|z_i^*) = \frac{T(z_i^*)}{z_i^*} \cdot z_{f,i}$) by calculating the individual’s federal tax due based on all reported information, dividing that by their reported income to generate an average tax rate, and multiplying that average tax rate by the hypothetical income assigned to Fred ($z_{f,i}$). We generate the spotlighting forecast ($\tilde{T}_S(z_{f,i}|z_i^*) = T(z_i^*) + T'(z_i^*) \cdot (z_{f,i} - z_i^*)$) by

calculating the individual's federal tax due based on all reported information, and then adding to that the product of their statutory marginal tax rate and the difference between Fred's income and their own. In equation (3.2), we estimate a model in which aggregate tax forecasts are formed by a mixture of these two heuristics and the true tax liability ($T(z_{f,i})$). In equation (3.3), this latter term is augmented to $T(z_{f,i}) + r(T(z_{f,i}))$, denoting the true tax due plus a *residual misperception function*. By including this term and estimating it with a flexible functional form, we can separately identify our candidate heuristics from general misperceptions of the tax schedule not attributed to the models defined above. In the estimates we present below, we model the residual misperception function as a fifth-order polynomial.

Table 2 presents non-linear least squares estimates of these models. Columns 1 and 3 present estimates of equation 3.2. Columns 2 and 4 present estimates of equation 3.3, integrating the residual misperception function into the analysis. Standard errors are clustered at the respondent level. Column 4 is our preferred specification because it utilizes all randomly sampled data and includes the residual misperception function.

The first two columns, which estimate the model from the mid-range sampling distribution, show a substantial weight on the ironing heuristic. In column 1, the point estimate implies 21% weight on the ironing heuristic. However, the point estimate on the spotlighting forecast is negative 9%—outside the range of valid probability values, and marginally significantly so. We view the estimation of invalid probabilities for heuristic propensity as evidence of model misspecification, and a demonstration of the difficulty of inference in this setting when non-income-dependent misperceptions are not accommodated.²² Illustrating that point, when the residual misperception function is included in this estimation in column 2, weight on the spotlighting heuristic becomes statistically indistinguishable from zero, while weight on the ironing heuristic increases to 29%. The contrast of columns 1 and 2 demonstrates the importance of allowing for residual misperceptions when estimating the propensity of these heuristics: since these heuristics can change the level of aggregate tax forecasts, their identification can be confounded with level effects when residual misperception is not accommodated.

In columns 3 and 4, we repeat the estimation exercise of columns 1 and 2 using the full sampling distribution. In these specifications, we again find substantial weight on the ironing forecast and effectively zero weight on the spotlighting forecast. In the fourth column, which includes a residual misperception function and utilizes all randomly sampled forecasts, we estimate an ironing propensity of 43% (clustered s.e. = 9.5%) and a spotlighting propensity indistinguishable from zero (−2%, clustered s.e. = 7.6%). This estimated ironing propensity is somewhat larger than, but statistically indistinguishable from, the estimate of 29% derived from mid-range forecasts. In sum, this analysis strongly supports the presence of a large subpopulation of ironers and provides no evidence supporting the presence of spotlighters.²³

Interpreting residual misperceptions: The estimates of our mixture model suggest that reliance on the ironing heuristic is common, but not universal. We now turn to characterizing the residual misperceptions held by those who do not iron.

22. To rationalize this result and illustrate the confound introduced by excluding controls for residual misperceptions, recall that we found systematic overestimation of the taxes due across the mid-range income distribution. Quantitatively, this overestimation cannot be generated by ironing. But because the spotlighting heuristic generates underestimation of taxes due outside of one's own bracket, placing negative weight on this heuristic is a simple way for the model to approximate our finding of systematic overestimation of tax levels.

23. Some readers may worry that our finding of near-zero spotlighting is driven by one extreme feature of a spotlihter's forecasts: predictions of negative tax liability for comparatively very low incomes. As we demonstrate in [Supplementary Appendix Table A3](#), this feature has little impact on our estimates. In that table, we recreate the analysis of Table 2, but replace spotlighters forecasts of negative tax liability with a forecast of zero tax liability. We find that this different coding has a negligible impact on our point estimates.

TABLE 2
Parameter estimates of heuristic-perception model

	(1)	(2)	(3)	(4)
γ_I : weight on ironing forecast	0.21*** (0.037)	0.29*** (0.052)	0.47*** (0.048)	0.43*** (0.095)
γ_S : weight on spotlighting forecast	-0.09* (0.050)	-0.02 (0.057)	-0.03 (0.062)	-0.02 (0.076)
Residual misperception function included	No	Yes	No	Yes
Income sampling distribution	Mid	Mid	Full	Full
Respondents	4,197	4,197	4,197	4,197
Forecasts	41,970	41,970	58,758	58,758

Notes: Standard errors, clustered by respondent, in parentheses. Presented are non-linear least squares estimates of ironing and spotlighting propensity. The estimated residual misperception function from columns 2 and 4 is plotted in Figure 4. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

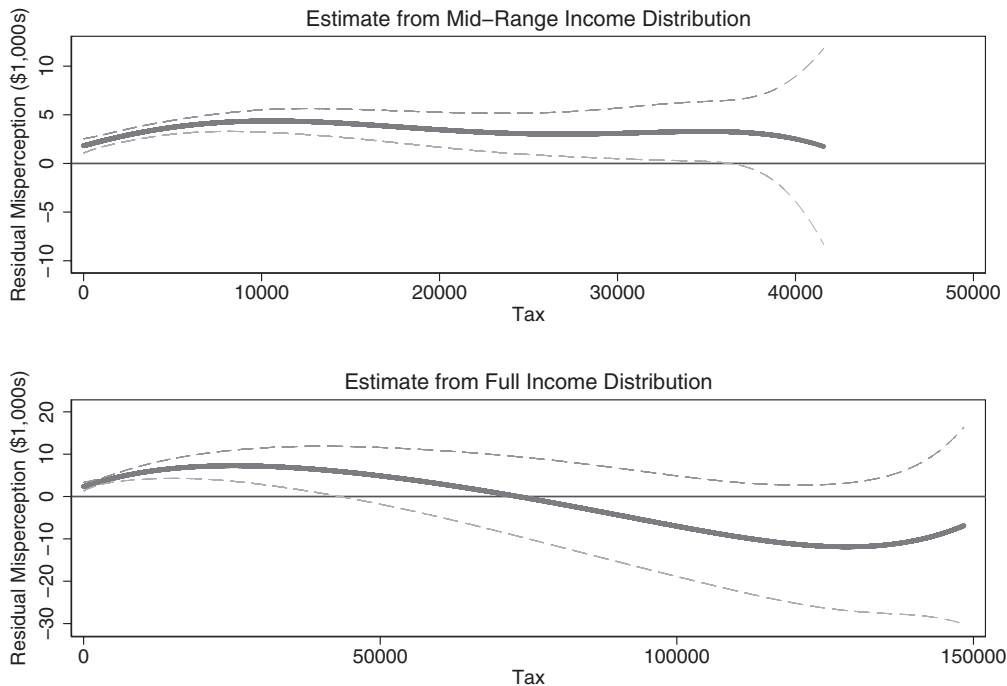


FIGURE 4
Estimates of residual tax misperception

Notes: This figure plots the residual misperception functions estimated in columns 2 and 4 of Table 2. Dashed lines indicate the boundaries of 95% confidence intervals. These estimates indicate systematic overestimation of the taxes due when true taxes are comparatively small. For sufficiently large tax liabilities, this bias reverses into systematic underestimation of the taxes due.

Figure 4 plots the estimates of the residual misperception function generated in the regressions of Table 2. The top panel presents the estimates generated from the mid-range sampling distribution. Residual misperceptions over the mid-range sampling distribution are characterized by a reasonably uniform overestimation of taxes due. The bottom panel presents the estimates incorporating the high-income sampling distribution. We again observe relatively stable overestimation over comparatively low tax bills. However this eventually transitions

to (statistically insignificant) underestimation of higher tax burdens. Taken at face value, the initial upward slope of residual misperceptions implies overestimation of the MTRs associated with comparatively small tax bills. The gradual downward slope that follows implies modest underestimation of the MTRs associated with large tax bills.

It is noteworthy that this simple representation of residual misperceptions arises despite its specification as a fifth-order polynomial. Our estimation procedure is capable of detecting substantial nonlinearity in residual misperceptions if they are present, but these analyses suggest that the misperceptions that remain are comparatively simple in structure. Because the residual is so simple in structure, our estimated heuristic propensities are insensitive to the parameterization of the residual misperception function. Re-estimating equation 3.3 with the residual misperception function specified as any polynomial of orders 1 through 10 results in estimated heuristic propensities within two percentage points of the estimates reported in Table 2 (see [Supplementary Appendix Table A4](#)). Estimates change more meaningfully when misperceptions are not included or are assumed to be constant, but these results suggest that a first-order polynomial is sufficient to remove the confounding influence of residual factors.

Care is needed in interpreting our estimates of residual misperceptions. When designing our estimation strategy, this component was included to capture any apparent non-scheduling misperceptions, either real or spurious. As examples of the latter category, note that a spurious appearance of misunderstanding of progressivity could arise under certain structures of nonclassical measurement error. Similarly, apparent forecasting bias may arise if respondents improperly treat our survey questions as if they ask about a tax filer more complex than the one considered. Similar bias would arise if respondents integrate tax burden from non-federal sources, such as state or FICA taxes. It is a crucial feature of our approach that such confounds result in perturbations of the form modelled by our residual misperception function, and thus are controlled for in a manner that removes their influence from the estimates of the scheduling heuristics' propensity. However, interpretation of residual misperception function must be conducted under the caveat that its shape may be influenced by such non-externally valid features. Consequently, out-of-sample predictive power of this component of the mixture model may fail.

Summary: When estimating our structural model of misperceptions, we find evidence of widespread reliance on the ironing heuristic and no evidence of reliance on the spotlighting heuristic. Our preferred specification implies 43% weight on ironing, no weight on spotlighting, and residual over-estimation of tax burdens that stays fairly constant throughout the income distribution but eventually turns to underestimation for very high incomes.

3.3.3. Ironing explains estimates of MTR misperceptions. Our approach to estimating heuristic propensity relies on forecasts of taxes due over a wide range of incomes. While such data are useful for identification, optimal response to tax policy is often contingent only on “local” knowledge of the tax schedule, and specifically knowledge of one’s own MTR. Because individuals have more reason to learn about taxes on incomes close to their own, a reasonable reader may worry that models estimated using tax forecasts over a wide range of income provide a misleading depiction of MTR misperceptions. In this subsection, we assess the degree to which our estimated model accounts for these local perceptions, and evaluate goodness of fit when the predictions are only based on our estimates of ironing propensity.

To address these questions, we assess the ability of our estimated model to fit the model-free estimate of own-bracket MTR underestimation reported in Table 1. We do this both by estimating our model using the full sample of income draws, and also using only the income draws that lie outside of the respondent’s tax bracket.

TABLE 3
Assessing models' fit of MTR perceptions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Model-free	Preferred specification				Out-of-sample ests.	
Ironing		X	X	X	X	X	X
Resid. misperceptions		X	X		X	X	
Spotlighting		X			X		
Scale of slope (β)	0.81 (0.044)	0.86 (0.020)	0.86 (0.024)	0.81 (0.040)	0.87 (0.019)	0.86 (0.025)	0.80 (0.042)
Diff from model-free β		0.056	0.055	0.008	0.062	0.057	0.006
p -value of H_0 : diff = 0		0.149	0.189	0.901	0.124	0.187	0.928

Notes: This table compares the degree of MTR underestimation found empirically to that which would arise from our preferred specification of our empirical model. As a model-free baseline for comparison, column 1 reports the scaling parameter estimated in the top panel of Table 1. Columns 2–4 present estimates of the scaling parameter predicted to arise under our estimated mixture model, progressively eliminating components of the model across columns. Columns 5–7 conduct an analogous exercise, but exclude local draws from the data used to estimate the forecasting model, and tests the ability of non-local forecasts to inform predictions of local tax understanding. Bootstrapped standard errors, resampled by subject with 1,000 iterations, in parentheses.

As repeated in the first column of Table 3, we found that perceptions of the slope of respondents' own tax bracket was scaled by a factor of 0.81, indicating an average underestimation of MTRs. In column 2, we re-estimate this regression while replacing respondents' actual forecasts with the forecasts predicted by the preferred specification of our model. We find a resulting scaling parameter of 0.86, quantitatively similar to (and statistically indistinguishable from) the model-free baseline.

To what degree do the different components of the mixture model contribute to this fit? Moving across columns 2 through 4, we progressively remove model components and reassess the fit to MTR perceptions. In column 3, we replace our MTR forecasts with those based on the estimated ironing propensity and residual misperception function, but setting the propensity for spotlighting equal to zero. We find that this has no meaningful effect on the resulting scaling parameter, consistent with the statistical insignificance of our estimate of spotlighting's propensity. In column 4, we further restrict the model to remove the influence of the residual misperception function: we forecast MTRs based on a 43% propensity to use the ironing heuristic, with remaining weight placed on the true tax forecast. In this analysis, we find that the resulting scaling of MTRs precisely matches that in the model-free baseline, with a statistically insignificant difference of less than one percentage point. In summary, accounting for ironing alone allows a quantitatively precise forecast of MTR perceptions.

The comparisons conducted above help assess the fit of our estimated model. However, this test of fit is explicitly within-sample: forecasts of taxes due in one's own bracket are used both for the estimation of the model and in the model-free validation. To provide a more stringent test of our model's ability to capture MTR perceptions, we construct an analogous out-of-sample test of fit. We re-estimate our model while excluding all data from respondents' own tax brackets.²⁴ We then use the estimated model to forecast tax perceptions within respondents' own brackets, and again compare the scaling. As shown in columns 5–7, this analysis yields results nearly identical to those in the within-sample exercise. Importantly, a simple model consisting of only ironers and correct forecasters predicts the scaling of MTRs to within a percentage point.

24. Compared to column 4 of Table 2, this restriction results in extremely similar estimates of heuristic propensity. We estimate an ironing propensity of 0.46 (clustered s.e. = 0.101) and a spotlighting propensity -0.04 (clustered s.e. = 0.079), and thus see differences of no more than 0.03 from the values in our preferred specification.

Summary: A simple mixture model of ironers and correct forecasters accurately predicts MTR misperceptions.

3.3.4. Heterogeneity analysis. The results of Table 2 suggest that aggregate tax misperceptions can be rationalized by placing significant weight on the ironing forecast. This is perhaps most naturally interpreted through a heterogeneous model in which some individuals have accurate beliefs (or accurate beliefs up to the perturbation of the residual misperception function) and some individuals employ the ironing heuristic. In such a model, our estimated coefficients may be interpreted as the propensity of use for each of the candidate forecasting rules. However, in principle our results could alternatively be rationalized by a homogeneous decision rule that places some weight on the truth and some weight on the ironing heuristic. While we believe that such a model would be difficult to psychologically motivate, we present individual-level estimates of our model to help rule out this possibility.

To begin, we estimate equation 3.2 at the individual level for each of the 3,552 respondents facing a non-zero tax rate.²⁵ Figure 5 plots a kernel-density estimate of the distribution of estimated individual classifications. In general, this distribution is quite diffuse. This is to be expected, since estimating two parameters from only 14 tax forecasts would lead to a distribution of point-estimates that is influenced by both the true parameters and individual estimation error. Notice, however, that the resulting estimates yield a sharply bimodal distribution. As illustrated in the figure, the peaks of this distribution correspond to the parameter values describing those relying fully on the ironing forecast and those relying fully on the correct tax forecast. Consistent with earlier analyses, no excess mass is seen at the parameter values corresponding to full reliance on the spotlighting forecast. While this analysis cannot rule out the existence of some intermediate cases, this distribution is consistent with a substantial population of pure ironers, in the sense intended by Liebman and Zeckhauser's (2004) presentation of the heuristic.²⁶

We can also perform the same estimation exercise while restricting individual-level parameter estimates to valid probabilities. To do so, we evaluate equation 3.2 over a grid of probability values and assign individuals to the grid point that minimizes the mean squared error of their forecasts. We again see strong support for the existence of pure types: 33% of respondents are classified as "true tax" forecasters, 33% are classified as pure ironing forecasters, 2% are classified as pure spotlighters, and the remainder are estimated at intermediate values. Similar results are obtained by repeating the analogue of this exercise that applies the model and data restrictions of each column of Table 2 (all such analyses are reported in Supplementary Appendix Tables A5–A8).

The individual classifications produced by this procedure help in determining which groups' tax perceptions respond to average tax rates. In Figure 6, we plot approximations of the average perceived tax schedule (analogous to Figure 2) separately for those who are "close" to being

25. Notice that for individuals facing zero tax, the ironing and spotlighting heuristics yield the same forecast, and are thus not separately identified.

26. Similar figures can be generated estimating equation 3.3, and by restricting the estimation sample to only the mid-range income distribution. In Supplementary Appendix Figure A1, we reproduce Figure 5 while applying the restrictions for each of the columns in Table 2. Since we cannot estimate residual misperceptions at the individual level, we use the estimated residual misperception function from the analysis of Table 2. Across all specifications, we continue to find a large mass at $\gamma_I = 1, \gamma_S = 0$, indicating that our inference about the existence of pure ironers is not confounded by the residual misperception function. However, when residual misperceptions are included, the density around $\gamma_I = 0, \gamma_S = 0$ is reduced by approximately half. This can be rationalized by interpreting the residual misperception function not as a literal forecasting rule by a pure "type," but as an approximation to heterogeneous remaining misperceptions beyond the heuristics we study.

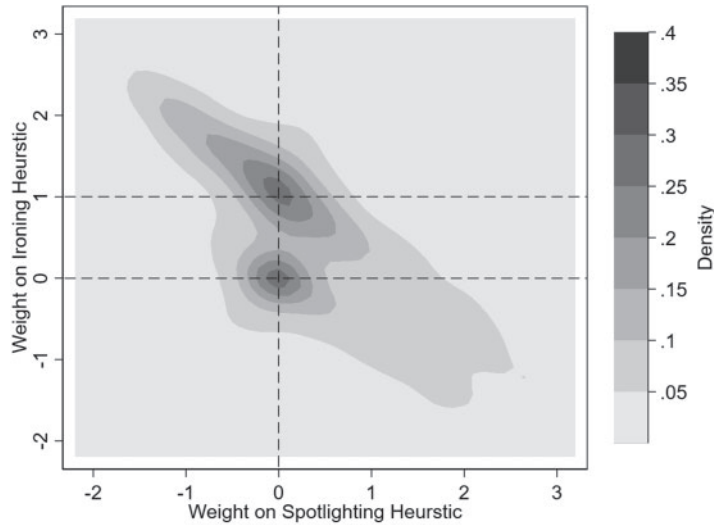


FIGURE 5

Individual-specific estimates of heuristic propensity

Notes: This figure presents a kernel-density estimate of the joint distribution of individual-specific ironing and spotlighting parameters, as estimated in the exercise described in Section 3.3.2. Note that individual-level NLLS regressions failed to converge for seven respondents. Bandwidth: 0.2. Kernel: Gaussian.

classified as ironers (specifically, $\hat{\gamma}_I \in [0.6, 1.4]$ and $\hat{\gamma}_S \in [-0.4, 0.4]$) and those who are not.²⁷ Within each group, we separately plot the perceived tax schedule for those above and below median income. Among those not classified as ironers, the average perceived tax schedules for the comparatively high and low income are nearly identical. In contrast, among those classified as ironers, perceptions are notably different across income groups. The perceived schedules are approximately linear, and come quite close to intersecting the true tax schedule evaluated at the average income for the group. In short, those labelled as ironers by our classification procedure have perceptions that satisfy the model’s core predictions.

3.3.5. Summary of robustness analyses. In [Supplementary Appendix B](#), we conduct extensive robustness checks on the sensitivity of our estimates to a variety of sample restrictions. Our empirical results persist when analysing taxpayers with comparatively high incentives for accurate tax knowledge such as the employed, those who complete their returns without outside assistance, and those of comparatively high income. Our results persist among respondents who might be suspected to be debiased, such as those who complete our survey after tax day, those of comparatively high age (and thus comparatively high experience with the tax system), or those of comparatively high confidence in their answers.

Our results are also robust to several possibilities for misunderstanding of the survey prompt. Allowing for the possibility that respondents’ forecasts reflected their beliefs about not just federal income taxes but the sum of federal and state and/or payroll taxes does not change our estimates of ironing propensity. This is because such misunderstandings take a structural form accounted for with the residual misperception function. Our results are also robust to restrictions of the sample to those whose tax returns are and are not “simple” like those of the hypothetical taxpayer Fred.

27. Figure 6 presents results for married filing jointly filers, the most common filing status in our data. Analysis of single filers, with very similar results, is available in [Supplementary Appendix Figure A2](#).

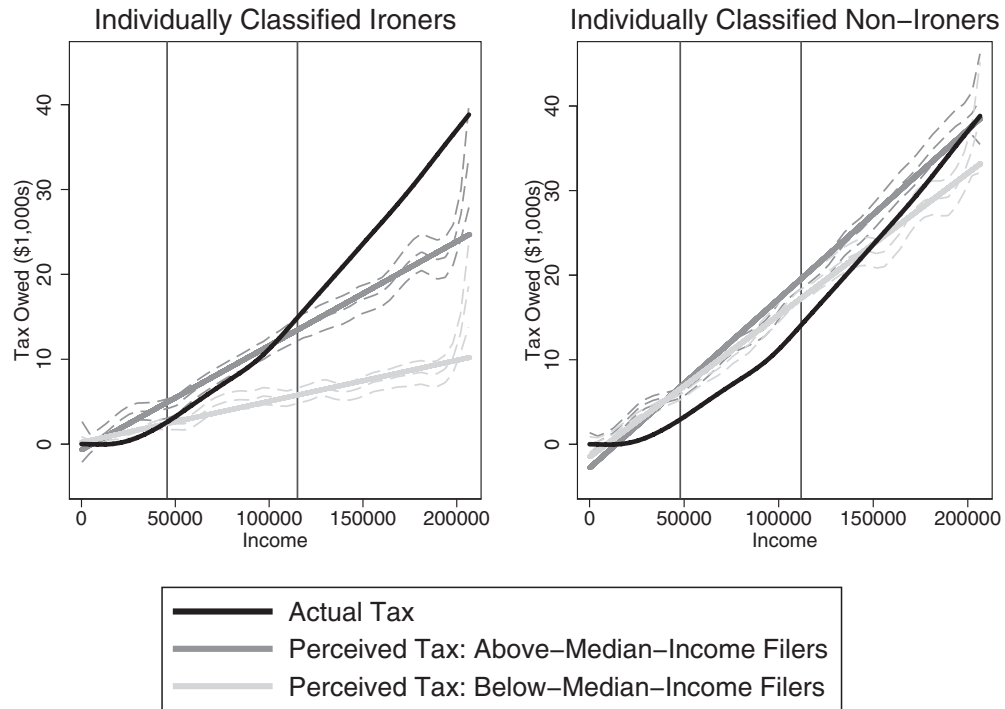


FIGURE 6

Examining perceived tax schedules by individual classification

Notes: This figure presents approximations of the perceived relationship between the income earned and taxes owed, as previously shown in Figure 2, plotted by classification of “ironers” and “non-ironers” from Figure 5. Results shown are for married-filing-jointly tax filers. “Ironers” are classified as individuals with an ironing parameter within 0.4 of 1 and spotlighting parameter within 0.4 of 0. For each panel, we separately plot the perceived tax schedule for above and below median filers (conditional on having non-zero tax), with the vertical lines indicating the average income within each group. Dashed lines indicate the local polynomial fits with 95% confidence intervals (bandwidth: 10,000. Degree of polynomial: 2. Kernel: Epanechnikov), and solid lines indicate fitted linear models.

Finally, our results are also robust to alternative treatments of inattentive respondents and Winsorization schemes.

Across the restrictions we consider, the estimated subgroup propensity to iron ranges from 24% to 58%, indicating widespread and cross-group prevalence. Across these robustness checks, we continue to find no evidence of spotlighting.

4. STUDY 2: INFERRING IRONING FROM CHOICE DATA

A key feature of Study 1 is that it examines perceptions of the actual U.S. income tax schedule. However, an important limitation is that we cannot directly verify that individuals indeed act on the beliefs that they state. To partially address this limitation, we conducted a complementary online experiment in which participants’ perceptions of the marginal tax rates can be directly revealed by their behaviour. Beyond utilizing choice data, the online experiment has several other desirable features. First, the experiment uses a different source of identifying variation. Rather than utilizing naturally occurring variation in participants’ tax rates, the experiment induced truly exogenous variation in average and marginal tax rates by varying the tax schedules that participants faced. Second, the experiment allows us to examine the extent to which scheduling might be endogenous to the complexity of the tax schedule. Third, the experiment focuses participants on

decisions about incremental changes to their taxable income, rather than focusing them on total tax paid—a framing manipulation that could in principle induce more attention to marginal tax rates. Fourth, the experiment also changes the frame by focusing individuals on after-tax income rather than on the taxes themselves.

Our experiment was [preregistered](#) on [aspredicted.com](#). We report how we determined sample size, all data exclusions, all manipulations, and all measures below. The full experimental protocol is available in the Supplementary Survey Appendix.

4.1. *Experimental design*

We designed the experiment to mimic a marginal earnings decision made shortly after receiving feedback on tax payment. Concretely, imagine a worker who has recently examined a paystub or entered their earnings information into tax preparation software such as TurboTax. As in this example, our experiment presents subjects with salient and clear information about the total tax and average taxes paid. After viewing this information, the subject makes a decision of whether to allocate a bonus to a taxable or non-taxable account. As we explain below, this decision allows us to infer individuals’ perceived MTR from their choices. When making this decision, information about the full tax code is available costlessly, but there are no reminders to consider marginal tax rates.

4.1.1. Summary of experimental protocol. The experiment began with a standard elicitation of informed consent and a CAPTCHA task. After this introduction, participants were presented with a summary of the task they would face and an initial presentation of the tax schedule. The schedule is randomly generated according to criteria we describe in detail later in this section. Figure 7 presents this screen.

As a reward for completing this study, you will receive a bonus. Your reward comes in two accounts, A and B.

We impose a tax on your earnings in account A, but not on your earnings in account B. Your final bonus will be the sum of the after-tax amounts from the two accounts. You will face choices on the next screen about how much we will put in each account. The tax that applies to account A is as follows:

# cents in A	10	20	30	40	50	60	70	80	90	100
Tax (in cents)	5	10	15	20	27	34	41	48	55	62

Once you have read these instructions, please answer the question below. You must answer this question correctly to proceed with this study.

FIGURE 7
Screenshot of tax schedules in Study 2

Notes: Screenshot of the presentation of tax schedules in Study 2.

After this explanation, participants were asked a basic comprehension question that tested their understanding of which accounts were taxable. Participants were not able to proceed with the experiment if they failed either this comprehension test or the CAPTCHA.

Participants were then told that, as a baseline, they are given 40 cents in account A and 60 cents in account B. For each account, we presented the total tax on the earnings and the effective (average) tax rate on the earnings. In the example provided in Figure 7, this prompt would have indicated 20 cents of tax and a 50% effective tax rate on account A. The tax amount and rate for account B were always 0 and 0%, respectively. We used the language “effective tax rate” in lieu of “average tax rate” to be consistent with the language used by tax preparation software such as TurboTax. The presentation of both the absolute tax and the average tax rate also mimics the summary screen of such tax preparation software.

Immediately after the summary, we included a button that, if clicked, would display the tax table again on the screen for use while participants make their decisions. This provides an additional measure of the number of participants who thought that additional information beyond the ATR was necessary. Because some participants could have clicked the button without an intention to actually study the tax table, we think that it is best to regard the propensity to click on the button as an upper bound on how many participants felt it was necessary to consult the tax table to make their decision.

On that same screen, participants were asked to make 12 decisions about additional money to be placed in the taxable and non-taxable accounts. These decisions were made in a multiple-price-list (MPL) format. In each decision, one option was adding 20 cents pre-tax to account A. The other option was a non-constant amount of earnings in account B, with the payment (in cents) taking the values $\{0, 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21\}$.

Following this decision, participants faced a common attention check and a battery of demographics questions. After these questions, one of the twelve MPL decisions was randomly selected and final compensation was determined based on that decision and reported to the subject.

4.1.2. Variation in tax schedules. We generated exogenous variation in the ATR and MTR, as well as in schedule complexity, by randomly assigning participants to one of fifty-four tax schedules. Half of these schedules were *simple*: they consisted of two brackets for income ranges $[0, 40]$ and $[40, 100]$. Half of the schedules were *complex*: they consisted of five brackets for income ranges $[0, 20]$, $[20, 40]$, $[40, 60]$, $[60, 80]$, and $[80, 100]$.

For each MTR/ATR pair, there was a unique simple schedule and a unique complex schedule constructed to feature those rates. For simple schedules, the rate in the first bracket determines the ATR and the rate in the second bracket determines the MTR. For complex schedules, we set the rate in the first two brackets to $ATR - 0.05$ and $ATR + 0.05$, respectively, averaging to the ATR. The rate in the third bracket, which governs the marginal incentives for the relevant decision in the study, is set to the desired MTR. The fourth and fifth brackets have rates of $MTR + 0.05$ and $MTR + 0.10$, respectively.

Our (ATR, MTR) combinations were generated by sampling sets of three schedules. Each set of three schedules had the form $\{(ATR_0, MTR_0), (ATR_0 + 0.3, MTR_0), (ATR_0 + 0.3, MTR_0 + 0.3)\}$. Within each set, there are large and exogenous differences in both the ATR and the MTR, which facilitates high-powered estimation of reliance on average versus marginal tax rates. To make sure that our results were not tied to any particular set, we generated nine such sets by drawing a value of ATR_0 and MTR_0 from the set $\{0.2, 0.3, 0.4\}$, uniformly and with replacement. Because we sampled with replacement, 26% of the two-bracket schedules had the same tax rate in both

brackets, and 15% of the five-bracket schedules had the same tax rate in the second and third bracket.

4.1.3. Quantifying revealed-perceived MTRs. We generate our measure of “revealed-perceived MTRs” using decisions in the MPL. If the participant chooses the option that he thinks has the highest financial payoff, answers in the MPL set-identify the perceived MTR. For example, if the participant perceived that the MTR was 0.2, he would expect to earn 16 cents post-tax if 20 cents are placed in account A. He should thus prefer to receive the bonus in account B if the amount offered is 17, 19, or 21 cents, and would take the bonus in account A otherwise. This pattern of decisions would imply that $(1 - \widetilde{\text{MTR}}) * 20 \geq 15$ and $(1 - \widetilde{\text{MTR}}) * 20 \leq 17$, allowing us to infer that $\widetilde{\text{MTR}} \in [0.15, 0.25]$. This measure of perceived MTR is our object of interest in this experiment. In principle, one could use approaches such as interval regression to analyse this dependent variable, as we do in [Supplementary Appendix C](#). However, the identified intervals are sufficiently narrow that assigning responses to their midpoint (*e.g.*, to 0.2 in the example) and relying on OLS regressions yields essentially identical results. In the body of the paper, we report OLS regressions with midpoint coding of the dependent variable.²⁸

This method of identifying revealed-perceived MTRs was previously applied in the experimental work of [de Bartolome \(1995\)](#). In that experiment, participants were presented with a single tax schedule and a comparatively coarse MPL, and the analysis revealed that a relatively large number of respondents had perceived MTRs in the bin that contained the ATR. This analysis is suggestive of ironing. However, participants who simply underestimate the MTR without relying on the ironing heuristic could similarly fall in that bin, as could participants who are inattentive to the tax schedule and either choose randomly or rely on some other rule of thumb. Variation in the ATR and MTR, as in our experiment, is crucial for separately identifying ironing from possibilities such as these.

4.2. *Sample for analysis and dataset preparation*

Our study ran on Amazon Mechanical Turk in December of 2018 and January of 2019. During this time, we collected 4,582 complete responses. We preregistered three exclusion criteria for our sample. First, we exclude any subjects who failed the attention check included at the end of the study. This requirement screens 714 responses (15.58% of the initial sample). Second, we exclude any subjects with MPL responses inconsistent with monotone preferences (*i.e.* not exhibiting a single switching point). This requirement screens an additional 179 responses (4.63% of the remaining sample). Finally, we included “trick” options at both ends of the MPL: one offering zero cents in the tax-free account (which should not be preferred unless one expects a 100%+ tax rate) and one offering twenty-one cents in the tax-free account (which should always be chosen unless one expects negative tax rates). We exclude subjects who do not take the dominant option for each, screening an additional 559 responses (15.15% of the remaining sample). These exclusions yield a final sample of 3,130 responses, closely in line with our preregistered target of 3,000. Our primary sample is comprised of 53% women, has a median age of 35, and has a median income in the range of \$40,000–\$49,999.

We chose to preregister these stringent inclusion criteria because we are most interested in analysing the responses of attentive subjects who show clear understanding of the task at

28. For participants who preferred 1 cent in the untaxed account over 20 cents in the taxable account, we code the revealed-perceived MTR interval to be $[0.95, 1]$, and the midpoint to be 0.975. For participants who preferred 20 cents in the taxable account over 19 cents in the untaxed account, we code the interval as $[0, 0.05]$ and the midpoint as 0.025.

hand. Of course, analysing even those who fail to meet that bar can be of interest, although we note that inattention to, or lack of comprehension of, our experiment need not be an externally valid indication of problems with understanding real tax systems. [Supplementary Appendix C](#) reproduces our results with inattentive responses re-included.

4.3. Results

Our core, pre-registered analysis estimates the regression $\widetilde{\text{MTR}}_i = \alpha + \beta_1 \text{MTR}_i + \beta_2 \text{ATR}_i + \epsilon_i$. Viewed through the lens of our empirical model, β_2 identifies the fraction ironing and β_1 identifies the fraction responding to MTRs. As discussed in Section 2.2, spotlighting and correct forecasting are not separately identifiable when examining only local forecasts, and thus β_1 estimates the pooled propensity of either behaviour. The constant term captures the average revealed-perceived MTR of those not responding to the true MTR or ATR, scaled by $(1 - \beta_1 - \beta_2)$. The behaviour of these remaining filers may be thought of as a rule-of-thumb that is relied on without reference to the schedule, consistent with inattention to taxes as in [Chetty *et al.* \(2009\)](#) and [Taubinsky and Rees-Jones \(2018\)](#).

Column 1 of Table 4 presents the results of this regression. Our estimate of the coefficient on ATR is consistent with 35% of our sample applying the ironing heuristic (s.e. = 2 p.p.). In contrast, our estimate of the coefficient on MTR is consistent with only 9% of the sample responding to this feature of the schedule (s.e. = 2 p.p.). Among the 44% of respondents who respond to one of the randomly varied features of the schedule, 79% respond to the ATR. Consistent with Study 1, these results suggests a remarkably high reliance on the ironing heuristic.

A strong prediction of our empirical model, consistent with the mixture model interpretation, is that the revealed-perceived marginal tax rates should increase linearly with the ATR and MTR. Consistent with this prediction, we find no evidence of nonlinear relationships. Comparing the fit of our preferred model to one with a dummy variable for each discrete level of ATR and MTR, we find no meaningful improvement (see [Supplementary Appendix Table 10](#)). A likelihood ratio test fails to reject the null of the linear model ($p = 0.417$), providing support for the functional form assumptions of our estimating equation.²⁹

Across the remaining columns of Table 4, we examine the sensitivity of the estimates to several different subsample restrictions. First, we provide separate estimates for “simple” (column 2) and “complex” schedules (column 3). Point estimates do not differ substantially across these samples; column 4 presents the estimated differences and standard errors from the fully interacted model and finds no significant differences. Furthermore, a likelihood ratio test fails to reject the null of the non-interacted model ($p = 0.164$). These results show no support for tax schedule complexity affecting the propensity to iron.

Next, we split our results by whether participants re-examined the tax table when given the opportunity. Interestingly, only 46% of participants chose to do so. And we continue to find substantial prevalence of ironing even among those reexamining the tax table; indeed, these subjects are marginally statistically significantly *more* likely to iron. But consistent with some participants choosing to inattentively rely on rules of thumb instead of examining the tax schedules, we do see that those who clicked have a statistically significantly smaller constant term.³⁰ Overall, these results show that many participants rely on the ironing heuristic without

29. [Supplementary Appendix Figure A3](#) plots the residualized relationship between average perceived tax rates and each of ATR (controlling for MTR) and MTR (controlling for ATR). The relationship appears remarkably linear when visually assessed.

30. The fact that the coefficients on the ATR and MTR still do not sum to one even for the subsample that clicked on the tax schedule is consistent with some participants arbitrarily clicking on the tax table without an intention to engage

TABLE 4
Ironing propensity in Study 2

	(1)	(2)	(3)		(4)	(5)		(6)	(7)
	Full sample	Simple	By complexity		Diff.	Re-examined tax table		No	Diff.
			Simple	Complex		Yes	No		
ATR coefficients	0.35*** (0.02)	0.34*** (0.03)	0.36*** (0.03)	−0.02 (0.05)	−0.02 (0.05)	0.40*** (0.03)	0.31*** (0.03)	0.09* (0.05)	0.09* (0.05)
MTR coefficients	0.09*** (0.02)	0.07** (0.03)	0.12*** (0.03)	−0.05 (0.05)	−0.05 (0.05)	0.09** (0.03)	0.10*** (0.03)	−0.01 (0.05)	−0.01 (0.05)
Constant	0.28*** (0.01)	0.30*** (0.02)	0.26*** (0.02)	0.04 (0.03)	0.04 (0.03)	0.25*** (0.02)	0.31*** (0.02)	−0.06** (0.03)	−0.06** (0.03)
p: LR test					0.164				0.007
Fraction Ironing	0.79*** (0.05)	0.83*** (0.07)	0.75*** (0.06)			0.82*** (0.06)	0.76*** (0.07)		
Fraction using MTR	0.21*** (0.05)	0.17** (0.07)	0.25*** (0.06)			0.18*** (0.06)	0.24*** (0.07)		
N	3,130	1,571	1,559			1,431	1,699		

Notes: Standard errors in parentheses. Presented are OLS estimates of the impact of random variation in ATR and MTR on perceived marginal tax rates. Column 1 presents our primary estimates. Columns 2 and 3 present estimates when the data are restricted to simple or complex schedules, with column 4 presenting the estimated differences in a fully interacted model. Columns 5 and 6 present estimates when the data are restricted to subjects who did or did not re-examine the tax table when given the opportunity, with column 7 presenting the estimated differences in a fully interacted model. Likelihood ratio tests of the fully interacted models, compared against the non-interacted models, are presented below the estimates. In the lower panel, we classify the fraction of “responsive” subjects (defined as those reacting to either the MTR or the ATR) who appear to be ironing versus using the MTR. Fractions are calculated by dividing the relevant coefficient by the sum of the two coefficients, with standard errors calculated with the delta method. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

taking the time to look up the tax table to make an optimal decision, even when doing so is nearly costless. This is despite the fact that in our experiment, examining the tax table to compute the tax on the incremental 20 cents is not more computationally costly than multiplying one’s average tax rate by 20. This suggests that either ironing is an automatic and habitual way of representing the world, or that individuals are confident that the ironing representation is a good one.

Finally, and in analogue to our analysis in Study 1, we ask to what extent ironing provides a complete explanation of the individuals’ misperceptions. To do so, we first estimate a benchmark of “maximum explainable variation” (Kleinberg *et al.*, 2017). The explainable variation that is due to systematic behavioural responses to the differences in our tax schedules is simply the R^2 of the regression of perceived MTRs on the 54 dummies for our tax tables. Given our large sample size, we have on average approximately 60 participants per tax table, and we are thus able to estimate this statistic with a reasonable degree of precision. The sampling error resulting from a finite number of participants allocated to any given tax table leads to (in our case, small) overfitting problem which makes the R^2 estimate to be a slight upper bound on the maximum explainable variation. We estimate that the maximum explainable variation corresponds to $R^2 = 0.1055$.

We contrast this with the R^2 of the regression model in column 1 of Table 4, which we find to be 0.0924. This implies that the simple linear model explains over 87.5% of the explainable

with it. It is similarly consistent with some respondents clicking on the tax table, deciding it is too complex to parse, and then choosing to rely on some rule of thumb instead.

variation in the data. The economic content of this result is that relaxing the assumptions of linearity, additive separability, and invariance to the complexity of the tax schedule does not meaningfully increase explanatory power. Consistent with this, we find that a likelihood ratio test fails to reject the null of our simple linear model ($p = 0.69$).³¹

We provide a number of robustness checks of these results in [Supplementary Appendix C](#). In particular, we conduct analyses relaxing our inclusion criteria, we consider alternative definitions of “simple” and “complex” that correspond to exactly 1 or 4 kinks, respectively, and we examine interactions with demographic covariates. Across these tests, we find little deviation from the results of the primary specification reported here.

Summary: Consistent with the results of Study 1, we find prevalent ironing and little evidence of other misperceptions.

5. WELFARE IMPLICATIONS OF IRONING

In this section, we explore the quantitative importance of ironing for welfare calculations in standard models of intensive-margin earnings decisions and distortionary taxation. Our model has the general features of the canonical frameworks of [Mirrlees \(1971\)](#) and [Saez \(2001\)](#), modified to allow for misperceptions as in [Farhi and Gabaix \(2018\)](#).³² To keep exposition concise, we briefly provide intuition for the important theoretical consequences and we focus attention on quantitative estimates corresponding to our preferred model specification. In [Supplementary Appendix D](#), we provide formal analysis that corresponds to the theoretical claims summarized here.

5.1. Model and assumptions

5.1.1. Economic setting. Individuals have a utility function $U(c, l)$, where c is consumption and l is labour. Individuals produce $z = wl$ units of income for every l units of labour, where the wage w is drawn from an atomless distribution F . The government cannot observe earnings potential w , and is thus restricted to setting taxes $T(z)$ as a function of earnings z . More generally, and as in [Feldstein \(1995, 1999\)](#), this model serves as a model of taxable income choice. This encompasses, for example, decisions over tax-preferred activities such as charitable contributions.³³

Optimizing individuals choose $z^* \in \operatorname{argmax}\{U(z - T(z), z/w)\}$. Ironers choose $z^* \in \operatorname{argmax}\{U(z - A(z^*)z, z/w)\}$, where $A(z^*) = T(z^*)/z^*$ is the average tax rate. Notice that for ironers, z^* is a fixed point of a decision process in which misperceptions are possibly shaped by z^* , while at the same time z^* is a perceived optimum given those misperceptions.³⁴ In

31. [Supplementary Appendix Table A10](#) examines how relaxing each of the three assumptions of our linear model improves model fit.

32. These standard models are partial equilibrium models in the sense that they assume wages are fixed. Note that in a general equilibrium model, the presence of ironing could affect wages themselves, as well as the labour supply elasticity with respect to those wages.

33. See [Chetty \(2009\)](#) for some exceptions to this generalization, and [Slemrod and Kopczuk \(2002\)](#) for discussion of its impact on the interpretation of labour-supply elasticity.

34. [Farhi and Gabaix \(2018\)](#) and [Liebman and Zeckhauser \(2004\)](#) implicitly use this solution concept in their study of optimal income taxation. In [Supplementary Appendix D](#), we formalize the solution concept and characterize existence or uniqueness for the types of misperceptions that we estimate. The solution concept may be reformulated as a special-case of Berk–Nash equilibrium ([Esponda and Pouzo, 2016](#)) and, as such, can be microfounded as a steady state of a dynamic process in which individuals follow a myopic best-response strategy while learning through a misspecified model. To formally embed our model in the Berk–Nash framework, we must re-interpret $\tilde{T}(z|z^*)$ as the mean of the individual’s belief, while allowing the individual to have a sufficiently diffuse prior so that no outcomes are “surprises”. See also [Gabaix \(2014\)](#) for a general approach to modelling boundedly rational misperceptions of incentive schemes.

Supplementary Appendix D.1, we provide existence and uniqueness results as well as basic comparative statics for this solution concept.

The social welfare function is given by

$$\int U(z^*(w, 1_\gamma) - T(z^*(w, 1_\gamma)), z^*(w, 1_\gamma)/w) dH + \lambda \int T(z^*(w, 1_\gamma)) dH, \quad (5.4)$$

subject to $\int T(z^*(w, 1_\gamma)) dH \geq 0$, where $1_\gamma \in \{0, 1\}$ is an indicator for ironing, H is the joint distribution over wage and ironing types, and λ is the marginal value of public funds. Denote the social marginal welfare weight at the current tax system by $g(w, 1_\gamma) = U'_c/\lambda$.

5.1.2. Assumptions for numerical results. We parameterize individual utility according to the functional form $U(z) = \log(z - T(z) - \frac{(z/w)^{1+k}}{1+k})$, a commonly used specification in optimal tax studies (e.g., Atkinson, 1990; Diamond, 1998; Saez, 2001). We parameterize the tax function $T(z)$ according to the U.S. tax code in 2014—the tax code relevant for forecasts in Study 1. In this model, assuming correct tax perceptions, the structural labour supply elasticity is determined by $\frac{1}{k}$. When tax rates are misperceived, the elasticity with respect to wages must be scaled by the term $\frac{1-\tilde{T}'}{1-T'}$, which takes an average value of 1.02 in our data—thus, while the formal calculation of elasticity is not identical, quantitatively the difference is negligible. In simulations, we will vary the parameter k across values from 2 to 5, capturing elasticities ranging from approximately 0.2 to 0.5. In a recent meta-analysis of labour-supply elasticity estimates, Chetty *et al.* (2011) report a preferred estimate of the intensive-margin Hicksian elasticity of 0.33, approximately corresponding to $k=3$.

Contingent on these parameters, we calculate the wage parameter that rationalizes reported earnings for each individual in the dataset. An individual’s wage parameter can be calculated according to the equation $w = (\frac{z^k}{1-\tilde{T}'})^{\frac{1}{1+k}}$. Since this calculation depends on the individual’s perceived marginal tax rate \tilde{T}' , we calculate this value both under the assumption of ironing and under the assumption of correct forecasting.

When considering the consequences of a policy reform, we forecast the aggregate consequences of the individual reactions implied by the specified utility model and individual utility parameters. We forecast each individual’s predicted response contingent on being an ironer or a correct forecaster, applying the relevant estimated wage parameter in each case. We aggregate these individual responses by assuming that behaviour is determined by the ironing model with probability $\gamma=0.43$, and otherwise determined by the correct forecasting model. This estimate is drawn from our preferred specification in Study 1.³⁵ We generate analogues to 95% confidence intervals by alternatively assuming that $\gamma=0.25$ or $\gamma=0.62$ —the boundaries of the 95% confidence interval on ironing propensity in our preferred regression model.

5.2. Results

5.2.1. Implication 1: Government revenue increases due to ironing, and this revenue is raised progressively. Thus, ironing increases social welfare. When the tax schedule is progressive, marginal tax rates will be higher than average tax rates, and thus ironing will lead to underestimation of marginal tax rates. As established in de Bartolome (1995) for a linear income

35. While our primary estimate from Study 2 is quantitatively similar, we believe our Study 1 estimates are most appropriate for this exercise due to their focus specifically on perceptions of the U.S. tax code.

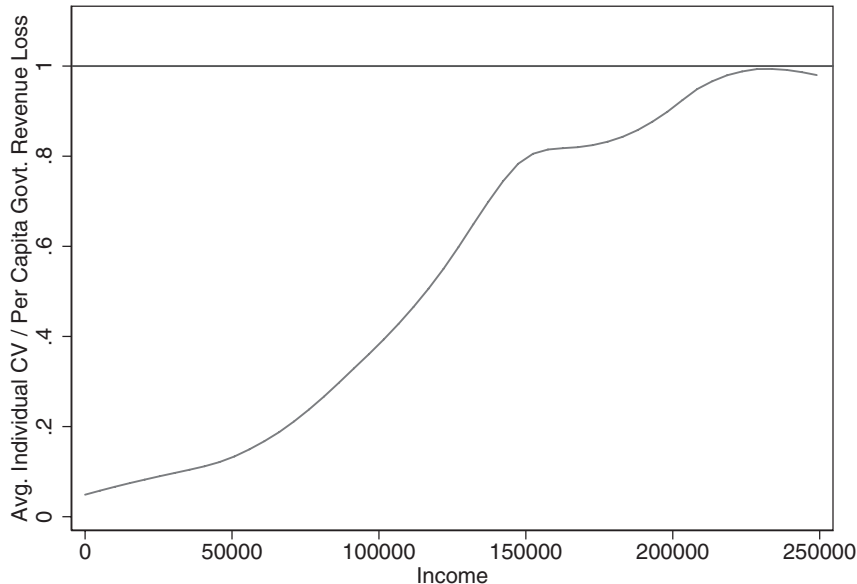


FIGURE 8

Consequences of debiasing across income distribution

Notes: This figure presents local polynomial estimates that summarize the consequences of ironing for progressivity. For each taxpayer, we calculate the compensating variation in income that would lead an ironing taxpayer to have the same utility level as achieved by a correct forecaster. The y-axis reports this value as a fraction of the per-capita loss of government revenue that arises from correcting ironing. Bandwidth: 25,000. Kernel: Epanechnikov.

tax, and in [Liebman and Zeckhauser \(2004\)](#) and [Supplementary Appendix D](#) more generally, this implies that labour earnings and thus government revenue will increase in the presence of ironers. Numerically, we find that under the U.S. tax schedule, our estimated ironing propensity leads to a 1.6–3.7% increase in government revenue (reported in column 2 of [Table 5](#)), depending on the labour supply elasticity. For our preferred elasticity of $\frac{1}{3}$, the revenue gain is 2.5% (95% CI: 1.5–3.7%).

While ironing raises revenue, it also generates individual misoptimization and therefore imposes costs on the affected individuals. Which individuals bear those costs significantly influences social welfare. In general, the cost of the mistake of ironing is proportional to a financial loss of $T'(z) - A(z)$, the difference between the marginal and average tax rates. To the extent that the difference between the marginal and average tax rate will increase with earned income, the financial burden of misoptimization will fall on the higher income individuals. For example, while the lowest income individuals will not misoptimize at all, the wedge will be substantial for the highest-income individuals of our sample.

[Figure 8](#) illustrates the estimated burden of misoptimization across different income levels, taking as given the structure of the U.S. income tax code and our estimates of ironing propensity. For each individual, we first calculate the compensating variation of ironing: that is, the amount of money that the individual would have to receive to be as well off ironing as he would be if he optimized with correct forecasts. We then plot the average compensating variation for each level of earnings, normalized by the population wide average of revenue generated by ironing on the right y-axis. This figure illustrates that the individual cost of misoptimization induced by ironing is increasing in income, and is generally well below the average revenue generated by its presence, suggesting the potential to exploit this bias and redistribute the extra government

TABLE 5
Revenue and welfare effects of ironing

Structural elasticity ($\frac{1}{k}$)	Increase in tax rev. (%)	Net welfare increase (%)		
		Low λ $\lambda = U'_{50}$	— $\lambda = \bar{U}'$	High λ $\lambda = U'_{90}$
1/2	3.7 [2.1, 5.3]	3.2 [1.8, 4.6]	3.4 [2.0, 4.9]	3.6 [2.1, 5.1]
1/3	2.5 [1.5, 3.7]	2.2 [1.3, 3.2]	2.3 [1.4, 3.4]	2.5 [1.4, 3.6]
1/4	1.9 [1.1, 2.8]	1.7 [1.0, 2.4]	1.8 [1.0, 2.6]	1.9 [1.1, 2.7]
1/5	1.6 [0.9, 2.3]	1.4 [0.8, 2.0]	1.4 [0.8, 2.1]	1.5 [0.9, 2.2]

Notes: The numbers presented contrast the revenue collected or welfare attained when comparing a population with perfect tax perceptions against one in which some portion of filers apply the ironing heuristic. The primary numbers presented are generated assuming that 43% of the population irons, as in our preferred specification. The bracketed numbers underneath present the calculation derived under the assumption that ironing propensity is either 25% or 62%—the boundaries of the 95% confidence interval of our preferred propensity estimate. The first column presents the structural elasticity in our assumed utility model: $U(z) = \log(z - T(z) - \frac{(z/w)^{1+k}}{1+k})$. The second column presents the additional government revenue collected when the ironers are present. The final three columns present estimates of the increase in social welfare attained due to the presence of ironers, under alternative assumptions on the cost of public funds. Welfare effects are expressed as the percentage of total tax revenues that a social planner would pay to avoid converting all ironers to correct forecasters.

revenue it provides in a welfare-enhancing manner. In short, the burden of ironing is starkly progressive.

The first two observations—that ironing counteracts the distortionary effects of taxation by raising earnings, and that it increases government revenue in a progressive fashion—lead to the implication that ironing leads to progressive revenue collection, which will typically be welfare-improving.

To quantify the impact of our estimated propensity of ironing on welfare, columns 3–5 of Table 5 present estimates of the fraction of current government revenue the social planner would pay to avoid reducing the rate of ironing to zero. Calculating social welfare requires specifying the value of public funds, λ . In our preferred specification, we adopt the standard assumption that λ is equal to the average marginal utility of consumption in the population.³⁶ To illustrate the sensitivity of results to that assumption, we additionally present results for a “low λ ” regime (in which we set λ to be equal to the 50th percentile of marginal utilities in our population) and a “high λ ” regime (in which we set λ to be equal to the 90th percentile of marginal utilities in our population). Across different assumed elasticities and values of public funds, we find that the improvement to social welfare realized from the presence of ironing is valued equivalently to an unfunded increase in government spending ranging from 1.4% to 3.6%, with 2.3% (95% CI: 1.4–3.4%) corresponding to our preferred specification. As compared to the raw increase in government revenue presented in column 2, this indicates that the welfare costs of individual misoptimization have a minimal offsetting effect to the additional spending funded by ironing.

5.2.2. Implication 2: Ironing increases the welfare benefits of progressive taxation.

As we have already shown, ironing results in progressive revenue generation when the income tax schedule is itself progressive. Note, however, that the presence of ironing becomes irrelevant

36. When calculating this average, we assume an income floor of \$6,000 to approximate the provision of social insurance that is outside of our current model.

TABLE 6
Revenue and welfare effects changing to flat tax

Structural elasticity ($\frac{1}{\bar{\epsilon}}$)	All correct forecasters		With ironers	
	Δ Tax Rev. (%)	Δ Welfare (%)	Δ Tax Rev. (%)	Δ Welfare (%)
1/2	5.2	-9.9	2.9 [3.9, 2.0]	-12.3 [-11.3, -13.4]
1/3	3.3	-11.6	1.9 [2.5, 1.2]	-13.2 [-12.5, -13.9]
1/4	2.5	-12.4	1.4 [1.8, 0.9]	-13.6 [-13.1, -14.1]
1/5	1.9	-12.9	1.1 [1.4, 0.7]	-13.8 [-13.5, -14.3]

Notes: This table summarizes the revenue collected or welfare attained as a result replacing the progressive tax schedule with a linear schedule that would be revenue-neutral assuming no change in behaviour. The first column presents the structural elasticity in our assumed utility model: $U(z) = \log(z - T(z) - \frac{(z/w)^{1+k}}{1+k})$. The second and third columns present the additional government revenue and welfare, respectively, resulting from the tax-rate change under the assumption of perfect tax perceptions. The fourth and fifth columns provide analogous calculations under the assumption that 43% of the population irons, as in our preferred specification. The bracketed numbers underneath present the calculation derived under the assumption that ironing propensity is either 25% or 62%, respectively—the boundaries of the 95% confidence interval of our preferred propensity estimate. Welfare effects are expressed as the percentage of total tax revenues that a social planner would pay to avoid going to the flat tax.

under linear, “flat” taxes, since such systems equate marginal and average tax rates. In effect, then, a tax simplification scheme that bring the tax schedule closer to a flat tax will reduce the socially beneficial influence of this bias. In other words, tax simplification, in addition to changing material incentives, can indirectly generate a type of debiasing.

To illustrate this numerically for the U.S. income tax system, we consider the welfare effects of moving to a flat tax. We constrain the marginal tax rate of the flat tax to be such that the amount of revenue raised would be identical in the absence of substitution to or from leisure: 11.06%.³⁷ As shown in columns 2 and 3 of Table 6, perfect tax forecasters on average increase their labour in response to this tax reform, leading to a 1.9–5.2% increase in tax revenue. However, because this reform leads to a less progressive tax system, and because we have assumed a social welfare function valuing redistribution, the reform leads to a substantial reduction in welfare. Quantitatively, this welfare loss is equivalent to a loss of 9.9–12.9% of government revenue under the pre-reform tax system.

Turning to the estimates accounting for ironing in columns 4 and 5, we see that the revenue benefits of the flat tax are dampened by the less elastic response of ironers. This lower revenue, combined with the fact that ironing amplifies the decrease in progressivity generated by the flat tax, results in a more severe welfare loss than would be obtained under the assumption of perfect tax perceptions. The welfare losses range from 12.3% to 13.8% of pre-reform government revenue. In our preferred specification, the welfare loss associated with moving to a flat tax is 13.2% of pre-reform government revenue (95% CI: 12.5–13.9%). Compared to the estimates that assume correct forecasting, this indicates that the welfare costs of this reform are 14% higher (95% CI: 8–20%) when the effects of ironing are incorporated.

Another simple way to analyse the impact of ironing on the benefits of progressivity is to analyse the optimal top marginal tax rate. Saez (2002) shows that the top marginal tax rate $\bar{\tau}$ satisfies $\frac{\bar{\tau}}{1-\bar{\tau}} = \frac{1-\bar{g}}{a\bar{\epsilon}}$ where \bar{g} is the average social marginal welfare weight on the top income earners, $\bar{\epsilon}$ is the structural elasticity, and a is the Pareto parameter of the income

37. Similar results obtain if we instead constrain the flat tax rate to raise the same amount of revenue after accounting for substitution effects (see Supplementary Appendix E).

distribution.³⁸ In [Supplementary Appendix D.3](#), we show that the top marginal tax rate satisfies $\frac{\bar{\tau}}{1-\bar{\tau}} = \frac{1-\bar{g}}{[(1-\bar{\gamma}_I)a+\bar{\gamma}_I]e}$, where $\bar{\gamma}_I$ is the propensity to iron among high-income earners. Since the Pareto parameter $a > 1$, the optimal top marginal tax rate is higher in the presence of ironing. For a Pareto parameter $a=2$ estimated by [Saez \(2002\)](#), for example, the presence of 43% ironers increases $\frac{\bar{\tau}}{1-\bar{\tau}}$ by 27%.

Our analysis of tax schedule design highlights the importance of establishing the mechanisms underlying misperceptions of marginal tax rates. Based on our estimated model, we are able to forecast the changes to misperceptions (and the behaviours they dictate) after reforms to the tax schedule—a task for which reduced-form estimates of MTR perceptions are insufficient.

5.3. *Interpretation and caveats*

Across these two classes of analyses—examining the welfare impact of introducing ironing under our current tax system, and examining the impact of ironing on a flat-tax reform—we find evidence that this bias serves a useful role for the social planner.³⁹ Ironing leads to additional progressive revenue collection compared to a baseline of perfect optimization, and this is consequential for welfare analysis of redistributive tax policy.

By focusing on the canonical income taxation framework, the welfare analysis here omits the cost of mistakes not related to choices about earnings and taxable income; for example, improper budgeting. Moreover, the standard model of earnings choice that we have adopted abstracts entirely from political economy issues, which would be critically important in assessing some costs of tax systems that generate misperceptions. We believe that there are meaningful, and potentially dramatic, costs associated with a populace coming to believe that a tax system is actively designed to mislead, and we note that these costs are absent from our model.

As a second note of caution, we emphasize that our finding that heuristic use improves social welfare is specific to domain that we study: misperceptions of the tax rates of the federal income tax schedule for earned income. We have abstracted from misunderstanding regarding various other components of the schedule. For the wealthy, optimal decision-making might additionally rely on knowledge of the alternative minimum tax or the estate tax.⁴⁰ For the comparatively low income, misunderstanding of the interaction of the tax schedule with assistance programs may generate additional misperceptions ([Romich, 2006](#)), and failure to optimize along these dimensions may be especially costly ([Currie, 2006](#)).⁴¹

5.4. *Summary of additional results*

In [Supplementary Appendix D](#), we support the implications of our simulation results in a formal theoretical framework. We first provide an instructive step-by-step analysis of a two-bracket model

38. For simplicity, we consider the case where there are no income effects on labour supply. See [Farhi and Gabaix \(2018\)](#) for a formula that includes income effects and a general formulation of homogeneous misperception.

39. This closely relates to the finding of [Sobel \(1984\)](#), who shows that social welfare costs of a monopoly are mitigated when consumers respond to average rather than marginal price. For other examples in which behavioural biases improve social welfare, see [Handel \(2013\)](#), [Handel and Kolstad \(2015\)](#), [Spinnewijn \(2017\)](#), [Handel et al. \(2019\)](#), and [Mullainathan et al. \(2012\)](#).

40. See [Kuziemko et al. \(2015\)](#) for documentation of misunderstanding of the estate tax.

41. A substantial literature documents misunderstanding specifically of the Earned Income Tax Credit (see e.g., [Liebman, 1998](#); [Romich and Weisner, 2000](#); [Chetty et al., 2013](#)).

in [Supplementary Appendix D.2](#), which elucidates the mathematical intuition behind our primary claims. We then generalize this in [Supplementary Appendix D.3](#), which provides formulas for the behavioural and welfare effects of raising tax rates on earners with incomes above a threshold. In [Supplementary Appendix D.3.3](#), we use that formula to calculate the top marginal tax rate, and in [Supplementary Appendix D.3.4](#) we use the formula to calculate the optimal income tax in a heterogeneous population of ironers. Our formula subsumes that of [Liebman and Zeckhauser \(2004\)](#) for the case of a population of only ironers, and complements the [Farhi and Gabaix \(2018\)](#) formula for the case of homogeneous partial ironers.

In [Supplementary Appendix E](#), we provide a series of robustness checks on our simulation results. We demonstrate that our highlighted implications still hold under weaker assumptions on the social planner's preference for redistribution, under different derivations of the flat-tax rate, and under different corrections for the absence of extremely high-income filers in our sample.

6. DISCUSSION

A large and growing literature in behavioural economics shows that people rely on heuristics when facing complex incentives. We contribute to this literature by studying misperceptions of income taxes—a notoriously complex set of incentives with active public debate promoting simplification. We show that much of the systematic misperception of the income tax can be explained by widespread reliance on a single, simple heuristic: ironing. The ability to account for misperceptions with a single parsimonious model allows rigorous analysis of questions about tax reform. We provide such an illustrative analysis, in which the welfare effects of ironing are positive and economically significant.

Moving beyond applications specific to the design of optimal tax policy, we highlight that our empirical estimates are relevant for broader classes of tax incentives. When considering the adoption of tax-preferred behaviours, the investment in human capital in the hopes of raising future wages, or the pursuit of financial investments that will only accrue at a future date, our results provide a unique view into the tax perceptions that could shape such decisions.

Of course, we urge both caution and further research before relying on our experimental estimates to predict responses to actual tax reforms. As with many other heuristics, we suspect that ironing might be most prevalent for “quick” decisions; *e.g.*, whether to work an extra shift or to make a tax-deductible charitable contribution. To the extent that heuristic use is a deliberate means of reducing cognitive costs, it may be less frequent in high-stakes labour-supply decisions than it is in our studies. At the same time, a countervailing force is that in practice, the large labour-supply decisions that rely on correct forecasts of tax rates involve many other dimensions that all require careful consideration; this additional complexity may leave little mental bandwidth for tax forecasting. For example, an individual choosing between two different jobs may, rightly or wrongly, be less concerned with correctly considering after-tax salaries than with workplace culture or livability of the different cities.

While further study of the elasticity of ironing propensity with respect to stakes is needed, some insights may be gleaned from analogous research on other heuristics. For example, while mental accounting, narrow bracketing, and the representativeness heuristic were originally documented in unincentivized survey studies, they have since been shown to play an important role in important field behaviours—*e.g.*, in the marginal propensity to consume out of the supplemental nutrition assistance program in the U.S. ([Hastings and Shapiro, 2018](#)), take up of long-term care insurance ([Gottlieb and Mitchell, 2015](#)), and the link between analysts' earnings-growth forecasts and stock returns ([Bordalo *et al.*, 2019](#)). [Camerer and Hogarth \(1999\)](#) provide a systematic analysis of

whether incentives affect heuristic use in experiments, and find no evidence that it does. While some reservation is needed when assuming that field behaviour will be governed by the heuristics that we document, this existing literature strongly supports the possibility.

We additionally caution readers that the population used in our studies is likely non-representative. Despite Study 1 matching the U.S. population on several key observable demographics, unobserved characteristics could influence selection into our online survey platform. While we have shown that the results from both studies are robust to a variety of sample restrictions, further work is merited to validate our results in further populations of interest. However, were heuristics and biases besides ironing present in the general population, they would likely be found in subsamples such as ours as well; as such, we do not view these issues as a hindrance to a demonstration of ironing’s comparative importance.

We are less reserved about our qualitative findings than we are about our point estimates. In particular, we do not see a theoretical reason to expect residual misperceptions beyond ironing to become more important when stakes are increased. This suggests that our finding that ironing provides a parsimonious account of MTR underestimation is less sensitive to concerns about external validity.

These results build towards a reasonably comprehensive account of income-tax-schedule misunderstanding that is much needed in the behavioural public finance literature. As illustrated in Section 5, our results are easily integrated into frameworks such as those of [Farhi and Gabaix \(2018\)](#), and in combination with their theoretical advances may broadly inform tax policy design. We believe that this line of inquiry has thus far received too little attention from behavioural scientists, perhaps because of its intrinsically tight connection to core economic questions rather than to core psychological questions. Beyond applications to tax policy, this line of inquiry can inform broader questions about mechanism design and misperceptions of complex incentives.

While ironing appears to be economically important, its psychological foundations remain ill understood. However, the experimental framework we have developed in Study 2 may be readily adapted for deeper study of this topic. For example, the extent to which ironing propensity depends on stakes or on the presence of attention-demanding stimuli can shed light on whether ironing is more of a deliberately chosen heuristic or if it’s more of a strongly held belief about the typical nature of incentives schemes in the real world. Variation in cues that stimulate attention to marginal tax rates, or to the number of brackets in the tax code, can similarly shed light on the degree to which ironing is automatic or deliberate. Altering the salience of average and marginal tax rates in experimental materials can be informative about the extent to which ironing is enhanced by the way information is conveyed in paystubs or tax forms. And more generally, studying the impact of information and feedback can provide insights into the robustness and generality of our results.

Finally, we note that the experimental framework we have developed can be readily modified to test for the schmeduling heuristics in complex incentive schemes other than tax codes. Further study of the prevalence of heuristic use across contexts and across subpopulations will provide more clarity on their welfare implications and economic importance. Exploring these and related questions is an important step toward a more psychologically grounded mechanism design. We view our studies as developing some foundations for this promising line of research.

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Supplementary Data

Supplementary data are available at *Review of Economic Studies* online.

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