A Model of Relative Thinking

Benjamin Bushong — Michigan State
Matthew Rabin — Harvard
Joshua Schwartzstein* — Harvard Business School

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Abstract

Fixed differences loom smaller when compared to large differences. We propose a model of relative thinking where a person weighs a given change along a consumption dimension by less when it is compared to bigger changes along that dimension. In deterministic settings, the model predicts context effects such as the attraction effect, but predicts meaningful bounds on such effects driven by the intrinsic utility for the choices. In risky environments, a person is less likely to sacrifice utility on one dimension to gain utility on another that is made riskier. For example, a person is less likely to exert effort for a fixed monetary return if there is greater overall income uncertainty. We design and run experiments to test basic model predictions, and find support for these predictions.

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*E-mails: bbushong@msu.edu, matthewrabin@fas.harvard.edu, and jschwartzstein@hbs.edu.

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1 Introduction

Amounts feel less significant when compared to larger things than when compared to smaller things. Perceptually, an inch on a yardstick seems smaller than an inch on a ruler. A price cut of $10 feels smaller to a person when she is considering spending $1000 on a product than when she is considering spending $100. Seeing a very big and very small house decreases the perceived size difference between two mid-size houses, and presumably reduces a shopper's willingness to pay for the bigger of the two.

Although the intuition of relative thinking pervades the psychology and neuroscience literatures, its formulation in these literatures—as well as in economics—varies. We follow Parducci (1965) and study how a given absolute difference can seem big or small depending on the *range* of alternatives under consideration. Our modeling of range-based relative thinking is related in approach to earlier research by Bordalo, Gennaioli, and Shleifer (2012, 2013) and Koszegi and Szeidl (2013) by considering within-dimension variation as an influence on choice, but to capture relative thinking we start from very different assumptions about the nature of this influence. Our main assumption is that a person puts less weight on a consumption dimension when outcomes along that dimension exhibit greater variability in the choice set he faces. This is consistent with the examples above and experimental evidence by Mellers and Cooke (1994), Soltani, De Martino, and Camerer (2012), and others that trade-offs depend on attribute ranges, where the impact of a given attribute difference is larger when the full range of options is broader.[1]

In this paper, we flesh out a model of "range-based relative thinking" that can be applied across circumstances, and draw out some of its implications. Although we point out some contradictory evidence and return at the end of the paper to discuss intuitions missing from our model, we demonstrate throughout the paper how our range-based approach captures a number of empirical phenomena in intuitive ways. The model matches known context effects from psychology and marketing—for example, proportional thinking (Thaler 1980, Tversky and Kahneman 1981) and decoy effects (e.g., Huber, Payne, and Puto 1982)—while clarifying limits to such effects. Our greater focus is on how the model also generates novel, unexplored economic implications. In the context of discretionary labor choices, the model says that a worker will choose to exert less effort for a fixed return when there is greater overall income uncertainty. The more uncertain a

[1]A similar theme is emphasized in recent neuroscience. Models of normalization, such as the notion of "range-adaptation" in Padoa-Schioppa (2009) or "divisive normalization" in Louie, Grattan and Glimcher (2011), tend to relate both the logic of neural activity, and the empirical evidence (reviewed in Rangel and Clithero, 2012) on the norming of "value signals", to the possible role of norming in simple choices. Fehr and Rangel (2011) summarize neuroscience evidence as saying that "the best and worst items receive the same decision value, regardless of their absolute attractiveness, and the decision value of intermediate items is given by their relative location in the scale." Insofar as value coding in the brain translate into choice, these models may provide backing for the ideas discussed in this paper.

worker is about daily earnings—realizing it could be very high or very low—the less motivated he will likely be to put in effort to earn an extra $10. We also designed experiments to confirm earlier experimental results that motivated our model, and to remove some of the confounds of those experiments. Results from every experiment we ran are supportive of wider ranges reducing people's sensitivity to differences within the range.

We present our model for deterministic environments in Section 2. A person's "consumption utility" for a K-dimensional consumption bundle c is separable across dimensions: $U(c) = \sum_k u_k(c_k)$. Rather than maximizing $U(c)$, however, we assume that a person instead makes choices according to "normed consumption utility" that depends not only on the consumption bundle c but also the comparison set C—which in applications we will equate with the choice set. We build on a recent economic literature begun by Bordalo, Gennaioli, and Shleifer (2012) in assuming that the comparison set influences choice through distorting the relative weights a person puts on consumption dimensions. Normed consumption utility equals $U^N(c|C) = \sum_k w_k \cdot u_k(c_k)$, where w_k captures the weight that the person places on consumption dimension k given the (notationally suppressed) comparison set C. Following Koszegi and Szeidl (2013), the weights $w_k > 0$ are assumed to be a function $w_k \equiv w(\Delta_k(C))$, where $\Delta_k(C) = \max_{c \in C} u_k(c_k) - \min_{c \in C} u_k(c_k)$ denotes the range of consumption utility along dimension k. Our key assumption, which departs from Koszegi and Szeidl (2013), is that $w(\Delta)$ is decreasing: the wider the range of consumption utility on some dimension, the less a person cares about a fixed utility difference on that dimension. For example, in searching for flights on a flight aggregator like Orbitz, our model says that spending extra money for convenience will feel bigger when the range of prices is $400 - $450 than when the range is $200 - $800. We also assume that $w(\Delta) \cdot \Delta$ is increasing, so that differences in normed utility are increasing in absolute magnitude when fixed as a proportion of the range: The $600 difference seems bigger when the range is $600 than the $50 difference seems when the range is $50. A basic implication of the model is a form of proportional thinking. For example—and consistent with examples and evidence by Savage (1954), Thaler (1980), Tversky and Kahneman (1981), and Azar (2011)—a person's willingness to exert effort to save money on a purchase is greater when the *relative* amount of money saved, measured in proportion to the range of spending under consideration, is higher.[2]

Section 3 explores context effects induced by relative thinking in riskless choice. When a person is indifferent between two 2-dimensional alternatives, the addition of a third to the comparison set influences his choices in ways consistent with experimental evidence. For example, our model predicts the "asymmetric dominance" or "attraction effect" proposed by Huber, Payne and Puto

[2]The notion of proportional thinking that is inherent in range-based relative thinking is a frequent motivator for the idea that people exhibit diminishing sensitivity to changes the further those changes are from a reference point. Range-based relative thinking is different: In the presence of greater ranges along a dimension, our model says *all* changes along that dimension loom smaller. When considering possibilities of large-scale decisions, smaller stakes seem like peanuts.

(1982): Adding a more extreme, inferior option to the choice set leads the person to prefer the closer of the two superior options. This is because the addition expands the range of the closer option's disadvantageous dimension by more than it expands the range of its advantageous dimension. Section 3 also characterizes limits of context effects based on bounds placed on the weighting function. Some inferior options, even if undominated, can never be "normed" into selection.

Section 4 presents our full model that includes choice under uncertainty. The key to the way we treat uncertainty in our model is that it is not only the range of expected values across lotteries that matters, but also the range of outcomes in the support of given lotteries. Roughly, we summarize each lottery's marginal distribution over $u_k(c_k)$ in terms of its mean plus or minus a measure of its variation. We then take the range along a dimension to equal the difference between the maximal mean-plus-variation among all lotteries vs. the minimal mean-minus-variation.

People will be more inclined to sacrifice on a dimension when it is riskier. In Section 5, we spell out implications of this basic prediction of the Section 4 uncertainty model. As in the worker example above, people are less willing to put effort into making money when either a) they earn money simultaneously from another stochastic source, or b) they faced a wider range of *ex ante* possible returns. In both cases, the wider range in the monetary dimension due to uncertainty lowers the workers' sensitivity to incremental changes in money. Likewise, workers are less willing to put in effort for a fixed return when they expected the opportunity to earn more, because this also expands the range on the monetary dimension and makes the fixed return feel small.

In Section 6, we present two experiments we designed to explore a basic property of our model that distinguishes it from other recent economic models of context effects: Given differences along a dimension loom smaller in the presence of bigger ranges.[3] We first present results from several vignette studies along the lines of classic proportional-thinking vignettes, but designed to isolate the impact of range effects. We then present results from a real-effort study that takes care to separate range effects from the impact of modifying other features of comparison sets (such as averages) that play a major role in other theories. In that experiment, we elicited participants' preferences rankings over four combinations of tasks and money, where these bundles involved a trade-off between potentially doing extra tasks to receive more money. One group of participants faced a menu of options with a wide range of the amount of tasks to complete and a narrow range of money; the other faced a menu with a narrow range of the amount of tasks to complete and a wide range of money. For reasons we describe in Section 6, we designed the menus such that the best

[3] Azar (2007) provides a theory of relative thinking built on diminishing sensitivity, where people are less sensitive to price changes at higher price levels. Kontek and Lewandowski (2017), on the other hand, contemporaneously propose a model where utility is range-dependent to study risk preferences in monetary lotteries. They assume that the outcomes of a given lottery are normed only according to the range of outcomes within the support of that lottery—other lotteries in the choice set do not influence a lottery's normed utility. Thus, unlike our model, theirs is not one of context-dependent choice or valuation.

and worst options were obvious and our interest was in which options participants ranked second versus third. These middle options were shared across menus, with the prediction that participants in the wide range of tasks and narrow range of money treatment would be more likely to rank the money-advantaged middle option above the fewer-tasks-advantaged middle option. Results from this and every experiment we ran support the idea that wider ranges reduce people's sensitivity to fixed differences within the range.

In many ways, the framework for our model most closely resembles Kőszegi and Szeidl's (2013) model of focusing, and indeed elements of our formalism build directly from it. Our model in the case of riskless choice has a very stark relationship to theirs: in reduced-form, we say the range in a dimension has the opposite effect as it does in their model.[4,5] Nevertheless, the basic force underlying their approach, as well as that of Bordalo, Gennaioli, and Shleifer (2012, 2013)—that attentional and focusing issues can lead wider ranges to enhance the weight a person places on a dimension—is both compelling and not inherently opposed to range-based relative thinking. Intuitively, focusing effects work through differences in the amount of attention paid to different dimensions; relative thinking effects through differences in the amount of attention paid to *changes* along different dimensions. To sharpen this point, we sketch a way of thinking about the interaction between focusing effects and relative thinking in Section 7. The rest of Section 7 concludes by discussing omissions and limitations of our model.

2 Relative Thinking: The Deterministic Case

We begin by presenting a special case of the model that applies to situations where a person chooses from sets of riskless options. In later sections we present the full model which also enables us to study choice under uncertainty, defining ranges as a function of available lotteries. The agent's "consumption" or "un-normed" utility for a riskless outcome is $U(c) = \sum_k u_k(c_k)$, where $c = (c_1, \ldots, c_K) \in \mathbb{R}^K$ is consumption and we assume each $u_k(c_k)$ is strictly increasing in c_k. However, the person does not maximize consumption utility, but rather "normed" utility, which is

[4] Their model isn't specified for the case of uncertainty, but extending it to treat uncertainty in a similar way as we do would presumably be straightforward.

[5] The underlying psychology of our model is more closely related to Cunningham (2013). Cunningham (2013) models proportional thinking in relation to the average size of attributes rather than as a percentage of the range, making his predictions dependent on the choice of a reference point against which the size of options is defined. In our understanding of Cunningham (2013) as positing zero as the reference point, a person would be *less* sensitive to paying \$1200 rather than \$1100 for convenience if the choices ranged between \$1100 and \$1200 than if they ranged between \$400 and \$1200. The model of pairwise normalization by Landry and Webb (2019), although operating through pairwise comparisons rather than overall averages, would similarly say that the difference between \$1200 and \$1100 looms a little larger when \$400 is included than when not. Our model says the narrower range would instead make people more sensitive; models of diminishing sensitivity would—fixing the reference point—say that the assessment of the difference between \$1100 and \$1200 is the same in both cases.

denoted by $U^N(c|C)$ given "comparison set" C.[6]

Throughout this paper, we equate the comparison set with the (possibly stochastic) choice set, though the model setup is more general.[7] Our model assumes that the comparison set influences choice by distorting the relative weight a person puts on each consumption dimension. More specifically, normed consumption utility equals

$$U^N(c|C) = \sum_k u_k^N(c_k|C) = \sum_k w_k \cdot u_k(c_k),$$

where w_k captures the weight that the decision-maker places on consumption dimension k given comparison set C.[8]

We make the following assumptions on w_k:

Norming Assumptions in the Deterministic Case:

N0(d). The weights w_k are given by $w_k = w(\Delta_k(C))$, where $\Delta_k(C) = \max_{c\in C} u_k(c_k) - \min_{c\in C} u_k(c_k)$ denotes the range of consumption utility along dimension k.

N1. $w(\Delta)$ is a differentiable, decreasing function on $(0,\infty)$.

N2. $w(\Delta)\cdot\Delta$ is defined on $[0,\infty)$ and is strictly increasing.

The first two assumptions capture the psychology of relative thinking, motivated by evidence and discussions in Parducci (1965), Mellers and Cooke (1994) and Soltani, De Martino, and Camerer (2012): the decision-maker attaches less weight to a given change along a dimension when the range of consumption utility along that dimension is higher. Put differently, as confirmed by Proposition A.1 in the appendix, these assumptions imply that a particular advantage or disadvantage of one option relative to another looms larger when it represents a greater percentage of the overall range.[9] We provide further support for this basic prediction in Section 6 below.

[6]Although we do not emphasize normative implications through most of the paper, our perspective is that norming may influence choice without affecting experienced utility.

[7]When a person makes plans prior to knowing which choice set he will face, options outside the *realized* choice set can matter. We will more carefully describe how this works when we consider choices over lotteries in Section 4.

[8]While this formulation is sufficient for analyzing choice behavior in the way we do, as we discuss in Section 7 this formulation could be inadequate to do cross-choice-set welfare analysis. In that context, we could instead consider mathematically re-normalized formulations such as

$$\tilde{U}^N(c|C) = \sum_k \min_{\tilde{c}\in C} u_k(\tilde{c}_k) + w_k \cdot (u_k(c_k) - \min_{\tilde{c}\in C} u_k(\tilde{c}_k)).$$

This re-normalization to $\min_{\tilde{c}\in C} u_k(\tilde{c}_k)$ may provide a more natural interpretation across contexts, since it implies that normed and un-normed decision utility coincide given singleton comparison sets.

[9]Even if one somehow found natural units to choose within a dimension, the natural unit of comparison is utility rather than consumption levels given our interest in tradeoffs across dimensions. In terms of capturing the psy-

Although one could use notions of dispersion that rely on more than just the endpoints, we follow Parducci (1965), Mellers and Cooke (1994), and Kőszegi and Szeidl (2013) by assuming that the range of consumption utility in the deterministic case (the "d" in *N0(d)* stands for deterministic) is simply the difference between the maximum value and the minimum value. Of course, at some level this is an approximation: levels of dispersion besides the literal range almost surely matter for choices.[10] We present the full assumption *N0* that handles lotteries below in Section 4.

Assumption *N2* assures that people are sensitive to absolute consumption utility differences. If a person likes apples more than oranges, then he strictly prefers choosing an apple when the comparison set equals $\{$(1 apple, 0 oranges), (0 apples, 1 orange)$\}$. While *N1* says that the decision weight on the "apple dimension" is lower than the decision weight on the "orange dimension"—since the range of consumption utility on the apple dimension is higher—*N2* guarantees that the trade-off between the two dimensions still strictly favors picking the apple. In particular, giving up 100% the range on the apple dimension looms strictly larger than gaining 100% the range on the orange dimension. This assumption is equivalent to assuming that the decision weight is not too elastic with respect to the range. In the limiting case where $w(\Delta) \cdot \Delta$ is constant in Δ, the agent only considers percentage differences when making decisions.

We sometimes add a final assumption, which bounds the impact of relative thinking:

N3. $\lim_{\Delta \to \infty} w(\Delta) \equiv w(\infty) > 0$ and $w(0) < \infty$.

This assumption says that a given difference in consumption utility is never negated by norming, and arbitrarily large differences are arbitrarily large even when normed. Similarly, it says a given difference in consumption utility is never infinitely inflated by norming, and arbitrarily small differences are arbitrarily small even when normed. While we assume that *N0-N2* hold throughout the paper, we specifically highlight when results rely on *N3*, since the limiting behavior of $w(\cdot)$ only matters for a subset of the results and we view this assumption as more tentative than the others.

The notation and presentation implicitly build in an important assumption: The weight on a dimension depends solely on the utility range in that dimension. The $w(\Delta)$ function yields sharp predictions once a cardinal specification of utilities is chosen—with the important restriction to

chophysics, using utility may miss neglect of diminishing marginal utility: a person faced with 100 scoops of ice cream may treat the difference between 2-3 scoops as smaller than if he faced the possibility of getting 5 scoops, even though he may be satiated at 5 scoops.

[10]In fact, research in psychophysics following Parducci's (1965) "range-frequency theory" documents the importance of both the range effects we emphasize, as well as frequency effects: An outcome of fixed position within the range appears smaller when its percentile rank is lower among outcomes in the judgement context.

dimension-separable utility functions.[11] To take a parameterized example, consider

$$w(\Delta) = (1-\rho) + \rho \frac{1}{\Delta + \xi},$$

where $\rho \in [0,1)$ and $\xi \in (0,\infty)$. When $\rho = 0$, the model corresponds to the classical, non-relative-utility model, where a person only considers level differences when making trade-offs. When $\rho > 0$, a marginal change in underlying consumption utility looms smaller when the range is wider. Compared to the underlying utility, people act as if they care less about a dimension the wider the range of utility in that dimension. Note that Assumptions *N2* and *N3* hold: *N3* requires $\rho < 1$ and $\xi > 0$. In the limit case as $\rho \to 1$ and $\xi \to 0$, the actual utility change on a dimension from different choices does not matter, just the percentage change in utility on that dimension.[12]

The model implies a form of proportional thinking. Consider the absolute advantage of consumption vector c' over consumption vector c along dimension k, $u_k(c'_k) - u_k(c_k)$, and its advantage as a proportion of the range, $(u_k(c'_k) - u_k(c_k))/\Delta_k(C)$. We formalize in Proposition A.1 of Appendix A.2 that a person's willingness to choose c' over c is increasing in (i) absolute advantages of c' versus c, fixing proportional advantages, and (ii) relative advantages of c' versus c as a proportion of the range, fixing absolute advantages.

Proposition A.1 implies, for example, that a person's willingness to exert e units of effort to save \$x on a purchase is greater when the relative amount of effort, measured in proportion to the range of effort under consideration, is lower or the relative amount of money saved, measured in proportion to the range of spending under consideration, is higher. As an illustration, consider the choice between consumption vectors (measured in utils)

don't purchase:	0	0	0
purchase without exerting effort to save \$:	v	$-p$	0
purchase and exert effort to save \$:	v	$-p+x$	$-e$,

where the first dimension is the utility from the product, the second the utility from money (p is the price), and the third the utility from not exerting effort. The ranges on the three dimensions are (v,p,e), so the person prefers exerting effort e to save \$x on a \$p purchase if and only if

[11] Once $w(\cdot)$ is fixed, affine transformations of $U(\cdot)$ will not in general result in affine transformations of the normed utility function. As such, like other models that transform the underlying "consumption" utility function, either $U(\cdot)$ must be given a cardinal interpretation or the specification of $w(\cdot)$ must be sensitive to the scaling of consumption utility. Our formulation also assumes additive separability, though we could extend the model to allow for complementarities in consumption utility to influence behavior similarly to how Kőszegi and Szeidl (2013, footnote 7) suggest extending their focusing model.

[12] In Appendix B we discuss a method for non-parametrically determining both $u_k(\cdot)$ and $w(\cdot)$ from behavior, which closely follows the approach in Kőszegi and Szeidl (2013). But, as spelled out below and taken to data in Section 6, the model makes directional comparative statics predictions in situations where $w(\cdot)$ is not fully recoverable.

$w(e) \cdot e < w(p) \cdot x$. Since the right hand side of this expression is decreasing in p, the person is less willing to exert effort to save a fixed amount of money when the base price of the product is higher.

In this manner, the model is consistent with evidence used to motivate proportional thinking, such as Tversky and Kahneman's (1981) famous "jacket-calculator" example, based on examples by Savage (1954) and Thaler (1980), and explored further by Azar (2011)—where people are more willing to travel 20 minutes to save \$5 on a \$15 purchase than on a \$125 purchase—so long as not buying is an option.[13] Diminishing sensitivity could also explain this pattern, but relative thinking makes additional intuitive predictions. For example, relative thinking says that traveling 20 minutes to save \$5 on a purchase seems more attractive when it is also possible to travel 50 minutes to save \$11. When not buying at all is an option, the additional savings does not expand the range along the money dimension, but does expand the range of time costs and therefore makes traveling 20 minutes seem small. See Section 6 for related experimental evidence.

Another property of the model is that the decision-maker's choices will be overly sensitive to the *number* of distinct advantages of one option over another, and insufficiently sensitive to their size. Consider the following consumption vectors (expressed in utils)

$$c^1 = (2,3,0)$$
$$c^2 = (0,0,5).$$

When $C = \{c^1, c^2\}$, then the decision-maker will exhibit a strict preference for c^1 over c^2 despite underlying consumption utility being equal: $2w(2) + 3w(3) > 5w(5)$, since $w(\cdot)$ is decreasing by assumption *N1*, implying that $2w(2) + 3w(3) > 5w(3) > 5w(5)$.

More starkly, consider a limiting case of assumption *N2* where $\Delta w(\Delta)$ is constant in Δ, so the decision-maker cares only about proportional advantages and disadvantages relative to the range of consumption utility. When two consumption vectors span the range of consumption utility, each advantage and disadvantage represents 100% of the range and looms equally large. Comparing the two vectors thus reduces to comparing the *number* of advantages and disadvantages in this case.

[13]Our explanation requires that "don't buy" is in the comparison set. While not explicitly stated as an option in the original problem above, we conjecture that people nevertheless contemplate the possibility of not buying the jacket and calculator.

Like explanations based on diminishing sensitivity, ours also relies on the idea that people narrowly bracket spending on a given item. Indeed, Tversky and Kahneman (1981) fix total spending in their example—they compare responses across two groups given the following problem, where one group was shown the values in parentheses and the other was shown the values in brackets:

> Imagine that you are about to purchase a jacket for (\$125) [\$15], and a calculator for (\$15) [\$125]. The calculator salesman informs you that the calculator you wish to buy is on sale for (\$10) [\$120] at the other branch of the store, located 20 minutes drive away. Would you make the trip to the other store?

If people broadly bracketed spending on the two items, then the range of spending would be the same across the two groups, and our model would not be able to account for the difference in the propensity to make the trip.

Appendix A.2 develops a more general result on how, all else equal, relative thinking implies that the attractiveness of one consumption vector over another goes up when its advantages are spread over more dimensions or its disadvantages are more integrated. This appendix also discusses this result in light of evidence by Thaler (1985) and others on how people have a tendency to prefer segregated gains and integrated losses, though the evidence on losses is viewed as far less robust.

3 Contextual Thinking and Choice-Set Effects

3.1 Classical Choice-Set Effects

The relative thinker's preference between two given alternatives typically depends on the full set of alternatives under consideration. Consider a pair of two-dimensional consumption vectors, c, c' (which are once again represented in utils) that have the property that $U(c) = c_1 + c_2 = c'_1 + c'_2 = U(c')$, where $c'_1 > c_1$ and $c'_2 < c_2$. That is, moving from c to c' involves sacrificing some amount on the second dimension to gain back the same utility in the first. When c and c' are the only vectors under consideration, the relative thinker is indifferent between them: $U^N(c'|\{c,c'\}) - U^N(c|\{c,c'\}) = w(c'_1 - c_1) \cdot (c'_1 - c_1) - w(c_2 - c'_2) \cdot (c_2 - c'_2) = 0$. What happens if we add a third consumption vector c''?

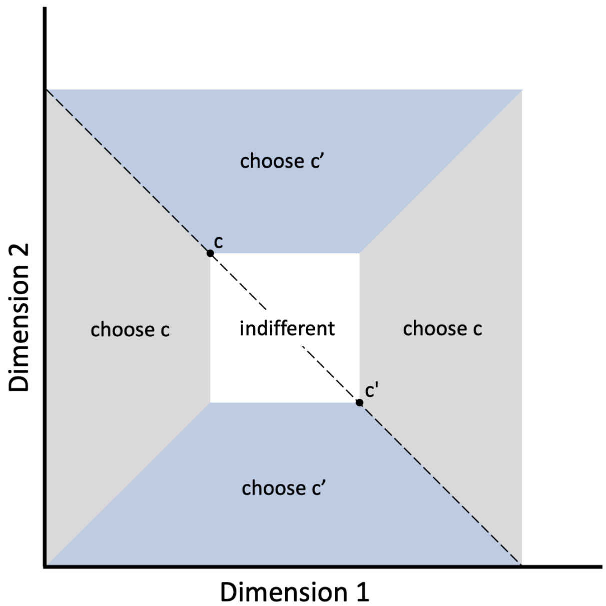
Figure 1 illustrates how the addition of an option influences the preference between c and c'. After presenting the full model that handles choice under uncertainty in Section 4, we will return to the figure and consider the area to the right of the diagonal, which depicts the impact of adding a superior option to the set. Focusing for now on inferior options, when c'' falls in the lighter blue area in the bottom region, its addition expands the range on c''s disadvantageous dimension by more than it expands the range on its advantageous dimension and leads the relative-thinker to choose c' over c. Symmetrically, when c'' falls in the darker grey area in the left region, its addition expands the range on c''s advantageous dimension by more than it expands the range on its disadvantageous dimension and leads the relative-thinker to choose c over c'. Finally, when c'' falls in the white area in the middle region, its addition does not affect the range on either dimension and the relative-thinker remains indifferent between c and c'.

To illustrate, suppose a person is deciding between the following jobs:

Job X. Salary: 100K, Days Off: 199
Job Y. Salary: 110K, Days Off: 189
Job Z. Salary: 120K, Days Off: 119,

where his underlying utility is represented by $U = \text{Salary} + 1000 \times \text{Days Off}$. A relative thinker would be indifferent between jobs X and Y when choosing from $\{X,Y\}$, but strictly prefer the

Figure 1: The impact of adding the *ex ante* possibility of being able to choose c'' on the relative-thinker's choice from realized choice-set $\{c, c'\}$, where each dimension is measured in utility units.



higher salary job Y when choosing from $\{X, Y, Z\}$: The addition of Z expands the range of Y's disadvantage relative to X—days off— by more than it expands the range of Y's advantage—salary.[14]

This pattern is consistent with the experimental evidence that adding an inferior "decoy" alternative to a choice set increases subjects' propensity to choose the "closer" of the two initial alternatives. Famously, experiments have found that adding an alternative that is dominated by one of the initial options, but not the other, increases the preference for the induced "asymetrically dominant" alternative.[15]

[14]Our basic results on choice-set effects also highlight a particular way in which the relative thinker expresses a taste for "deals" or "bargains". The addition of the "decoy" job Z makes Job Y look like a better deal in the above example—while getting 10K more salary in moving from Job Y to Job Z requires giving up 70 days off, getting 10K more salary in moving from Job X to Job Y only requires giving up 10 days off. But our model fails to capture some behavioral patterns that may reflect a taste for bargains. Jahedi (2011) finds that subjects are more likely to buy two units of a good at price $\$p$ when they can get one for slightly less. For example, they are more likely to buy two apple pies for $1.00 when they can buy one for $.96. While a taste for bargains may undergird this pattern, our model does not predict it: adding one apple pie for $.96 to a choice set that includes not buying or buying two apple pies for $1.00 does not expand the range on either the money or the "apple pie" dimensions.

[15]We emphasize laboratory evidence on attraction effects because we believe it directly speaks to basic predictions of choice-set dependent models. For various reasons, some of which are emphasized below in Section 3.2, we are

This *asymmetric-dominance* or *attraction* effect was initially shown by Huber, Payne and Puto (1982), and has been demonstrated when subjects trade off price vs. quality or multiple quality attributes of consumer items (e.g., Simonson 1989), the probability vs. magnitude of lottery gains (e.g., Soltani, De Martino, and Camerer 2012), and various other dimensions including demonstrations by Herne (1997) over hypothetical policy choices and Highhouse (1996) in hiring decisions.[16] Consistent with our model, similar effects (e.g., Huber and Puto 1983) are found when the decoy is not dominated but "relatively inferior" to one of the two initial alternatives. Whether these findings are related to range-based relative thinking is less clear, however. Huber and Puto (1983) argue that it is difficult to explain the evidence as resulting from "range effects" because the likelihood of choice reversals seems to be insensitive to the magnitude of the range induced by the position of the decoy. Wedell (1991) shows something similar, and Simonson and Tversky (1992) cite all this evidence as "rejecting" the range hypothesis. While some recent papers report similar findings (e.g., Castillo 2020), a meta-analysis by Heath and Chaterjee (1995) suggest that range effects do in fact exist in this context, as have more recent studies by Soltani, De Martino, and Camerer (2012) and Padamwar, Dawra, and Kalakbandi (2019).

Our basic results on choice-set effects contrast with those of Bordalo, Gennaioli, and Shleifer (2013) and other recent models, including Kőszegi and Szeidl (2013) and Cunningham (2013), that likewise model such effects as arising from features of the choice context influencing how attributes of different options are weighed. We describe this in detail in Appendix C, and Somerville (2019) as well as Landry and Webb (2019) provide more extensive treatments on differences between models.[17] Here, we primarily confine attention to comparing our predictions to Kőszegi and Szeidl's (2013) because their model also assumes that decision weights are solely a function of the range of consumption utility, which makes it the simplest to compare. Since it makes the opposite assumption on how the range matters, namely that decision weights are *increasing* in the range, it makes opposite predictions to ours in all two-dimensional examples along the lines illustrated in Figure 1. Their model says, for example, that adding Job Z will lead people to choose Job X be-

less convinced that these effects are necessarily important in the field. Recent studies that provide other reasons to question the practical significance of attraction effects include Frederick, Lee, and Baskin (2014) as well as Yang and Lynn (2014).

[16]While initial demonstrations by Huber, Payne, and Puto (1982) and others involved hypothetical questionnaires, context effects like asymmetric dominance have been replicated involving real stakes (Simonson and Tversky 1992; Doyle et al. 1999; Herne 1999; Soltani, De Martino, and Camerer 2012; Somerville 2019). They have also been demonstrated in paradigms where attempts are made to control for rational inference from contextual cues (Simonson and Tversky 1992, Prelec, Wernerfelt, and Zettelmeyer 1997, Jahedi 2011)—a potential mechanism fomalized by Wernerfelt (1995) and Kamenica (2008). Closely related is the "compromise effect" (Simonson 1989), or the finding that people tend to choose middle options.

[17]Soltani, De Martino, and Camerer (2012) develop a model that shares similar motivations, but is presented with a different focus: Their model shows how the biophysical limits of neural representations can account for range effects in a specific choice context. Our model instead takes range effects as given, but fleshes out the assumptions necessary to broaden the domain of application to a greater variety of economic contexts.

cause its addition draws attention to Days Off. The predictions of their model in two-dimensional examples seem hard to reconcile with the laboratory evidence on attraction effects summarized above, as well as with our experimental evidence presented in Section 6. We explore the possibility in Section 7 that "focusing effects" may be more important in choice problems involving many dimensions than in two-dimensional problems like these.

None of these models, including ours, capture certain forms of the compromise effect (Simonson 1989; Tversky and Simonson 1993). In our model, a person who is indifferent between 2-dimensional options c, c', and c'' without relative thinking will remain indifferent with relative thinking: he will not display a strict preference for the middle option. Likewise, Bordalo, Gennaioli, and Shleifer (2013) observe that their model does not mechanically generate a preference for choosing "middle" options. Kőszegi and Szeidl (2013) and Cunningham (2013) also do not generate these effects.[18]

An alternative interpretation for why trade-offs depend on ranges along consumption dimensions—giving rise to the sorts of choice-set effects we emphasize in this section—is that this follows as a consequence of inference from contextual cues, broadly in the spirit of mechanisms proposed by Wernerfelt (1995) and Kamenica (2008). In some circumstances, a person who is uncertain how to value an attribute dimension may rationally place less weight on that dimension when its range is wider, perhaps by guessing that hedonic ranges tend to be similar across dimensions, and therefore guessing that the hedonic interpretation for a change in a dimension is inversely related to the range in that unit. While we believe that such inference mechanisms likely play an important role in some situations, evidence suggests that they do not tell a very full story. There is evidence of range effects in trade-offs involving money and other dimensions that are easily evaluated, such as in Soltani, De Martino, and Camerer (2012), where people make choices between lotteries that vary in the probability and magnitude of gains. Mellers and Cooke (1994) show that range effects are found even when attributes have a natural range that is independent of the choice set, for example when they represent percentage scores, which naturally vary between 0 and 100.

3.2 The Limits of Choice-Set Effects

We now provide bounds for the choice-set effects that result from relative thinking. Given any two options c and c', the following proposition supplies necessary and sufficient conditions on their relationship for there to exist a choice set under which c' is chosen over c.

Proposition 1.

1. *Assume that each $u_k(c_k)$ is unbounded above and below. For $c, c' \in \mathbb{R}^K$ with $U(c') \geq U(c)$,*

[18] For a review of models aimed at capturing the compromise effect, see Kivetz, Netzer, and Srinivasan (2004).

either c' would be chosen from $\{c,c'\}$ or there exists c'' that is undominated in $\{c,c',c''\}$ such that c' would be chosen from $\{c,c',c''\}$.

2. *Assume that each $u_k(c_k)$ is unbounded below. For $c,c' \in \mathbb{R}^K$ with $U(c) \neq U(c')$ there is a C containing $\{c,c'\}$ such that c' is chosen from C if and only if*

$$\sum_{i\in A(c',c)} w(\delta_i(c',c))\cdot\delta_i(c',c) + \sum_{i\in D(c',c)} w(\infty)\cdot\delta_i(c',c) > 0, \tag{1}$$

where $A(c',c) = \{k : u_k(c'_k) > u_k(c_k)\}$ denotes the set of c''s advantageous dimensions relative to c and $D(c',c) = \{k : u_k(c'_k) < u_k(c_k)\}$ denotes the set of c''s disadvantageous dimensions relative to c.

Part 1 of Proposition 1 shows that if c' yields a higher un-normed utility than c, then there exists some choice set where it is chosen over c. This part only relies on *N0(d)*, or in particular that the person makes a utility-maximizing choice from C whenever the range of utility on each dimension is the same given C, or whenever $\Delta_j(C)$ is constant in j.[19] The intuition is simple: so long as utility is unbounded, one can always add an option to equate the ranges across dimensions. For example, while we saw before that the relative thinker prefers $(2,3,0)$ over $(0,0,5)$ from a binary choice set, this finding says that because the un-normed utilities of the two options are equal there exists a choice set containing those options under which the relative thinker would choose $(0,0,5)$. In particular, a person would choose $(0,0,5)$ from $\{(2,3,0),(0,0,5),(5,-2,0)\}$.

The second part of the proposition uses the additional structure of Assumptions *N1-N2* to supply a necessary and sufficient condition for there to exist a comparison set containing $\{c,c'\}$ such that the person chooses c' over c.[20] Condition (1) is equivalent to asking whether c' would be chosen over c when the comparison set is such that the range over its advantageous dimensions are the smallest possible (i.e., $u_i(c'_i) - u_i(c_i)$), while the range over its disadvantageous dimensions are the largest possible (i.e., ∞). In the classical model (with a constant w_k), this condition reduces to $U(c') > U(c)$. In the limiting case—ruled out by *N3* – where $w(\infty) = 0$, the condition is that c' has *some* advantageous dimension relative to c (i.e., is not dominated). More generally, as spelled out in Appendix A.3, the difference in un-normed utilities between the options cannot favor c "too much" and c' must have some advantages relative to c that can be magnified.

Taken together, the two parts of the proposition say that the impact of the comparison set is bounded in our model. In particular, if $U(c') > U(c)$, it is always possible to find a comparison set under which the agent displays a preference for c' over c. However, it is only possible to find a comparison set under which the agent displays a preference for c over c' when (1) holds.

[19] As a result, the first part of Proposition 1 also holds for Kőszegi and Szeidl (2013).

[20] As the proof of Proposition 1 makes clear, the conclusions are unchanged if C is restricted such that each $c'' \in C\setminus\{c,c'\}$ is undominated in C.

Our model implies two additional limits to comparison-set effects. First, our model says that people maximize un-normed consumption utility when decisions involve sufficiently large stakes: Supposing each $u_k(\cdot)$ is unbounded, one can show that for all comparison sets C, there exists a $\bar{t} > 0$ such that if c' is an un-normed utility-maximizing choice from C, then $t \cdot c'$ is a normed utility-maximizing choice from $t \cdot C$ for all $t > \bar{t}$. One intuition is that absolute differences scale up with t, but proportional differences do not, so absolute differences dominate decision-making as t gets large.

Second, as shown in Appendix A.3 (Proposition A.4), for any option c, there exists a choice set C containing c together with "prophylactic decoys" such that c will be chosen and, for any expansion of that set, only options that yield "approximately equivalent" un-normed utility to c or better can be chosen. This means, roughly, that once C is available no decoys can be used to leverage range effects to make a consumer choose any option inferior to c. With unbounded utility and Assumption *N3*, it is always possible to add options that make the ranges on dimensions sufficiently large such that further expanding the choice set will not make some dimensions receive much larger decision weights than others. One potential application of this result lies in examining competition in a product market. For example, a firm that wishes to sell some target product can always market other products that would not be chosen, but prevent other firms from introducing options that frame sufficiently inferior products as superior. This suggests that relative thinking may influence the options that are offered to market participants by more than it influences ultimate choices.[21]

4 The Full Model

Section 2 presented the special case that our model reduces to when there is no uncertainty. We now present our full model that allows for uncertainty. Formally, the decision-maker chooses between lotteries on $\mathbb{R}^K$, with a choice set $\mathscr{F}$ that is a subset of the set of all lotteries on $\mathbb{R}^K$. The deterministic case of Section 2 lends itself to a single notion of range (once a comparison set is specified), but elides some issues that arise in the case where the comparison set contains options that generate stochastic outcomes on one or more dimensions.

Suppose, for instance, that Nomi is a day laborer who must make a choice between working Job A that pays \$100 for 10 hours of work, Job B that pays \$110 for 12 hours of work, or standing in

[21] These conclusions depend on the market structure as well as the technologies that are available to firms. Monpolists may have an incentive to market decoys that get consumers to buy inferior products. In competitive situations, consumers may still buy inferior products if prophylactic decoys are prohibitively costly to market, for example if they must be built in order to market them or if there is sufficient consumer heterogeneity that some consumers will actually demand these products if they are offered. A more complete analysis of competition with decoys, which is left for future work, would need to grapple with such issues.

a queue for day laborers. If she stands in line—call this option Q—she faces *ex ante* uncertainty over the job she is offered. The amount of hours is variable: with equal likelihood, the number of hours she will have to work is $11 \pm h$. The pay is variable: She will be paid \$55 with probability q, \$155 with probability r, and \$105 with probability $1-q-r$, where (for the sake of simplicity) assume that the amount of money offered is independent from the number of hours offered. Nomi's intrinsic, un-normed utility is that each hour of work is worth \$10. If her only two options were A and B, our earlier results on deterministic choice say she would always choose A since this is a balanced choice: it is worth it to her to give up \$10 in income to save two hours of work. If she can also choose not to work, she will continue to choose A: she'd be indifferent between not working or choosing A from the binary choice set, but will strictly prefer choosing A when B is included since it expands the range on the disutility-of-working dimension by more than it expands the range on the utility-from-money dimension. But what will Nomi choose—Options A, B, Q, or not working—as a function of the value of h, q, and r? To answer such a question, our formulation includes a definition of range when some options are stochastic.

The two simplest formulations, both of which would map onto the Section 2 definition in the deterministic case, are to look at the range of expected values of lotteries in the choice set in each dimension, or to take the highest and lowest possible outcomes that can occur in any lottery. The first can be formalized as taking the range equal to $\Delta_k^{\exp}(\mathscr{F}) = \max_{F\in\mathscr{F}} E_F[u_k(c_k)] - \min_{F\in\mathscr{F}} E_F[u_k(c_k)]$. The second can be formalized as taking the range equal to $\Delta_k^{\text{supp}}(\mathscr{F}) = \max_{c\in\cup_{F\in\mathscr{F}}\text{supp}(F)} u_k(c_k) - \min_{c\in\cup_{F\in\mathscr{F}}\text{supp}(F)} u_k(c_k)$.

A problem in the first case (taking the range to equal $\Delta_k^{\exp}(\mathscr{F})$) is that only the range of outcomes across lotteries would matter, not the range of outcomes within lotteries. This formulation would say, for example, that the amount of uncertainty Nomi faces in hours worked if she enters the queue (captured by the level of h) would not impact how she trades off hours worked against the level of pay. Intuitively, however, increasing this uncertainty would decrease Nomi's sensitivity to hours worked, for example making higher-paying and greater-hours-worked job B look more attractive relative to lower-paying and lower-hours-worked job A.

A problem in the second case (taking the range to equal $\Delta_k^{\text{supp}}(\mathscr{F})$) is that it would treat low and high probability outcomes the same. This formulation would say, for example, that the possibility that Nomi could get a job that pays \$155 by standing in the queue would impact her sensitivity to pay independently of the likelihood, r, of getting such a job. And the impact of the possibility of \$155 on the range would remain large as $r \to 0$. Intuitively, however, increasing this probability should decrease Nomi's sensitivity to pay, for example making higher-paying and greater-hours-worked job B look less attractive relative to lower-paying and lower-hours-worked job A. That is, a \$5 return to an hour of work looms small when a \$55 return to an hour of work is possible—and even smaller when a \$55 return to an hour of work is probable. And, while realistic nonlinear probability weighting (Kahneman and Tversky 1979) could mitigate the following effect, the impact of the possibility of the \$155 job on the range should vanish to zero as the probability of being offered such a job tends to zero.[22]

Guided by such intuitions, our goal is to provide a formulation of ranges that satisfies the following criteria:

1. The range along a dimension depends on within-lottery ranges, not just between-lottery ranges.

2. The range along a dimension depends on probabilities, not just possible outcomes.

To satisfy these criteria, we take the following approach: We summarize every lottery's marginal distribution over $u_k(c_k)$ by the mean plus or minus its variation around the mean, where variation is measured by something akin to the standard deviation around the mean, and then take the range along a dimension to equal the difference between the maximal and minimal elements across the summarized distributions. The actual measure of variation we use for a given lottery F is proportional to the "average self-distance" of that lottery, $\int\int |x' - x| dF(x) dF(x')$, which is the average distance between two independent draws from F. We do not believe that a person literally calculates average self distance: Our use of this statistic is to approximate the idea that a person's perception of the range of outcomes is increasing in dispersion. We believe very little of our analysis would qualitatively change if classical standard deviation or other notions of dispersion were used.[23]

Formally, given a comparison set $\mathscr{F}$, we define the range along dimension k to equal

$$\Delta_k(\mathscr{F}) = \max_{F \in \mathscr{F}} \left(E_F[u_k(c_k)] + \frac{1}{2} S_F[u_k(c_k)] \right) - \min_{F \in \mathscr{F}} \left(E_F[u_k(c_k)] - \frac{1}{2} S_F[u_k(c_k)] \right), \tag{2}$$

where $E_F[u_k(c_k)] = \int u_k(c_k) dF(c)$ equals the expectation of $u_k(c_k)$ under F, and $S_F[u_k(c_k)] = \int\int |u_k(c'_k) - u_k(c_k)| dF(c') dF(c)$ is the average self-distance of $u_k(c_k)$ under F. Note that the range along a dimension collapses to the previous riskless specification when all lotteries in $\mathscr{F}$ are degenerate. Note also that when $K = 1$ and $\mathscr{F} = \{F\}$ is a singleton choice set, then we have $\Delta(\mathscr{F}) = S_F[u(c)]$.[24]

[22]Insofar as people overweight low probabilities in risky choice, adding this feature might extend the ranges on dimensions involving low-probability outliers relative to dimensions without such outliers.

[23]"Average self-distance" is a term Koszegi and Rabin (2007) coined, but the identical measure had earlier been discussed by researchers under different terms, such as the L-scale or mean difference. Yitzhaki (1982) argues that the mean difference provides a more central notion of statistical dispersion in some models of risk preference, since it can be combined with the mean to construct necessary conditions for second-order stochastic dominance. Kőszegi and Rabin (2007) in fact show it to be especially relevant for models of expectations-based-reference-dependent utility; as such, using it as a measure of dispersion may facilitate combining our model with reference dependence.

[24]The proof of Lemma H.1 in Appendix H establishes that, for any lottery F, $E[F] + 1/2 \cdot S[F] = E_F[\max\{c, c'\}]$,

We assume the weights w_k satisfy the following assumptions, which generalize the conditions from Section 2.

Norming Assumptions:

N0. The weights w_k are given by $w_k = w(\Delta_k(\mathscr{F}))$, where $\Delta_k(\mathscr{F})$ is given by (2).

N1. $w(\Delta)$ is a differentiable, decreasing function on $(0,\infty)$.

N2. $w(\Delta)\cdot\Delta$ is defined on $[0,\infty)$ and is strictly increasing.

Assumption *N0* expands the definition of the range from *N0(d)* to the more general definition of (2), while the rest of the norming assumptions remain as they were in the deterministic case. Given the comparison set, the decision-maker evaluates probabability measure F over $\mathbb{R}^K$ according to:

$$U^N(F|\mathscr{F}) = \int U^N(c|\mathscr{F})dF(c),$$

where $U^N(c|\mathscr{F}) = \sum_k w(\Delta_k(\mathscr{F}))\cdot u_k(c_k)$ as in the riskless case.

To build more intuition, we return to the Nomi example and additionally consider an example that connects to experimental paradigms on context-dependent preferences.

Example 1. Write Nomi's un-normed utility function as $U = m - 10\cdot h$, where m is money and h is hours worked. Here, $c_1 = m$, $u_1(c_1) = c_1$, $c_2 = h$, $u_2(c_2) = -10\cdot c_2$. Nomi chooses between four lotteries: not working (NW), taking job A, taking job B, and the lottery Q representing standing in the queue and taking whichever job is offered. To derive the range, we first write the expected value and average self-distance for each lottery:

Lottery	$(E[u_1(c_1)]\ ,\ E[u_2(c_2)])$	$(S[u_1(c_1)]\ ,\ S[u_2(c_2)])$
NW	$(0,0)$	$(0,0)$
A	$(100,-100)$	$(0,0)$
B	$(110,-120)$	$(0,0)$
Q	$(105+50(r-q),-110)$	$(100[q(1-q)+r(1-r)],10h)$

We now apply the formula (Equation (2) from above) for ranges. The range on money is always determined by 0 on the lower end and $\max\{110, 105+50[r(2-r)-q^2]\}$ on the upper end, while

and we can similarly establish that $E[F]-1/2\cdot S[F] = E_F[\min\{c,c'\}]$. This provides an alternative expression for $\Delta_k(\mathscr{F})$:

$$\Delta_k(\mathscr{F}) = \max_{F\in\mathscr{F}} E_F[\max\{u_k(c_k),u_k(c'_k)\}] - \min_{F\in\mathscr{F}} E_F[\min\{u_k(c_k),u_k(c'_k)\}].$$

the range on hours worked is determined by $\min\{-120, -110-5h\}$ at the lower end and 0 at the upper end. This yields:

$$\Delta_1(\mathscr{F}) = \max\{110, 105+50[r(2-r)-q^2]\}$$
$$\Delta_2(\mathscr{F}) = \max\{120, 110+5h\}.$$

There are several features of these ranges worth noting: (i) The range along the disutility-of-working dimension 2 is increasing in h: the range along a dimension depends on within-lottery ranges, not just between-lottery ranges. (ii) The range along the utility-from-money dimension 1 is increasing in r and decreasing in q: The range along a dimension depends on probabilities, not just possible outcomes. (iii) The range along the utility-from-money dimension 1 converges to 110 as $r \to 0$, $q \to 0$: Vanishingly low probability outcomes do not influence the range.

Example 2. The decision-maker makes plans knowing he faces choice set $\{c, c'\}$ with probability q and choice set $\{c, c''\}$ with probability $1-q$, so that $\mathscr{F} = \{(1,c), (q,c'; 1-q, c), (q,c; 1-q, c''), (q,c'; 1-q, c'')\}$. Supposing $c = (0,0), c' = (-1,1)$, and $c'' = (-1,2)$, the range along the first dimension is $\Delta_1(\mathscr{F}) = 1$ and the range along the second is $\Delta_2(\mathscr{F}) = 2-q^2 \in [1,2]$.

The first example derives the range of outcomes that Nomi is influenced by, without fully solving for what she chooses. (We leave that as a fun exercise for the reader.) The second example shows that when the choice set people ultimately face is uncertain, they may be influenced by options that are not in the realized choice set. Return to Figure 1 and consider what happens when the comparison set can differ from the realized choice set, which will allow us to analyze how the relative-thinker's choice between c and c' is influenced by having contemplated the possibility of being able to choose a *superior* option. Some experimentalists (e.g., Soltani, De Martino and Camerer 2012) induce such a wedge between choice and comparison sets by having subjects first evaluate a set of alternatives during an "evaluation period" and then quickly make a selection from a random subset of those alternatives during a "selection period". Consider the situation, for instance, where the person makes plans prior to knowing which precise choice set he will face and makes choices from $\{c, c'\}$ with probability $1-q$ and makes choices from $\{c, c', c''\}$ with probability q—under this interpretation, Figure 1 illustrates the relative-thinker's choice when $\{c, c'\}$ is realized and $q > 0$. In the grey area to the right of the diagonal line (the blue area can be symmetrically analyzed), the addition of c'' to the comparison set expands the range of c''s advantageous dimension by more than it expands the range of its disadvantageous dimension, pushing the relative-thinker to choose c from $\{c, c'\}$.

These results connect with a smaller experimental literature that examines how making subjects aware of a third "decoy" alternative—that could have been part of the choice set but is not—influences their preferences between the two alternatives in their realized choice set. While the overall evidence seems mixed and debated, as far as we are aware the cleanest experiments from the perspective of our model—for example, that make an effort to control for rational inference from contextual cues—have found that adding "asymmetrically dominant" (or "close to dominant") decoys to the comparison set decreases experimental subjects' propensity to choose the asymmetrically dominated target when the decoy is not present in the choice set (e.g, Soltani, De Martino, and Camerer 2012). Relatedly, Jahedi (2011) finds that subjects are less likely to buy a good (for example, an apple pie) if they are aware that there was some probability they could have bought two of the same good for roughly the same price—for example, that there was some probability of getting a two-for-one deal on apple pies. Finally, these results are consistent with van den Assem, van Dolder, and Thaler's (2012) evidence that game show contestants are more willing to cooperate in a variant of the Prisoner's Dilemma when the gains from defecting are much smaller than they could have been: if any non-pecuniary benefits from cooperating are fairly flat in the stakes relative to the monetary benefits from defecting, making the stakes small relative to what they could have been also makes the benefits from defecting appear relatively small.[25]

These results and examples also bring up a question we've been sidestepping: how sticky is the range? After all, a person may not follow through on a complete contingent plan formed with ranges $(\Delta_k)_{k=1}^K$ in mind if, at some contingency, those are no longer the ranges he has in mind. Return to the example of Nomi and suppose she is able to turn down a job after entering the queue, but has to make her decision quickly. Imagine that she could either be offered a job that pays \$155 with 11 hours of work or a job that pays \$105 with 11 hours of work ($q = 0, h = 0$). Suppose further that she is offered the job that pays \$105. In her quick decision of whether to accept the job is she still thinking about the possibility that she could have been offered \$155? We suspect she is, just like the experimental participants in the Soltani, De Martino, and Camerer (2012) study were clearly thinking the options that were potentially available in the evaluation period when they quickly made a choice between a subset of those options in the selection period. In such instances, the right way to apply our model is as in Example 2 above, where a person forms the range prior to knowing the exact choice set she faces.[26]

[25]A contrasting finding in the experimental literature has come to be labeled the "phantom decoy effect" (Pratkanis and Farquhar 1992): presenting a dominant option declared to be unavailable can bias choice towards the similar dominated option (Highhouse 1996; Pettibone and Wedell 2007; Tsetsos, Usher and Chater 2010). Some of this may be due to rational inference: taking an example inspired by Highhouse (1996), if job candidates vary in interview ability and test scores, then knowledge that a job candidate with extremely high interview ability and medium test scores is no longer on the market may provide a signal that interview ability is more important than test scores, leading a person to select a candidate with high interview ability and medium test scores over a candidate with medium interview ability and high test scores.

[26]While our framework follows others where lagged expectations influence choices (e.g., Koszegi and Rabin 2006, 2007) by assuming that a person needs to form plans in order for ranges to be sticky, memory may also play an important role where previously available options are included in the comparison set (e.g., Bordalo, Gennaioli, and Shleifer 2020) even if the person does not form plans.

This leaves open the question of when precisely the range is formed, as with other models where lagged expectations (e.g., Koszegi and Rabin 2006) influence choices. Suppose Nomi is waiting in a very long queue, and by waiting in the queue she gives up the possibility of choosing jobs A and B. In evaluating a job offer after waiting a long time, does she still think about features of jobs A and B (e.g., the possibility of working 12 hours in job B), or did the range of outcomes she considered adjust as she waited in line? Searching for answers to such qustions is an active area of research (see, e.g., Heffetz 2018). For now, analyst judgement is required in determining the moment that ranges sink in.

5 Tradeoffs Across Dimensions Under Uncertainty

This section draws out how uncertainty influences the rate at which people trade off utility across dimensions. Consider a simple example where somebody chooses how much effort to put into a money-earning activity, but also earns money from another stochastic choice. He has two consumption dimensions—money and effort—and his un-normed utility is given by

$$U = r \cdot e \pm k - f \cdot e,$$

where r equals the return to effort, $e \in \{0,1\}$ denotes his level of effort, $\pm k$ indicates an independent 50/50 win-k/lose-k lottery, and f represents the cost to effort. A person maximizing expected utility would choose $e^* = 1$ if and only if $r/f \geq 1$. Notably, his effort is independent of k.

By contrast, our model says that increasing k will decrease effort: the more income varies, the smaller will seem an additional dollar of income from effort, and so the less worthwhile will be the effort. It is easy to derive that the relative thinker works so long as

$$\frac{r}{f} \geq \frac{w(f)}{w(r+k)},$$

where the right-hand side of this inequality is increasing in k, and greater than 1 for large enough k. This implies that the relative thinker is less likely to work when k is larger: increasing uncertainty on a dimension decreases his sensitivity to incremental changes in utility along that dimension.[27]

[27] If marginal utility over money is convex, as is often assumed in explaining precautionary savings using the neoclassical framework, then income uncertainty will have the opposite effect. In such a case, expected marginal utility is increasing in income uncertainty, so higher income uncertainty will increase the propensity to exert effort to boost income. If the less conventional assumption of concave marginal utility is made, then more uncertainty would, as in our model, decrease the value on money. But in either case, the effects would be calibrationally small for modest increases in uncertainty. Loss aversion, by constrast, makes a bigger and less ambiguous opposite prediction to ours. Consider a situation in which people are able to commit in advance to take effort. Applying the concept of choice-acclimating equilibria from Kőszegi and Rabin (2007) and assuming linear consumption utility, loss aversion predicts no impact of higher income uncertainty on the propensity to exert effort: The decision is determined solely by consumption utility.

To state a more general result, for lotteries H, H' over $\mathbb{R}$, let $H + H'$ denote the distribution of the sum of independent draws from the distributions H and H'. Additionally, for lotteries F_i over $\mathbb{R}$, $i = 1, \ldots, K$, let $(F_1, \ldots, F_K)$ over $\mathbb{R}^K$ denote the lottery where each c_i is independently drawn from F_i.

Proposition 2. *Assume $K = 2$ and each $u_i(\cdot)$ is linear for $i = 1, 2$.*

1. *Let F_1, F_2 be lotteries on $\mathbb{R}$ and G_1, G_2 be lotteries on $\mathbb{R}^+$. If (F_1, F_2) is chosen from $\{(F_1, F_2), (F_1 - G_1, F_2 + G_2)\}$, then (F_1, F_2') is chosen from $\{(F_1, F_2'), (F_1 - G_1, F_2' + G_2')\}$ whenever F_2' is a mean-preserving spread of F_2 and G_2' is a mean-preserving spread of G_2. Moreover, the choice is unique whenever $F_2' \neq F_2$ or $G_2' \neq G_2$.*

2. *Let F_1, F_2 be lotteries on $\mathbb{R}^+$. Suppose the person faces the distribution over choice sets of the form $\{(0,0), (-\tilde{x}, \tilde{y})\}$ that is induced by drawing $\tilde{x}$ from F_1 and $\tilde{y}$ from F_2. If $(0,0)$ is preferred to realization $(-x, y)$ given the resulting comparison set, then $(0,0)$ is strictly preferred to $(-x, y)$ if instead the distribution over choice sets is induced by drawing $\tilde{x}$ from F_1 and $\tilde{y}$ from $F_2' \neq F_2$, where F_2' first order stochastically dominates a mean-preserving spread of F_2.*

Part 1 of Proposition 2 generalizes the above example, and says that if the person is unwilling to sacrifice a given amount from one dimension to the other, he will not do so if the second dimension is made riskier. Notably, the proposition extends the example by allowing the person to influence the amount of risk he takes. To illustrate, consider a simple modification of the example where exposure to risk goes up in effort, and utility equals $U = e \cdot (r \pm k) - f \cdot e$. The proposition says that, again, the worker is less likely to exert effort when the amount of income uncertainty, k, is higher: the wider range in the monetary dimension reduces the worker's sensitivity to incremental changes in money.

Part 2 says that a person becomes less willing to transfer a given amount of utility from one dimension to a second when the background distribution of potential benefits on the second dimension becomes more dispersed or shifted upwards. For example, suppose a person is indifferent between exerting effort e to gain \$100 if he made plans knowing \$100 is the return to effort. Then this person will not exert effort if, *ex ante*, he placed equal probability on earning \$50, \$100, or \$150. And he will be even less likely to exert effort for \$100 if he were *ex ante* almost sure to be paid \$150 for effort, since this further expands the range on the money dimension and makes earning \$100 feel even smaller.

Consider a second situation in which the opportunity to exert effort comes as a surprise and the person thus previously expected to not exert effort. In this case, loss aversion predicts that the presence of a 50/50 win-k/lose-k lottery over money increases the person's willingness to exert effort: Returns to effort are shifted from being assessed as increasing gains to partially being assessed as reducing losses.

While we know of no direct field evidence speaking to our predictions, there is suggestive supporting evidence. For example, insuring farmers against adverse weather shocks such as drought can increase their willingness to make high-marginal-return investments.[28] While this investment response could in principle result from risk aversion if investment returns negatively covary with the marginal utility of consumption—for example, investment in fertilizer could have a lower return when rainfall and consumption are low and the marginal utility of consumption is then high—it may also in part result from similar mechanisms to those we highlight: Our model predicts a first-order positive investment response *even when investment returns are uncorrelated with the newly insured risk*, thus broadening the set of circumstances where we would expect expanding insurance coverage to boost profitable investment.

Suggestive evidence also comes from laboratory findings on relative pay and labor supply.[29] Bracha, Gneezy, and Loewenstein (2015) examine how one's relative pay impacts decisions on whether and how hard to work. Most relevant to the current discussion, they find that the willingness to complete a task for a given wage is inversely related to the previous wages offered for a related task. People are less likely to show up to complete a survey for either \$5 *or* \$15 if they were previously offered \$15 to complete a related survey than if they were previously offered \$5.[30] Although a cleaner test of our model's predictions would more directly manipulate expectations, this is consistent with the model if, as seems plausible, expectations of future wages are increasing in the size of previous wages: Increasing the probability attached to a higher wage offer increases the range attached to money, thereby increasing the reservation wage.

We provide additional supportive evidence in the vignettes study of the next section.

6 Experiments

To explore more directly some of the predictions of range-based relative thinking, we conducted a pair of experiments on Amazon's Mechanical Turk (" MTurk"). These experiments build on earlier ones, but attempt to isolate the impact of ranges from other aspects of choice contexts, such as averages or medians, that have been featured in other theories of context dependence. Because the designs leverage some of the results above that clarify the relationship between range-based

[28]See, e.g., Karlan et al. (2014), Cole, Gine, and Vickery (2017), and Mobarak and Rosenzweig (2012), who find that uncertainty reduction through insurance seems to increase investments such as fertilizer use and weeding.

[29]The implication of our model that uncontrollable noise to income reduces a person's incentive to exert effort to boost income is reminiscent of a basic assumption of the "expectancy theory" of motivation in psychology (Vroom 1964), which assumes that the lack of control over a performance outcome is demotivating. Tests of this assumption find mixed results. Sloof and van Praag (2008), for example, conduct an experiment where noise does not impact performance in either direction, but also supply references for the limited research on this question.

[30]And, as one would expect, people like high wages: People are more likely to show up to complete a survey for \$15 if they were previously offered \$15 than to show up to complete a survey for \$5 if they were previously offered \$5.

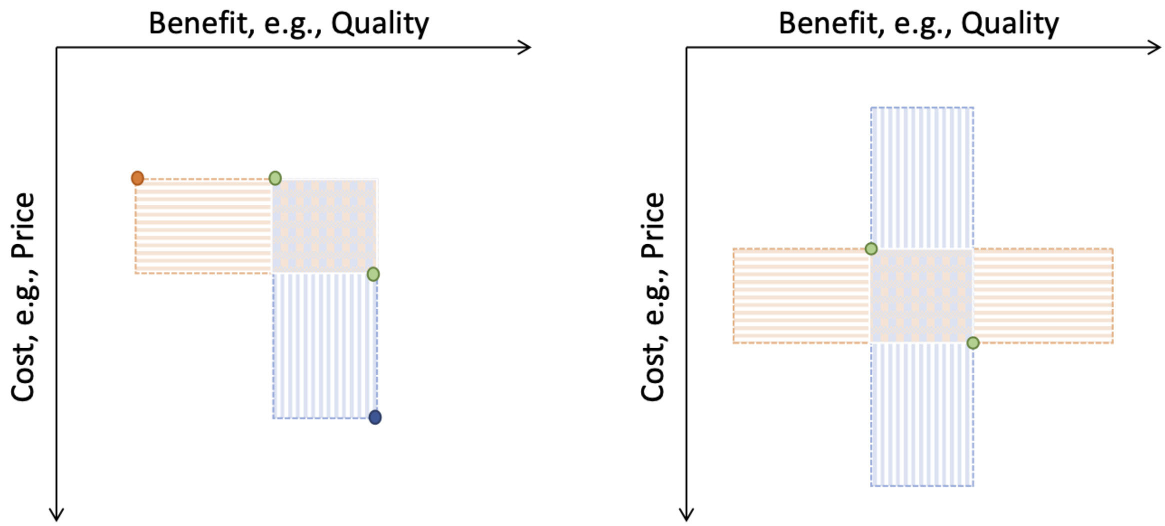
relative thinking and some forces underlying other approaches, we hope these experiments can also contribute to a more complete and systematic investigation of range effects in choice.

The basic premise underlying both experiments is depicted in the right panel of Figure 2. The left panel depicts a classic decoy or attraction-effect design, where one of the dimensions is "good" and one "bad." This setup captures, for instance, choices that vary in quality and price, as well as the experimental setup we describe below. The two target options (in decoy-effect parlance) are depicted in green. As we described earlier in Section 3, one such attraction effect is that the addition of the blue decoy to the initial binary set leads participants to favor the quality-advantaged target. Another attraction effect is that the addition of the orange decoy to the initial binary set leads participants to favor the price-advantaged target.

We showed in Section 3 that range-based relative thinking predicts the attraction effects described above. However, the addition of either the blue or orange decoy impacts not only the ranges along each dimension, but also other (perhaps important) features such as averages or medians. Indeed, it is not possible with the addition of a single decoy to vary the range without varying the average.[31]

Our experiments aim to more carefully isolate the impact of ranges. Figure 2b sketches the key idea. As in previous studies on attraction effects, we consider two target options designed such that participants are close to indifferent between them in a binary choice. However, since we seek to examine the impact of expanding ranges while fixing averages and medians, we do not explore the impact of adding a single decoy. Instead, we consider how the preference between the two target options differs in the context of the blue rectangle, where the range along the vertical dimension is wider than the range along the horizontal dimension, to the preference in the context of the orange rectangle where the range along the horizontal dimension is wider than the range along the vertical dimension. Our experiments provide several ways of instantiating this sort of design, making it clear how we trigger the blue and orange rectangles.

[31]Thus, existing experiments in economics using such setups that provide evidence consistent (e.g., Soltani, de Martino, and Camerer 2012; Somerville 2019) and inconsistent (e.g., Castillo 2020; Bondi, Csaba, and Friedman 2018; Andersson, Carlson, and Wengstrom 2016) with range-based relative thinking have not fixed other aspects of the choice context when varying ranges. Dertwinkel-Kalt et al. (2017) present experimental evidence from a design aimed at testing predictions of Bordalo, Gennaioli, and Shleifer (2012). Their results are supportive of Bordalo, Gennaioli, and Shleifer's predictions and inconsistent with predictions from the basic reference-independent version of our model. However, as the case with attraction-effect designs, in the Dertwinkel-Kalt et al. design salient aspects of the choice context are not fixed when varying ranges. This includes prices relative to expectations which are important not only in Bordalo, Gennaioli, and Shleifer (2012) but central to models such as Koszegi and Rabin (2006). This lack of control makes it difficult to draw strong conclusions about the existence or direction of range effects from their experiment.



(a) Classic Decoy Design

(b) Idea Behind Our Designs

Figure 2: Isolating the impact of the range. The height and width of orange, horizontally-striped, rectangles depict narrow ranges on cost and wide ranges on quality that lead participants to view the cost-advantaged green target more attractive than the quality-advantaged green target. The height and width of blue, vertically-striped, rectangles depict wide ranges on cost and narrow ranges on quality that lead participants to view the quality-advantaged green target more attractive than the cost-advantaged green target.

6.1 Vignettes

First, we report results from a "vignettes" experiment in which participants answered a series of hypothetical-choice questions. We recruited adults from the United States ($n = 500$; analysis sample $n = 492$) who had previously completed at least 100 prior tasks on MTurk with a 95% approval rating.[32] Participants were paid $1.00 for answering three hypothetical questions of research interest as well as five demographic questions. The survey took an average of 3.5 minutes to complete. We asked participants each of three vignette-style questions (in randomized order). These designs are motivated by Figure 2, but the real-effort experiment presented in the next section will be more directly linked to the figure.

The first question was a variant of the famous jacket-calculator vignette (Tversky and Kahneman 1981, Thaler 1980), explored more recently by Azar (2011) and Shah, Shafir, and Mullainathan

[32] We remove from our analysis participants who failed an attention check. In Appendix E, we offer additional details and report all experiments conducted. We conducted two pilots aimed at calibrating magnitudes to ensure that a similar fraction of participants would choose each target option over the other when ranges were balanced across dimensions. In Appendix E, we also give instructions and materials for each experiment; the full data set is available by request.

(2015). We included this question only to provide a baseline for behavior and to check whether the MTurk population's behavior matched measurements from other populations. Concerned with ceiling-effects cited in Shah, Shafir, and Mullainathan (2015), we reduced the size of the discount to $25, from $50 in their version. Our version of this question follows:

> Imagine you have spent the day shopping. One item you have been shopping for is a laptop [*pair of headphones*]. At the end of the day, you find yourself at a store that has the brand and model you want for $1000 [*$100*]. This is a good price but not the best you have seen today. One store—a thirty minute detour on your way home—has it for $975 [*$75*]. Do you buy the $1000 laptop [*$100 headphones*] and go home, or do you instead decide to take the detour to buy it [*them*] for $975 [*$75*] at the other store?

We randomly assigned each participant to one of the two conditions described above.[33] When shopping for a laptop, 48% of participants ($n = 248$) said they would drive to the other store. When shopping for headphones, 73% of participants ($n = 244$) did so ($p < .001$ for difference in proportions).[34] We thus replicate existing findings for this paradigm.

Our second hypothetical question introduced a related thought experiment motivated by Figure 2b. This vignette induces wider or narrower ranges (analagous to the blue or orange rectangles in the figure) through manipulating *ex ante* uncertainty about available options.

> You went to a store to buy a phone, expecting to pay between $490 and $510 [*$190 and $810*] and expecting the trip to the store to last between 5 and 55 [*15 and 45*] minutes. You've spent 30 minutes at the store and it turns out the phone you want costs exactly $500. Right before buying it, the clerk at the check-out counter says you could save $5 on the phone by filling out a 15-minute survey, bringing the total time at the store up to 45 minutes and the total cost of the phone down to $495. Do you fill out the survey?

Each participant faced *ex ante* uncertainty, framed as either a narrow range in money and a wide range in time or a wide range in money and a narrow range in time. We call these treatments "narrow money" and "wide money", respectively. Our model predicts that participants are more likely to say they would fill out the survey in the narrow-money treatment. Indeed, in the narrow-money condition (without brackets above; $n = 255$), 58% of participants said they were willing to complete the survey. In the wide-money condition ($n = 237$), 44% of participants said they

[33]As we detail in Appendix G, randomization produced balance on all characteristics we measured (age, income, and gender).

[34]All p-values are from Fisher's exact test. Since our hypotheses are all directional, one-sided tests are arguably more appropriate. We report the p-values for two-sided tests to be conservative and follow convention.

were willing to complete the survey ($p = .003$ for difference in proportions). This corresponds to an effect size of approximately 14 percentage points or roughly half the magnitude of the (well-studied and replicated) effect in our first vignette.

Our third vignette varied ranges with ex post uncertainty. We presented participants with a scenario in which another person faced uncertainty over their wages and that uncertainty had not yet been resolved.

> Tarso has been working at the same restaurant for years and after a long shift, he is ready to go home. As he packs his things, he notices a group of four people enter and sit at a booth in the corner. He quickly thought to himself: should I stay or should I go? His work shares tips and he suspects that he would earn a $5 tip from the remaining table. Tarso is uncertain about his tips thus far, but suspects he earned between $35 and $40 [*$15 and $60*] thus far from the pooled tips tonight. Therefore if he stays, Tarso thinks he'll earn between $40 and $45 [*$20 and $65*]. Do you think he: (a) stayed and served one final group; (b) left for the night?

Insofar as participants do a good job putting themselves in Tarso's shoes, our model says that participants will more frequently predict that Tarso will stay in the narrow-range (without brackets above) condition.[35] In this condition ($n = 236$), 67% of participants thought Tarso would stay and serve another table. In the wide-range condition ($n = 256$), 55% of participants thought Tarso would stay and serve another table ($p = .006$ for difference in proportions). This corresponds to an effect size of approximately 12 percentage points.

Results from all three vignettes in this experiment (summarized in Table 1) are in line with the predictions of our model. As with any vignette study, we could not completely control how participants interpreted the questions. But we find it hard to imagine any subjective sense by the participants that did not correspond to the wider-range treatments being interpreted as wider ranges as defined in our theory.[36] One could imagine some interpretations by participants that made the forces predicted by other models come into play, however. For example, perhaps participants subjectively viewed the average as larger in wide-range conditions, e.g., discounting low prices of phones in the wide-range condition of the second vignette because they don't seem realistic.

[35] We presented this vignette in third person because we guessed that many participants would have limited experience waiting tables.

[36] Consider, for example, the second vignette, and let F_k^T denote the subjective distribution of $k \in \{\text{prices, minutes}\}$ in treatment $T \in \{\text{narrow \$, wide \$}\}$. The subjective range along dimension k in treatment T is $S_{F_k^T}(u_k(c_k))$, where we are assuming that the choice of whether to fill out the survey is interpreted as a surprise that does not influence the range. As a result, our prediction that participants are more likely to fill out the survey in the narrow-$ treatment holds so long as this average self-distance is larger along the money dimension in the wide-$ treatment than the narrow-$ treatment and is lower along the minutes/effort dimension in the wide-$ treatment than the narrow-$ treatment. The analysis of the third vignette is similar.

In that case, predictions of normalizations based on the scale of options in the choice set, such as Cunningham (2013) and Landry and Webb (2019), would coincide with predictions of range-based normalization, and so the evidence would only support these theories collectively against theories predicting that wider ranges increase the weight placed on each increment within a range. We think even such alternative explanations are unlikely to explain our full pattern of results; it seems unlikely, for instance, that participants in third vignette could have confused the wider range for higher average, given that all tip amounts seem credible. It seems even less likely in the real-effort experiment we next turn to, where the probabilities of available options are objective and clearly specified.

Table 1: RESULTS, EXPERIMENT 1

	Drive for Discount		Survey After Purchase		Extra Work	
Variable	headphones	laptop	narrow $	wide $	narrow $	wide $
Choice = Yes	72.6%	47.5%	57.6%	43.9%	66.9%	54.7%
Observations	248	244	255	237	236	256

6.2 Real Effort

Our second design involved real-effort decisions. We recruited participants ($n = 570$) by the same criteria as in the vignettes experiment, basing this number of participants on a rough back-of-the-envelope power calculation. Participants were paid $1.00 for completing an initial block of work and were given the option to earn additional money based on their choices. The experiment took an average of 33 minutes to complete with an average pay of $4.60.

Each participant completed five initial real-effort tasks. The task consisted of counting characters in a matrix; see Figure A.1 in the Appendix for a visual depiction of the real-effort task. This initial learning session was designed to reduce inference about the task difficulty from the set of questions we asked. For each task, a new matrix was presented to the participant, and the symbol they were required to count changed.[37] On average, participants completed each initial task in about 73 seconds.

After completing the initial tasks, we then asked a single question about participants' willingness to complete more of the same task. Specifically, we asked participants their preferences over four combinations of additional tasks and additional money, trading off receiving more money for

[37]We utilized this particular task to reduce the possibility of cheating and to make each individual task require effort, since the changing target requires significant focus.

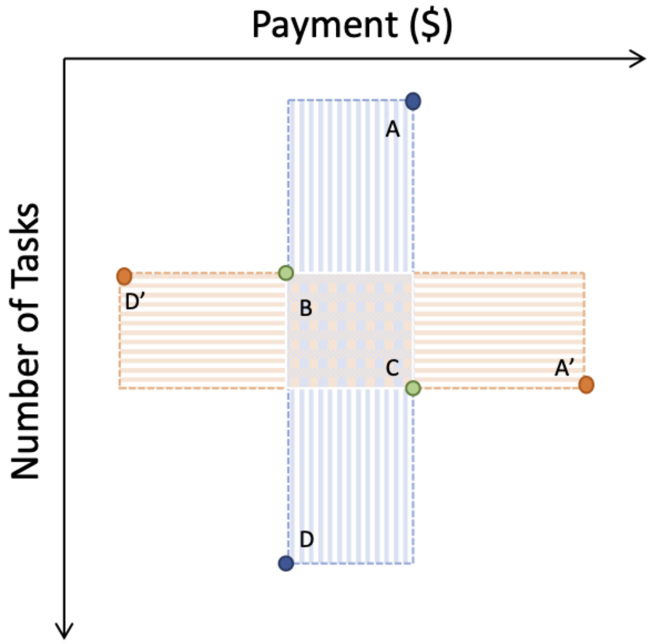


Figure 3: *Schematic of real-effort experiment design.* Participants ranked their preference from one of two sets: either $\{A, B, C, D\}$, which we call the *wide-effort* treatment, or $\{A', B, C, D'\}$, which we call the *wide-money* treatment.

needing to do more tasks. Our experimental variation stemmed from varying the ranges of money and tasks that participants faced in a between-subjects manipulation.

Table 2: CHOICE SETS, REAL-EFFORT EXPERIMENT

Wide-Effort Treatment		*Wide-Money Treatment*	
A	($2.80, 2 tasks)	A'	($4.50, 14 tasks)
B	($2.20, 14 tasks)	B	($2.20, 14 tasks)
C	($2.80, 18 tasks)	C	($2.80, 18 tasks)
D	($2.20, 30 tasks)	D'	($0.50, 18 tasks)

The choice sets of our two treatments are presented in Table 2. In a given menu, the order of presentation of the options was randomized across participants. In "wide effort", effort ranges from 2 tasks to 30 tasks while money ranges between $2.20 and $2.80; in "wide money", money ranges from $0.50 to $4.50 while effort ranges from 14 tasks to 18 tasks. Critically, both treatments preserved the averages of the money and effort dimensions.

Figure 3 graphically depicts the menus, highlighting how the choice sets above instantiate the design sketched in Figure 2b. A notable feature of the menus is that there is one (obviously) best option in each (A and A') and one worst option (D and D'). If we simply elicited choices between the four alternatives, we would be unable to detect any effect of range. So instead we elicited *incentivized rankings* from participants. Specifically, participants ranked each alternative from 1 (best) to 4 (worst). Their ranking was incentivized according to the following mechanism: we drew two of the four options at random, and the person was given their preferred option from those two. We explained this mechanism in simple language and presented a short quiz to ensure comprehension. There are two main ways participants may have interpreted the task: as heuristically providing a deterministic ranking or as literally choosing between lotteries over outcomes. Either way, our model of range-based relative thinking predicts that participants are more likely to rank C above B in the wide-effort treatment than in the wide-money treatment. Appendix F shows this formally.

Before turning to results, we emphasize three key features of the design. First, as noted above, to isolate range-based relative thinking from average-based normalization (e.g., as emphasized in Cunningham 2013), the *average* attribute value along each dimension is fixed across treatments. Second, we utilize *single-question elicitation,* which limits the scope for theories of memory retrieval or cuing (e.g. Bordalo, Gennaioli and Shleifer 2020). Insofar as the base pay ($1) and number of initial tasks (5) serve as a norm for the wage range—perhaps suggesting that the task is "worth" $0.20—this norm remains constant across treatments. Third, decoy options feature *symmetric dominance*. The decoy options D, D' are dominated by *both* options and the decoy options A, A' dominate both options. This feature limits the scope for certain forms of reason-based choice that predict people will gravitate towards options that asymmetrically dominate an alternative or away from options that are asymmetrically dominated by an alternative. See, e.g., Castillo (2020) for a discussion of the importance of this feature.

Results from the experiment support the predictions of range-based relative thinking. The results are summarized in Table 3, with further analysis provided in Table A2 of Appendix G. We find that 46% of participants in the wide-effort treatment ranked C higher than B, while only 36% of participants in the wide-money treatment did so ($p = .011$ for difference in proportions). These results include responses from a small number of participants who ranked clearly dominated options first or dominant options last. Restricting the sample further to responses that (1) rank the clearly best alternative (A or A') first and (2) rank the clearly worst alternative (D or D') last excludes 11% of the sample (65 participants); of the 505 responses left in doing so, 49% of participants in the wide-effort condition ranked C as their second choice, while only 34% of participants in the wide-money condition did so ($p = .001$ for difference in proportions). After conducting the experiment and analyzing both completed surveys and partial responses, we noticed from IP addresses that 34 responses came from participants who seem to have attempted the survey multiple times. Excluding these additional 34 responses does not appreciably change the results—of the 471 responses left, C was ranked second by 48% in the wide-effort condition and 34% of participants in the wide-money condition ($p = .003$ for difference in proportions).

Table 3: RESULTS, EXPERIMENT 2

	Wide Effort		Wide Money	
Ranking	Count	Percent	Count	Percent
B higher than C	158	54%	178	64%
C higher than B	136	46%	98	36%
A ≻ B ≻ C ≻ D	132	45%	162	59%
A ≻ C ≻ B ≻ D	126	43%	85	31%
B highest	12	4.1%	10	3.6%
C highest	4	1.4%	7	2.5%
Other	20	6.8%	12	4.3%
# of Participants (Whole Sample)	294		276	

Notes: Table 3 does not notationally distinguish between A and A' or D and D'. Percents do not sum to 100% due to rounding.

7 Discussion

We motivated our model with a motivating premise of many literatures: big ranges desensitize decisionmakers to incremental changes along dimensions. This intuition is present not only in applications of range-frequency theory in psychophysics and range-adaptation more recently in neuroscience, but is also invoked in more far-flung literatures. Take, for example, the rather robust debate economists and psychologists had over methods of contingent valuation (see, e.g., Kahneman et al. 1999). In surveys (and in jury verdicts), the valuations people assign to the badnesses of outcomes are way too insensitive to scale—e.g., a remarkably similar level of harm is assessed for small oil spills and massive ones.[38] Similar insensitivities are found in the domain of health policy

[38]The contingent-valuation literature more broadly discusses apparent scope neglect in stated willingness to pay (WTP). For example, Desvouges et al. (1993) asked people to state their willingness to pay to avoid having migratory birds drown in oil ponds, where the number of birds said to die each year was varied across groups. People were completely insensitive to this number in stating their WTP: the mean WTPs for saving 2000, 20,000, or 200,000 birds were \$80, \$78, and \$88, respectively. Frederick and Fischoff (1998) provide a critical analysis of interpretations of such insensitivity—coined the "embedding effect" by Kahneman and Knetsch (1992). While some have been tempted to interpret such evidence as reflecting standard considerations of diminishing marginal rates of substitution, others have argued more plausibly that the insensitivity could reflect range-like effects where, even if the underlying willingness-to-pay function is linear, the displayed willingness-to-pay across subjects could be highly concave. Indeed, studies have found that people are much more sensitive to quantities in within-subject designs. Hsee, Zhang, Lu and Xu

(see, e.g., Olsen, Donaldson, and Pereira 2004).[39] We believe that range-based relative thinking is additionally a likely interpretation of findings of *subadditivity* across domains: Desvousges, Mathews, and Train (2015) found that the total willingness to pay to avoid badnesses was triple when asked about different attributes separately than when asked jointly, and Bateman et al. (1997) confirm such a "part-whole bias" in a real-stakes consumption experiment.

Notwithstanding such evidence and intuitions, as well as the findings in our experiment, the evidence cited throughout the paper is more mixed on the presence and direction of range effects. This suggests that some countervailing intuitions in other models are also generally in play, and that some inconsistencies may be due to the incompleteness and underspecification of our model, as well as of others. We conclude by fleshing out some ways in which our theory is incomplete and how one might try to build a more complete theory.

7.1 Focusing Effects

On the surface, the intuition of our model is inconsistent with intuitions built into models such as Bordalo, Gennaioli, and Shleifer (2012, 2013) and Kőszegi and Szeidl (2013) that people pay more attention to dimensions with bigger ranges than smaller ones. Indeed, the Koszegi and Szeidl (2013) formulation is the opposite of ours because it says both that a person pays more attention to dimensions with wider ranges *and* pays more attention to a fixed increment within a wider range. While range-based relative thinking cannot be combined with the latter effect, it can be combined with the former: A job-seeker may start paying attention to the number of vacation days once this varies sufficiently between jobs, but additional variation may cause her to be less willing to forego income for vacation days. By neglecting focusing effects, our model assumes that the effect of a reduced proportion of a range outweighs a greater focus on wide ranges. However, a model that combines focusing and relative thinking effects could provide a more complete picture of the net effect of wider ranges.

It is possible that which factor dominates is very indeterminate. This may help explain some

(2013) apply a similar principle to develop a method to boost charitable donations. Interestingly, people have argued that within-subject designs may also not accurately elicit true WTP, again because of range-effects. As Frederick and Fischoff (1998, page 116) write:

> we suspect that valuations of any particular quantity would be sensitive to its relative position within the range selected for valuation but insensitive to *which* range is chosen, resulting in insensitive (or incoherent) values across studies using different quantity ranges.

[39] Although we know of no direct evidence, it is our impression that there is likewise less sensitivity to the scale of incentives *across* experiments than *within* an experiment. Relative thinking predicts, for example, that an experimental participant's willingness to work for $5 vs. $10 might be similar across experiments, where the $5 and $10 would each represent 100% of the range on money, and will be less similar when considering both within an experiment, where $5 would be 50% of the monetary range but $10 would be 100%.

seemingly inconsistent experimental results on the net effect of expanding the range. But a tantalizing possibility comes from noticing that our analysis above primarily emphasizes examples where people's decisions are likely guided by a clear, low-dimensionality trade-off—between money and effort, money and quality, risk and return, etc. Per Figure 1 in Section 3 as well as the content of Section 6, we believe that evidence and intuition in domains with two dimensions contradicts many of the sharp, direct predictions of assuming that a more variable dimension leads to greater weight on fixed incremental changes in that dimension. Yet those examples are indeed cases where people's attention is directed to the relevant dimensions.

In situations where dimensions may be neglected, the bigger-range-increases-incremental-weight hypothesis might be the dominant force, perhaps by approximating the idea that people stochastically notice or pay attention to dimensions according to their range.[40] In this light, it is notable that most of the examples provided by Kőszegi and Szeidl address trade-offs across many dimensions. A crude formulation of how to discern the relative weight, for instance, might hold that people pay attention solely to the two dimensions with the greatest ranges, and make choices according to range-based relative thinking in those dimensions. We propose a less crude formulation in Appendix D that allows for the possibility that the focusing intuition might dominate in many-dimensional choices, but maintains the feature that relative thinking will dominate in two-dimensional choices.[41]

7.2 Other Missing Elements

The most conspicuous additional omission from our model is reference dependence, in the spirit of Kahneman and Tversky (1979). Indeed, variants of the notion of diminishing sensitivity built into their model have been incorporated into, e.g., Bordalo, Gennaioli, and Shleifer (2012) as well as Cunningham (2013). Formally integrating reference dependence into our model would not only allow us to incorporate diminishing sensitivity and loss aversion, but let us look at their *interaction* with relative thinking. Quite how to integrate these two elements into models of range effects is less clear. One intriguing intuition that plays out in ongoing work is that the range effects operate on both the diminishing-sensitivity and loss-aversion components in such a way that the availability of bigger and riskier choices mutes the concavity in these components to make a person act less risk averse. For example, if a homeowner is required to purchase some sort of insurance policy,

[40] In models of inattention such as Gabaix (2014) and Schwartzstein (2014), the range of potential realizations on some dimension of concern might naturally be a determinant of the likelihood that people pay attention.

[41] This formulation would still not account for the mixed nature of the evidence even over relatively few dimensions. Along with the examples cited in this paper where people seem less sensitive to given increments when ranges are wider, there are several papers (e.g., Bondi, Csaba, and Friedman 2018; Andersson, Carlson, and Wengstrom 2016) providing evidence that wider ranges may increase sensitivity. This suggests the need for further exploration of the conditions under which focusing effects dominate relative thinking effects and vice-versa, and perhaps indicates that some of the factors below—or new ones—are affecting results.

adding policies with higher deductibles and lower premia to an existing menu could, even if not chosen, lead her to choose a higher deductible among the smaller set of policies.

Our model shares two important limitations with other theories of context-dependent preferences. First, we don't have much of an explanation, much less a formal theory, of which options are included in what could be called the "comparison set". The connotation in presentations such as ours is that the comparison set is somewhere in between (1) the actual choice set, (2) the "narrowly bracketed" set of options a person thinks of as in play for an act of decisionmaking, or (3) the set of options that seem "plausible" given her preferences. But the first possibility is typically unrealistic given that true choice sets are often massive; the second is not very satisfying given that a model of context effects would seemingly want to explain what the person considers rather than assume it; and the third belies the fact that we're considering theories of people potentially not choosing their most preferred option, and it is hard to know which of the non-optimal choices count as "plausible". If, say, we are analyzing a consumer deciding whether to buy a car with or without a car radio, she could additionally consider buying two cars and whether to move closer to her job instead of buying a car; it is not clear how we decide that buying two cars is outside her comparison set—but that buying a radio that isn't really worth it to her is; and why she is considering the car purchase in isolation from other choices. In lieu of more satisfyingly precise resolutions to such questions, we have tried to stick to examples where our predictions are not sensitive to the specific choice of comparison set within intuitively-reasonable possibilities, but it is hard to fully evaluate that intuition without a framework to think about it.

A second limitation is shared with all models featuring multiple dimensions: Such models must have a notion of what those dimensions are. For example, consider extending our model to handle dynamics. Such an extension requires assumptions about whether the person treats consumption at different points of time as different dimensions and, as we showed in a previous working paper version of this paper (Bushong, Rabin, and Schwartzstein, 2017), such assumptions will drive results. Or consider framing effects. We implicitly illustrate examples of such effects above in some of the evidence we cite, where range effects are clearly in play but build from dimensions that are induced by particular experimental designs.[42] Formulating a model that does not allow for such framing effects has the disadvantage of missing large chunks of reality, but the advantage of highlighting forces that systematically hold across frames.

Finally, we note that our analysis fails to provide guidance on how to think about the welfare

[42]For example, Soltani, De Martino and Camerer (2012) appear to induce participants to treat (Probability Gain, Magnitude Gain) as dimensions by asking them to choose between lotteries of the form "gain g with probability p". Conversely, the studies by Walasek and Stewart (2015, 2018) appear to induce participants to treat gains and losses as separate dimensions by making the scales of losses and gains salient. Presumably different experiments and (more importantly) different real-world settings could induce different dimensions. For example, "states of the world" determining lottery payoffs could be made salient if all gambles are presented in terms of the dollar outcomes associated with heads and tails of the same coin.

implications of the context effects we predict. We are not aware of research, for instance, that identifies whether people consider their (normed) choices mistakes in retrospect, or what kinds of interventions might elicit a useful contemporaneous assessment of the right actions. Nor do we know of evidence on the well-being people experience during or after choices that are influenced by ranges. The interpretation that seems most consonant with our presentation—that relative thinking influences choice but not experienced utility—seems realistic in many situations. For example, a person's job satisfaction may be largely divorced from the range of vacation days across other jobs she considered. However, in some situations it also seems more plausible that the same norming that affects a person's choice directly affects the way she experiences that choice. For example, in situations involving risk, the difference between losing \$10 and \$5 may genuinely *feel* smaller when losing \$100 was possible. The model does not provide guidance on when relative thinking reflects a mistake or corresponds to true experienced well-being.[43]

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[43] A likely possibility is that experienced well-being at the time of choice may be normed according to the ranges in the choice set, but the utility experienced in later consumption is divorced from those ranges. So, for instance, if the presence of opportunities to gain or lose large amounts of money causes a person to attend less in her choices to the difference between losing \$100 or losing \$50 then she may also be desensitized experientially to finding out whether she has lost the \$100 or the \$50. But the difference in experiences she has access to later based on which amount she loses may be unaffected by the norming.

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Appendix Figure

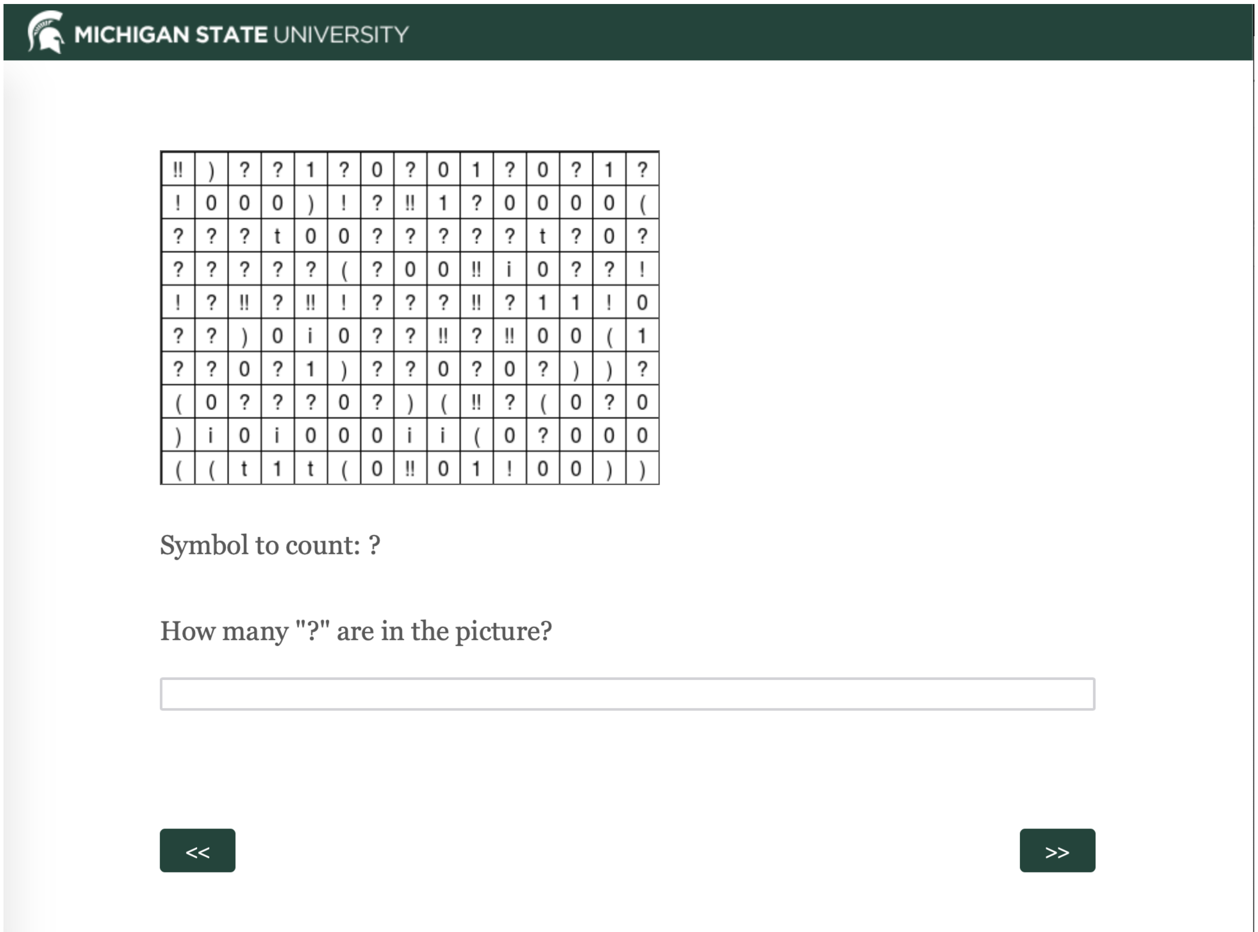

Figure A.1: *Screenshot of the counting task from the real-effort experiment.* The symbol to count as well as the matrix changed with each trial.

Supplementary Material and Data Availability Statement

Supplementary material and appendices containing proofs, further theoretical results, and further information on the experiments are available at the Review of Economic Studies online. Replication files for the experiments are available at https://doi.org/10.5281/zenodo.3967674