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How different types of participant payments alter task performance

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Abstract

Researchers typically use incentives (such as money or course credit) in order to obtain participants who engage in the specific behaviors of interest to the researcher. There is, however, little understanding or agreement on the effects of different types and levels of incentives used. Some results in the domain of statistical reasoning suggest that performance differences — previously deemed theoretically important — may actually be due to differences in incentive types across studies. 704 participants completed one of five variants of a statistical reasoning task, for which they received either course credit, flat fee payment, or performance-based payment incentives. Successful task completion was more frequent with performance-based incentives than with either of the other incentive types. Performance on moderately difficult tasks (compared to very easy and very hard tasks) was most sensitive to incentives. These results can help resolve existing debates about inconsistent findings, guide more accurate comparisons across studies, and be applied beyond research settings.

Keywords:participant methodology, monetary incentives, judgments under uncertainty, statistical probability, performance.

1 Introduction

In the behavioral sciences, research participants typically must be provided with some type of incentive for their participation (much like employees typically must be paid). Although it has long been noted that the amount of incentive provided to animals can influence subsequent performance (e.g., the Crespi Effect; Crespi, 1942, 1944), the use of research incentives for humans has been characterized by both inconsistencies across fields and controversy about effectiveness. The norm in psychological research is to tie research participation to course credit (often as part of an introductory psychology course) or occasionally some other form of set payment amount (i.e., a flat-fee). In contrast, the norm in economics research is to pay participants with money and to scale those payments to performance within the research (i.e., performance-based incentives).

It has recently been noted that such discrepancies in methodology can have implications for cross-disciplinary variations in results and theoretical conclusions from research. Retrospective reviews of past studies have made the case that there is a real issue regarding the effects of participant incentives, but they disagree on what these studies show (Camerer & Hogarth, 1999; Hertwig & Ortman, 2001; Rydval & Ortmann, 2004). Camerer & Hogarth (1999) focused on performance-based incentives and found little evidence for global improvements in performance, but more subtle effects of reduced variability in responses, reduced presentation effects, and perhaps performance improvements specifically in judgment tasks that are "responsive to better effort." Ortmann & colleagues (Hertwig & Ortmann, 2001; Rydval & Ortmann, 2004), found similar results as Camerer & Hogarth, but also found reason to be more optimistic about the effects of financial incentives. They concluded that "in the majority of cases where payments made a difference, they improved people's performance" (p. 394) and that "although payments do not guarantee optimal decisions, in many cases they bring decisions closer to the predictions of the normative models. Moreover, and equally important, they can reduce data variability substantially" (p. 395).

Within psychology there has been general debate about the effectiveness of incentives (generally, financial incentives), with some arguing for and finding that incentives are important motivators (Epley & Gilovich, 2005; Shanks, Tunney, & McCarthy, 2002; Stone & Ziebart, 1995), but others taking contrary positions or finding null results (Crano, 1991; Jenkins, Mitra, Gupta, & Shaw, 1998; Wright & Anderson, 1989). Two factors complicate this controversy. The first factor is the use of diverse behaviors on which the effects of incentives have been assessed, ranging from simple perceptual tasks (e.g.,

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Pritchard & Curtis, 1973) to complex social coordination tasks (e.g., Parco, Rapoport, & Stein, 2002). If, as is often supposed, financial incentives should increase effort on tasks, this will be manifested only for tasks on which additional effort yields clear response improvement. (Tasks in which participants are already performing at or near their best are not likely to show much improvement, nor are tasks that are so difficult as to be beyond the participant's abilities.) The second factor is the type of incentive used. When financial incentives are used in psychology they are typically flat-fee payments, which are more directly analogous to the non-financial course credit "payments" that are the norm in psychology, but both of these are very different — in terms of incentive structure — from performance-based financial incentives. It therefore remains unclear how different types of incentives do (or do not) systematically affect performance across different types of tasks and different levels of task difficulty.

In experimental economics, by contrast, researchers commonly use performance-based financial incentives and reject the methodology typical of psychology as insufficient in several respects (Hertwig & Ortmann, 2001). Specifically, it is argued that performance-linked incentives serve to: a) reduce variance in performance, b) avoid problems of satiation (i.e., more money is always desirable), thereby maintaining high levels of attention and motivation, c) make the target behaviors clear and easy to establish, and d) maximize efforts towards optimal behavior or performance.

1.1 Theoretical implications of incentives

Understanding the effects of different types and levels of incentives on performance is also important in assessing — and sometimes even resolving — controversies about experimental effects. For example, Brase, Fiddick, and Harries (2006) found that an ongoing dispute about the effectiveness of different numerical formats on statistical reasoning could in principle be resolved entirely by taking into account the different participant populations and different incentives used across studies. Starting with "high water mark" performances of over 70% of participants demonstrating correct statistical reasoning (using flat-fee paid participants from top-tier national universities), a drop in performance of about 20 percentage points was found with movements from monetary payments to course credit. An additional 20 percentage points drop in performance was found with changes from top-tier university participants to regional university participants. Thus, for example, a 51% correct statistical reasoning performance found by Sloman, Over, Slovak, and Stibel (2003) is not at all incompatible — as they imply — with the 72% correct performance found by Cosmides and Tooby (1996) on the same task. A sufficient explanation is the different incentives used: voluntary participation after university lectures in the former, and flat-fee paid participation in the latter.

One can look at general trends in this literature over the past decade, sorting performance both by the types of presentation of statistical reasoning tasks — using naturally sampled frequencies and pictorial representations generally aid performance — and by the type of incentives used. As Table 1 shows, there is a curious pattern: incentives seem to facilitate performance for the easier tasks presented in natural frequencies, but they have little effect on the harder tasks presented in normalized numbers. Despite the fact that these tasks are conceptually isomorphic (i.e., Bayesian inference), the nature of the incentives appears to interact with the level of task difficulty. There are no comparable studies of Bayesian reasoning in which performance-based financial incentives were used.

Despite wide interest and implications, little systematic empirical data have been produced on this issue and much of what does exist are retrospective analyses of prior, heterogeneous studies (such as Table 1, with the exception of Brase, et al., 2006, which is the only study of these that manipulated participant incentives at a variable). The aim of the present research was to compare performance across different types of incentive conditions, while also systematically varying task difficulty but holding constant the fundamental nature of the task. Within this context, it was predicted that:

1. Performance will improve with the use of financial incentives, specifically:
   (a) when the incentives are performance-based, rather than flat-fees, and
   (b) when the judgment task is of intermediate difficulty, rather than very difficult or very easy (i.e, "responsive to better effort," in the words of Camerer and Hogarth, 1999).
2. Increased effort on tasks when using performance-based incentives will also be evident in measures other than correct performance (similar to findings of reduced response variability, reduced errors, and faster reaction times; Camerer & Hogarth, 1999; Hertwig & Ortmann, 2001; Crespi, 1942, 1944).

2 Method

A total of 704 participants were provided with a Bayesian reasoning task to solve. In approximately equal proportions, these participants were given either: a) course research participation "points", b) paid a flat fee, or c) paid a flat fee plus an incentive amount for attaining the correct

Table 1: Some recent results in Bayesian inference tasks: Percent of participants reporting the correct posterior probability in statistical reasoning tasks, based on the type of incentives used and type of presentation of the task. Results presented here include only participants from national universities (see Brase, et al., 2006) and only conditions in which the type of presentations clearly fell within the given categories.

	Flat fee payment	In-class / course credit
Normalized numbers (e.g., percentages)	16%[a] 20%[b]	30%[c] 20%[d]
Normalized numbers, with pictures		48%[d]
Natural frequencies	46%[a] 68%[b] 64%[e]	42%[c] 41%[d] 40.5%[e]
Natural frequencies, with pictures	76%[b] 70.8%[e] 92%[b] (active)	45%[d] 46.7%[e]

[a] Gigerenzer and Hoffrage, 1995; standard probability and standard frequency formats, average rates
[b] Cosmides & Tooby, 1996: conditions E1-C1, E5, E6-C1, E6-C2, and conditions E1-C2, E2-C1, E3-C1, E3-C2, average rates; pictorial conditions: Experiment 4
[c] Evans, et al., 2000: Frequency Easy/Frequency Question versus Probability/Probability Question conditions in Experiments 1–2
[d] Slomin, et al., 2003: Experiments 1, 1B, and 2
[e] Brase, Fiddick, & Haries, 2006: Experiments 1, 3, and 4

response. Participants were also given, in equal proportions, one of five variants of the same task which varied in difficulty.

2.1 Participants

All 704 research participants were undergraduates at the University of Missouri-Columbia, enrolled in introductory courses (Introductions to Psychology, to Social Psychology, to Abnormal Psychology, etc.). All participants were run within the same calendar year (paid participants were all within the same semester). Participant debriefings provided information about the nature and purpose of the research, but did not give the correct answer to the tasks. (To discourage participant cross-talk, only participants who specifically asked for the correct answer were given that information and were also admonished to not discuss it with anyone.) The goal was to obtain participant samples in ways representative of current and prior research, while controlling for as many other factors as possible.

254 participants received one course research credit in Introductory Psychology for participating (with a total semester requirement of 12 half-hour credits), utilizing the existing research participation system. These participants included 127 females and 126 males (1 participant failed to report a gender), and had an average age of 19.9 years.

242 other participants were recruited via psychology lectures other than Introductory Psychology and participated immediately after the lectures (these courses were also large introductory topics courses for which Introductory Psychology was not a prerequisite and none were Cognitive Psychology courses in which subject matter related to this task may have been discussed). Participation was voluntary, and prospective participants were instructed that they could not participate more than once, even if in different classes. Each participant received $5.00 for participating, regardless of performance, an amount found just sufficient, in informal surveying, to elicit some participation. Participants included 154 females and 88 males, and had an average age of 19.7 years.

Another 208 participants fitting the same criteria were recruited by visiting lectures other than those visited previously. These participant received either $3 (for participation) or $9 (the initial $3, plus $6 for correct task solutions). These included 128 females and 79 males (1 participant failed to report a gender), with an average age of 20.1 years.[1]

[1]The design of this study does not include full random assignment of participants (there was random assignment to the task format conditions, but not the incentive type conditions), potentially raising issues of participant comparability. This was purposefully done to compare different incentive participation types, which generally require different recruitment mechanisms, even though all the participants were undergraduates, in introductory courses, at the same university, in the same time period. Indeed, less controlled comparisons are routinely done in literature reviews (see Brase, et al., 2006). It is also instructive to think through the practical and ethical implications of a hypothetical study that used completely random assignment of one group for all incentive conditions: If participants were randomly assigned to different incentive conditions there could be dissatisfaction and/or anger towards the experimenter for several reasons (e.g., missing out on money, missing out on course credit, missing out on more money compared to other participants, etc.). For this reason, it is unclear if such a study would be able to pass an ethics review. Alternatively, if participants were allowed to choose which incentive condition they wanted to be in, there would not only be a lack of random assignment but also potential self-selection confounds.

Table 2: Percentage of participants who reached the correct answer (10 out of 28, or .357) to a Bayesian reasoning task (across five types of formats) when (a) receiving course credit for their participation, (b) receiving a flat fee payment of $5 for their participation, or (c) receiving a performance-based payment ($3 for an incorrect answer or $9 for a correct answer).

	Course credit payment	Flat fee payment ($5)	Performance incentive ($3/$9)	Overall
Percentages	0.0% (n=0/50)	4.3% (n=2/47)	9.5% (n=4/42)	4.3% (n=139)
Percentages with picture	28.0% (n=14/50)	26.5% (n=13/49)	40.5% (n=17/42)	31.2% (n=141)
Natural frequencies	23.5% (n=12/51)	29.2% (n=14/48)	54.8% (n=23/42)	34.8% (n=141)
Natural frequencies + picture	40.4% (n=21/52)	33.3% (n=16/48)	65.9% (n=27/41)	45.4% (n=141)
Natural frequencies + active picture	54.9% (n=28/51)	44.0% (n=22/50)	63.4% (n=26/41)	53.5% (n=142)
Overall	29.5% (n=254)	27.7% (n=242)	46.6% (n=208)	34.0% (n=704)

2.2 Materials

Within each incentive condition, participants were randomly given one of five different task formats, all variants of the same Bayesian inference task (i.e., a task of determining the posterior probability of an event, given some new information to be combined with an initial base rate). This type of task was selected for two primary reasons: it relates to and extends findings in previous research (Brase et al., 2006; Cosmides & Tooby, 1996; Sloman et al., 2003), and it is a task that is amenable to modifications that make it easier or more difficult for participants to successfully complete; hence it provides a good test case for the question of whether financial incentives differentially improve performance on moderately challenging tasks that are responsive to better effort.

Although every task had the same correct answer, previous research has established that: a) using natural frequencies (i.e., non-normalized, categorized whole numbers) improves performance (e.g., Gigerenzer & Hoffrage, 1995; Hoffrage, Lindsey, Hertwig, & Gigerenzer, 2000) , b) adding pictorial representations also improves performance to a somewhat lesser extent (Brase et al., 2006; Cosmides & Tooby, 1996), and c) active construction of pictorial representations may sometimes also aid performance (Cosmides & Tooby, 1996; but see Brase, 2009). Thus, without changing the fundamental nature of the task, this study was able to manipulate task difficulty via these format changes. The five task variants, from most difficult to least difficult, were: 1) a problem using percentages information (i.e., normalized numbers); 2) a problem using percentages and supplemented with a pictorial representation; 3) a problem using natural frequencies; 4) a problem using natural frequencies and supplemented with a pictorial representation; and 5) a problem using natural frequencies and supplemented with a pictorial representation that required participants' active construction using the picture. The full text of the five task conditions are provided in the Appendix. These tasks were ordered in terms of difficulty based on prior study results (see Table 1), and the text was based on tasks used in Girotto and Gonzalez (2001).

2.3 Design and procedure

All participants first completed a sheet of general study information and receipts (for the conditions that involved monetary payments). This was followed by the actual Bayesian reasoning task. Upon completions, participants were instructed to bring their consent form, receipt, and task to the experimenter, who took these materials, paid the participants (in the relevant conditions), and completed the receipts as necessary.

3 Results

Table 2 provides descriptive statistics for all conditions. Responses were considered correct if and only if they were some form of the correct answer of 10/28 (e.g., 10/28, 5/14, or .357 in decimal form). Performance on different tasks, collapsing across incentive types (rightmost column) showed substantial differences, ranging from 4.3% to 53.5%. Performance under different incentive types, collapsing across task formats, ranged from 27.7% to 46.6%.

These data were used to perform a binary logistic regression analysis, with task performance as the target variable and incentive type and task format as categorical predictors with indicator contrasts and the reference categories as course credit incentive and normalized percentages format. This analysis showed a significant overall model for regression analysis (Chi-square=130.32, df =6, $p < .001$; see Table 3). Specifically, performance-based

Table 3: Results from binary logistic regressions using type of participant payment and task format as as predictor variables and task performance as the target (dependent) variable.

Variable	Odds Ratio (95% Cl)	Significance[a]
Course Credit Payment vs. Flat-Fee Payment	0.899 (0.595–1.359)	.614
Performance-based Payment	2.410 (1.587–3.660)	<.001
Normalized Percentage Format vs. Percentages + Pictures Format	10.725 (4.359–26.390)	<.001
Natural Frequencies Format	12.676 (5.169–31.082)	<.001
Natural Freqeuncies + Pictures Format	20.328 (8.327–49.621)	<.001
Natural Frequencies + Active Pictures	28.664 (11.739–69.994)	<.001

[a] Significance levels of the contrasts were evaluated using the Wald statistic (the ratio of the beta coefficient to its standard error, squared). More specific comparisons were performed, using difference of proportions tests, to evaluate particular issues in more detail.

incentives produced significantly better performance than course credit (p<.001), but flat-fee incentives were no different from course credit. Participants performed significantly worse on the normalized percentage format than on all other tasks (all p<.001).

3.1 Incentives and performance

The logistic regression established that course credit and flat fee incentives (set at $5) had similar effects with regards to task performance. Although either of these incentives can be increased or decreased to alter the level of incentive they provide (e.g., increasing the number of course credits or increasing the dollar amount), both appear to motivate performance similarly. Performance-based incentives, however, elicited higher levels of performance than either of the other incentive conditions (comparing flat fee incentives to performance based incentives: 27.7% versus 46.6%: z=4.15, p<.001, h=.39). This was not due to appreciably higher overall levels of incentives provided to the participant population as a whole, however; the performance-based incentives conditions yielded an average payment of $5.84, compared to the flat-fee incentive rate of $5.00.

Comparing the course credit incentive conditions to the performance-based incentive conditions, it appears that a performance-based incentive had greater impact for cognitive tasks of medium difficulty, relative to very difficult or very easy tasks. Specifically, the performance improvements when using the more difficult percentage format tasks (top two rows of Table 2) were 9–12 percentage points, comparing across these types of payments. Performance improvements were in the range of 25–31 percentage points for the medium difficulty tasks (third and fourth rows of Table 2), and then declined again to an 8 percentage point change for the easiest task using both natural frequencies and interactive pictures (fifth row of Table 2). Although tentative, these descriptive statistics suggest that improvements in performance due to the use of performance-based incentives may differ as a function of task difficulty. It is not clear, however, whether such differences reflect equal intervals of difficulty change. For example, an improvement from 4% to 10% may not be equivalent to a change from 44% to 60% in terms of experienced difficulty. This consideration also applies to the results reviewed in Table 1.

3.2 Task formats and performance

Collapsing across types of incentives used, the patterns of performance replicated previous findings that natural frequencies elicit better performance than normalized numbers (percentages) and that adding pictorial representations also facilitate performance (as shown by the overall row totals in the right-most column of Table 2). Natural frequencies elicited better performance than percentages, both with text only (4.3% versus 34.8%: z=6.42, p<.001, h=.84) and with pictures (31.2% versus 45.4%: z=2.45, p=.007, h=.29). The effect of natural frequencies, however, was much larger in the absence of a pictorial aid. Pictures consistently elicited better performance than text alone, both with percentages (4.3% versus 31.2%: z=5.88, p<.001, h=.77) and with natural frequencies (34.8% versus 45.4%: z=1.82, p=.035, h=.22). The effect of pictures, however, was larger when used with percentages rather than natural frequencies. Taken together, these results suggest that the use of natural frequencies and the use of pictures are both enhancing performance independently, but via similar (partially overlapping) routes, either by eliciting frequentist representations (Brase, Cosmides, & Tooby, 1998, Brase, 2002, 2009; Gigerenzer & Hoffrage, 1995) or by eliciting some better representation of nested-set relationships (Sloman et al., 2003).

Table 4: Percentage of participants, under each incentive condition, who reached the correct answer (10 out of 28, or .357), the most frequent incorrect answer (10% or 10 out of 100), and other answers. Incentive conditions were: (a) receiving course credit for their participation, (b) receiving a flat fee payment of $5 for their participation, or (c) receiving a performance-based payment ($3 for an incorrect answer or $9 for a correct answer). A higher Other/Hit Rate Ratio indicates that proportionately more incorrect answers were likely effortful calculations.

	Course credit payment	Flat fee payment ($5)	Performance incentive ($3/$9)
Correct response	29.5%	27.7%	46.6%
Hit rate response (10%)	32.3%	38.0%	23.1%
Other responses	38.2%	34.3%	30.3%
Other responses / Hit rate ratio	1.183	.903	1.312

3.3 Changes in correct/incorrect response patterns with different incentive types

Past surveys have noted a reduction of variability of responses as a function of monetary incentives, but such an assessment is difficult with the present data because responses for Bayesian reasoning tasks are generally scored as either correct or incorrect (i.e., dichotomously). The number of different (incorrect) responses is problematic because diversity of such responses could be due to either lack of effort (e.g., random responses) or greater effort (e.g., increasingly complicated calculations without reaching the correct answer). Therefore, the assessment method used here was to compare selected types of incorrect responses for indications of increased effort on task, which is often the presumed source of reduced variability. The most frequent incorrect answer was to respond with the overall hit rate (10% or 10 out of 100), which is most likely due to low effort (because it is simply repeated from the text of the task; see Appendix). Other incorrect answers are often, although not always, indicative of greater effort. Table 4 shows that, with performance-based incentives, participants made fewer simple responses of the overall hit rate as an answer (in addition to being more likely to reach the correct answer), compared to either of the other two incentive conditions

4 Discussion

Performance-based incentives can elicit significantly better performance than either flat-fee or course credit incentives. Furthermore, the effectiveness of incentives may be sensitive to the task, with more improvement of performance on tasks of intermediate difficulty. This pattern could be a result of either general increases in effort that yield improvement only in intermediate difficulty tasks, or a result of discretionary increases in effort put into a task when participants perceive a high likelihood that the additional effort could attain the correct response and that a correct response will be rewarded.

This pattern of results can be understood in psychological terms as increased motivation in anticipation of greater rewards or (not mutually exclusively) in economic terms as participants maximizing an objective function, given their available cognitive capital and the particular production function of the experiment (see the capital-labor-production framework of Camerer & Hogarth, 1999). More generally, if one is dealing with smaller or more sensitive effects within a field of study, the influences of participant incentives can potentially explain the otherwise mysterious appearance, disappearance, and reappearance of effects (e.g., an effect that manifests as a 20 percentage point change from a fixed criterion could be found with a study using performance-based incentives, fail to be replicated in a study with fixed course credit incentives, then be found again using performance-based incentives, and so on). This is particularly important within the field of psychology because little attention has been paid to varying participant recruitment methods (see Brase, et al., 2006). One remaining issue is whether there could be any subtle differences in participant demographics (e.g., age, gender ratios, intelligence) between course credit situations — usually introductory psychology students — and flat fee situations, which are often not restricted to introductory psychology classes. The present study followed the sampling procedures typically used for these incentive types, keeping the demographics as consistent as possible (same university, same types of courses, etc.). Further research could attempt to obtain even more unequivocally homogeneous groups to ensure that the effects of different incentive conditions are stable.

The results of this research also further clarify the roles of natural frequency numerical formats and of pictorial representations in statistical reasoning. Both manipulations are effective additions for improving performance, and they appear to be additive, but not entirely independent, factors. The fact that there is a larger effect of pictures with normalized frequencies (compared to natural frequencies), holds implications for ongoing theoretical debates about the nature of statistical reasoning (see Brase, 2008, 2009).

Some aspects of the generalizability of these results to other tasks and to other incentive types remain to be more fully explored. The context story used for the Bayesian reasoning task in this research was that of a college admission test (see Appendix), but these results should generalize to isomorphic conditional reasoning situations in medical, legal, and clinical contexts (e.g., Hoffrage, Lindsey, Hertwig, & Gigerenzer, 2000). Furthermore, these results converge with other studies (using different types of context stories) on the effects of numerical formats and of pictorial aids (e.g., Brase, 2002, Brase et al., 1998; Gigerenzer & Hoffrage, 1995; Sedlmeier, 1999). There are, however, important issues of generalizability with regards to even more diverse types of tasks (e.g., perceptual judgments, procedural tasks, and memory performance) and different methodologies. There are some areas in which it is currently unclear if these findings apply and there are some areas in which they likely do not apply:

1. Although money is a common and easily standardized incentive, it is worth considering other forms of incentives. First, there has been some concern about the broader, negative social effects of monetary rewards (i.e., "monetization") on subsequent decision making and interpersonal behavior (Parco, Rapoport, & Stein, 2002; Saini & Monga, 2008; Vohs, Mean, & Goode, 2006), Second, the use of monetary incentives can prohibitively increase the cost of research activities in many situations. Also, other incentives may work as well or better than money in terms of performance/cost ratios; for example food, drink, or even human contact (Hayden et al., 2007) may have more economical performance/cost relationships (as noted earlier, though, these incentives would raise potential issues of satiation). A final possibility is to structure incentives within the research experience itself; for example, giving explicit "points" to participants for accurate performance or releasing participants earlier from the study as a function of their initial performance.

2. Applied outside of the research methodology arena, these results may provide guidance for how to pay people for their time (e.g., salary/hourly wages) or their performance (e.g., commission based payments). Depending on specific circumstances, the improvements in performance using incentive-based payments could more than offset the differences in average payments per person (in this study, $5.00 versus $5.84). Further research could also potentially utilize additional methodologies, such as measuring solution times and analyses of any written work that participants produce on their way to their answers, to obtain a clearer understanding of individual differences in responses.

3. Whereas some studies (such as this one) are concerned primarily with reducing errors and bias in responses, other studies are focused on characterizing the nature of the errors and biases that exist. In such situations, incentives are probably not necessary (and in fact could reduce the amount of sought after response types).

4. More powerful incentives can promote more objectively correct answers only in situations where there actually is an objectively correct answer. In some situations there is not a single correct answer (e.g., the response is a matter of opinion, the predicted response is based on a normative model, or the response is a choice between gambles). The general instructions given to participants in this particular study (see Appendix) were meant, in part, to deter interpretive responses by asking for the "typical" outcome (in case some people were inclined to answer in terms of subjective/probabilistic arguments) and explicitly giving instructions indicating that written calculations were allowed.

5. Finally, the finding that tasks of intermediate difficulty tend to show the largest shift in performance when given performance-based incentives raises issues about how to assess the difficulty level of tasks and the interaction of this assessment with individual differences in skill level (see Lord & Novick, 1968).

In summary, assessments of task competence need to take into account the incentives used in those assessments. Although conclusions about the generalizability of these implications across psychology and the rest of the behavioral sciences await more extensive research, there appear to be potentially far-reaching ramifications. These effects are likely to hold across a large number of decision making and other psychological phenomena that involve moderately effortful inferential procedures and could help explain a variety of reported discrepancies and variations in experimental results.

So what should be done to deal with this situation? As a practical matter, it is not feasible to dictate that all behavioral research be conducted with one type of incentive. On the other hand, planned research that endeavors to replicate prior findings must make sure to faithfully follow not only the stimuli and other materials of the prior work but also pay attention to the nature of participants' incentives in the original research. *Post hoc* comparisons across studies need to be more careful about comparing results from similar tasks but with dissimilar participant recruitment processes. Finally, results within research projects (e.g., multi-study reports) should freely compare relative levels of performances across different studies only if those studies have used the same recruitment methodology. When comparisons across disparate types of participants or recruitment methods is necessary, it should be clearly recognized that this is essentially a possible confounding variable that could be influencing the results.

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Appendix

Full texts of the Bayesian reasoning tasks used in the study (for all tasks the correct answer is 10/28; or .357 in decimal form). All tasks were preceded by the following general instructions:

"The following question asks for your judgments about what the outcome will be in a certain situation. Please give your answer in the space provided. If you believe that the answer may change each time the situation described occurs, please give us what you believe the "typical" outcome will be. You may use any part of this page to write out calculations, as long as you put your final answer in the space provided."

A) Percentages

The applicants for admission to a prestigious university have to pass an evaluation that involves an in-person interview. Here is some information about the results of last year's applicants. There was a 10% chance that an applicant was accepted. All the applicants that were accepted had passed the in-person interview. However, if the applicant was rejected, there was still a 20% chance that he or she passed the in-person interview.

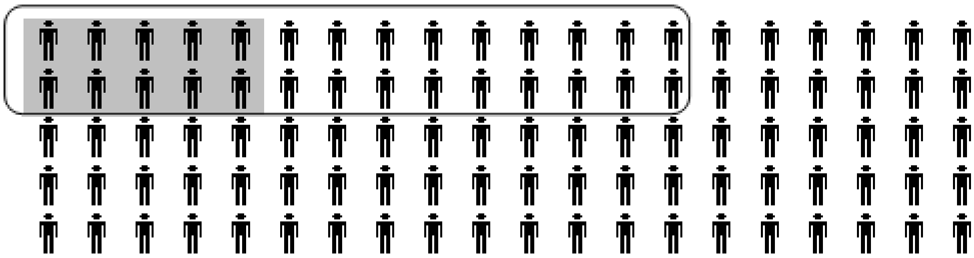
Imagine we randomly select an individual from this year's applications— Janet. Janet is taking the in-person interview. If she passes the in-person interview, what are the chances Janet will *actually* be accepted to the university?

____

B) Percentages with Picture

[same initial paragraph as condition A]

The picture below summarizes the above information, and is provided for you to use in the process of answering the following item. All the chances for different outcomes are represented by the 100 figures printed below (in 5 rows of 20). The area that has a darkened background is the chances that an applicant is accepted. The area that is inside the circle is the chances that an applicant passed the in-person interview.



Imagine we randomly select an individual from this year's applications— Janet. Janet is taking the in-person interview. If she passes the in-person interview, what are the chances Janet will *actually* be accepted to the university?

____

C) Natural Frequencies

The applicants for admission to a prestigious university have to pass an evaluation that involves an in-person interview. Here is some information about the results of last year's applicants. 10 out of every 100 applicants were accepted. All the applicants that were accepted had passed the in-person interview. However, 18 of the 90 rejected applicants also passed the in-person interview.

Imagine we randomly select 100 individuals from this year's applications. All these applicants are taking the in-person interview. Out of the applicants who pass the in-person interview, how many will *actually* be accepted to the university? ____ out of ____

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D) Natural Frequencies + Picture

[same initial paragraph as condition C]

The picture below summarizes the above information, and is provided for you to use in the process of answering the following item. The applicants are represented by the 100 figures printed below (in 5 rows of 20). Figures that have a darkened background are the number of applicants that were accepted. Figures that are inside the circle are the applicants that passed the in-person interview.

[same picture as Condition B]

Imagine we randomly select 100 individuals from this year's applications. All these applicants are taking the in-person interview. Out of the applicants who pass the in-person interview, how many will *actually* be accepted to the university? ____ out of ____

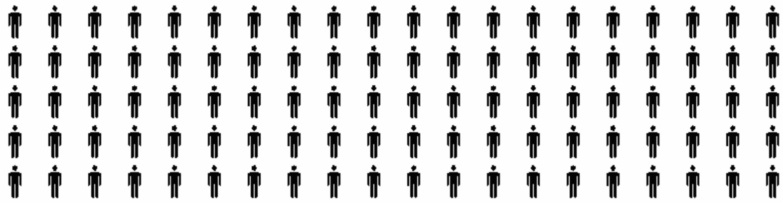
E) Natural Frequencies + Active Picture

[same initial paragraph as condition C]

The picture below is provided for you to use in the process of answering the following item. The applicants are represented by the 100 figures printed below (in 5 rows of 20). Please create a picture of the above information.

1. Draw circles around the number of applicants that were accepted;

2. Then draw check marks (✓) across the number of applicants that passed the in-person interview.



Imagine we randomly select 100 individuals from this year's applications. All these applicants will be taking the in-person interview. Out of the applicants who pass the in-person interview, how many will *actually* be accepted to the university? ____ out of ____

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