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Private and Public Relative Performance Information under Different Incentive Systems

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An abstract of
a dissertation submitted to the Faculty of the Graduate School of Emory
University in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in Business

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Abstract

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This study investigates the conditions under which providing relative performance information to employees has a positive effect on effort and performance. Specifically, I study, via an experiment, the effect of relative performance information (present or absent) on effort and performance under two incentive systems that do not tie employees' compensation to peer performance (flat-wage or individual performance-based). Furthermore, given the presence of relative performance information, I examine the effect of the type of relative performance information disclosure (private – employee's anonymity is preserved or public – employees' anonymity is not preserved) on effort and performance under a flat-wage and an individual performance-based contract. Using theory from psychology, I predict and find that relative performance information positively affects effort and performance under the two incentive systems and that this positive effect is greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Also, I predict and find that when relative performance information is present, publicly (vs. privately) disclosing relative performance information positively affects effort and performance, and this effect is greater under an individual performance-based compensation contract than under a flat-wage compensation contract.

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Acknowledgements

I greatly appreciate the guidance and support of my dissertation chair, Kristy Towry, and dissertation committee members, Gary Hecht and Kathryn Kadous. I would like to thank Lawrence Brown, Jacob Burnberg, Willie Choi, Harry Evans, Sukari Farrington, Lynn Hannan, Vicky Hoffman, Marcus Kirk, Tim Mitchell, Donald Moser, Budina Naydenova, William Tayler and the workshop participants at Emory University, Georgia State University, and the University of Pittsburgh for their helpful comments. I gratefully acknowledge the financial support provided by the Institute of Management Accountants Foundation for Applied Research Doctoral Student Grant Program, and the Goizueta Business School at Emory University.

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I. INTRODUCTION

Firms commonly provide relative performance information (RPI) to their employees, even when employees are compensated based solely on their individual performance (Anderson et al. 1982; Nordstrom et al. 1990; Wikoff et al. 1982). In banking, for example, some branch managers disclose to their tellers the number of new accounts opened by each of their colleagues, even though tellers' compensation is independent of peer performance. Although economic theory discusses in depth the effect of providing RPI when employees' compensation is based on team performance (via mechanisms such as peer pressure and mutual monitoring, Kandel and Lazear 1992), it is silent on the effect of such information when employees' compensation does not depend on the performance of their peers. Therefore, this common practice is something of a mystery to scholars who study efficient contracting. I add to the literature that provides insights into this mystery, using theory from psychology to investigate the conditions under which RPI can positively affect employees' effort and performance when compensation is not tied to peer performance.

Using an experiment, I study this issue in a two-stage process. First, I examine how the presence of RPI affects effort and performance and whether this effect is moderated by the type of incentive system (flat-wage or individual performance-based).[1] Second, given that RPI is present, I investigate the effect of the type of RPI disclosure (private – employee's anonymity is preserved, or public – employee's anonymity is not

[1] I use the term "flat-wage" to refer to compensation contracts that do not explicitly provide compensation based on absolute or relative task performance (i.e., salary-based contracts). I use the term "individual performance-based" to refer to piece-rate compensation schemes that provide compensation based on absolute but not on relative task performance.

preserved) on effort and performance and how this effect is moderated by the type of incentive system.[2]

At stage one (RPI present or RPI absent), I rely on social comparison theory to develop the hypotheses. According to social comparison theory (Festinger 1954), people strive to be at least slightly better than others when performing tasks that are indicative of an important ability. RPI allows for social comparison, which can result in competition and have a positive effect on effort and performance. Indeed, previous research (Kerr et al. 2007; Murthy 2008) finds that RPI can positively affect employees' performance even when compensation is independent of peer performance. I replicate this finding and extend the existing literature by showing that the positive effect of RPI on effort and performance depends on the incentive system type.

I provide two reasons for the interaction between RPI and the incentive system (flat-wage or individual performance-based). First, as emphasized by Festinger (1954), individuals engage in social comparison to understand how their own abilities compare to the abilities of others. Hence, the stronger the relationship between task performance and ability, the more useful RPI is for social comparison purposes (Martin 2000). I posit that providing performance-based incentives reduces the noise in the ability-performance relationship and increases the validity of making inferences about ability based on RPI. Providing incentives does so by reducing the possibility that differences in performance are simply due to differences in levels of effort. Second, incentives eliminate the demotivating effect that RPI may have on the best performers under a flat-wage contract

[2] For example, Wikoff et al. (1982) observed the use of RPI in a furniture manufacturing plant, where a graph with performance information was prominently displayed, substituting each employee name with a single letter. Only the employee to whom the letter was assigned knew that the letter corresponded to his name.

(Kerr 1983; Orbell and Dawes 1981; Schnake 1991). Incentives do this by eliminating the possibility that the best performers are played for a "sucker" by the other performers, who withhold effort. Based on these two reasons, I predict and find that the positive effect of RPI is greater under a performance-based compensation contract than under a flat-wage compensation contract.

At stage two (RPI is present and provided either privately or publicly), I extend the existing literature by showing that when it comes to predicting the effect of RPI on effort and performance, it is important to know not only whether RPI is provided but also how it is provided. The negative and positive feelings that result from performance comparison (Major et al. 1991) are exacerbated by publicity (Smith 2000). People are motivated to avoid negative and to seek positive feelings in order to maintain a positive self-image (Beach and Tesser 1995; Tesser 1988). Hence, I predict that publicly (vs. privately) disclosing RPI will have a positive effect on effort and performance. This positive effect will be greater under an individual performance-based compensation contract than under a flat-wage compensation contract due to a perceived stronger relationship between ability and performance under the former contract. The experimental results support this prediction.

This research provides an important refinement to the theory on RPI by examining the situations under which RPI can improve performance, even when the existing economic theory would predict no effect. It also provides useful insights for practice. Disclosing RPI to employees is costly (Crowell and Anderson 1982; Pfeffer and Sutton 1999). The cost comes not only from collecting and distributing this information, but also from the possibility that such information may reduce cooperation among employees. To design effective information and incentive systems, a company needs to understand when providing relative performance feedback will have a positive effect on performance and be able to weigh such benefits against the cost of doing so. This understanding can lead to the design of internal information systems and incentive systems that promote maximum effort and optimal performance among employees.

The rest of the paper is organized as follows. Section II develops the hypotheses. Section III presents the experimental design. Section IV reports the results. Section V summarizes and discusses the results.

II. THEORY AND HYPOTHESES

2.1 Economic Theory on the Effect of RPI on Employee Effort and Performance

Economic theory examines in depth the effect of providing RPI when the agent's compensation depends on peer performance. Two incentive schemes that tie compensation to peer performance are tournament-based and team-based compensation. A review of the main findings of this literature is provided.

2.1.1 Tournaments

Under a tournament, the agent's compensation depends only on his rank and not on his absolute performance. RPI is used to calculate each agent's rank, i.e. RPI is used for relative performance evaluation (RPE). Tournaments are utilized to induce competition among agents.

Holmstrom (1979) studies a principal-agent relationship where a risk-neutral principal employs a risk- and effort-averse agent. The agent takes a private action *a* that together with a random state of nature *s* determines the payoff $x = x(a, s)$.[3] The problem is to determine how to share the payoff *x* optimally between the principal and the agent. Holmstrom shows that if a signal *y* provides information about the agent's action *a* or about the state of nature *s* over that provided by *x* alone (i.e. signal *y* is informative) then *y* is valuable for contracting and should be used in the compensation contract (if it can be costlessly obtained and used in the contract). According to Holmstrom (1979), basing the agent's compensation on the pair (*x, y*) instead of only on *x* can either improve risk sharing between the risk-neutral principal and risk-averse agent without reducing the agent's incentive to exert effort or provide the agent with greater incentives to exert effort without increasing his risk exposure.

Holmstrom (1982) goes a step further and examines the informativeness of RPI in a multi-agent environment. In a multi-agent environment, the uncertainty that each agent faces can be split into uncertainty that is shared by all agents (common uncertainty θ) and uncertainty that is specific to each agent (idiosyncratic uncertainty ε). Holmstrom (1982) proves that an aggregate measure such as average peer performance may capture the information about common uncertainty. This allows for filtering of the effect of common uncertainty from the agent's output and hence a better understanding of the agent's unobservable action *a*. Based on the above, Holmstrom (1982) posits that RPI is valuable and should be used for RPE if agents face some common uncertainty. In such cases, the information that can be gained from performance comparison is valuable. Holmstrom acknowledges that RPE leads to competition among agents. However, he argues that this competition is only a consequence of agents' attempts to use RPI. The author claims that

[3] Action *a* is the agent's input. This input is costly for the agent. The terms action and effort are used interchangeably.

if agents' outputs are independent (i.e., no common underlying uncertainty exists), there are no benefits from competition. Also, Holmstrom (1982) asserts that tournaments are collusion proof because they induce a zero-sum game between agents.

Lazear and Rosen (1981) study the effect of providing RPI under a tournament compensation scheme. In their model, each agent's output x_i is a function of the agent's action (effort) a_i, idiosyncratic error ε_i, and common error θ. Lazear and Rosen (1981) show that if the agent is risk-averse and the common error θ is large, the tournament produces superior outcomes compared to an individual performance-based incentive scheme. Their reasoning is the following: if the agent is risk-averse, the principal needs to compensate him for risk. Under an individual performance-based incentive scheme, the agent's risk equals $\varepsilon_i + \theta$. However, under a tournament, the common error θ is eliminated because it influences all agents. This means that the tournament improves risk-sharing between the risk-neutral principal and the risk-averse agent and hence reduces the agent's compensation cost. Additionally, Lazear and Rosen show that in a tournament, where the agent's payoff depends on his relative performance and not on his absolute performance, the agent should value RPI. The reason given by the authors is that, if agent does not know precisely his own ability, he can use RPI to figure out his optimal strategy (i.e., how much effort to invest).

Indeed, Gibbons and Murphy (1990) demonstrate that RPI can be useful for the principal to learn about agents' abilities (learning model). In their model, each agent's output x_i is a function of the agent's ability η_i, idiosyncratic error ε_i, and common error θ.[4]

[4] The only difference between this model and the one in Lazear and Rosen (1981) is that agent's action (effort) a_i is replaced by agent's ability η_i.

According to this paper, RPI takes care of the common uncertainty θ in performance and leaves performance a function of ability η_i and idiosyncratic nose ε_i.

Similarly to Holmstrom (1982), Mookherjee (1984) argues that one agent's compensation should depend on another agent's output only if they share common uncertainty. Furthermore, this paper proves that if the agents are risk-averse and the principal can impose sufficiently heavy punishments on them, the principal can attain the first best solution when the agent's production uncertainties are perfectly correlated (there is no idiosyncratic risk, all the risk is common risk). However, Mookherjee (1984) disagrees with Holmstrom's claim that tournaments are collusion proof. Mookherjee ascertains that tournaments are vulnerable to collusion among agents. He shows that agents can collude in order to reduce their effort levels while leaving the probability distribution of compensation intact (work less for the same payoff). Subsequent research (Baiman 1990; Dye 1984; Prendergrass 1999) agrees with this claim, pointing out that under a tournament incentive scheme, agents have a strong incentive to collude against the principal, but no incentive to help each other, even if this could improve their absolute performance.

Lazear (1989) argues that RPI should be used for RPE purposes in order to increase competition among agents only if collusion among agents is impossible. In cases when collusion is possible, the author suggests using a team-based compensation scheme to induce cooperation. Villadsen (1995) expands this idea by proving that a contract that aims to induce cooperation among agents uses RPI less for RPE than a contract that seeks to induce competition among agents.

2.1.2 Team-Based Compensation

Under team-based compensation, the agent's payoff depends on the performance of the whole team. Here RPI is not used for RPE but to provide means for team members to monitor each other. Team-based compensation schemes are used to induce cooperation among agents.

Kandel and Lazear (1992) predict that relative performance information will affect performance when agents' compensation depends on the performance of their peers. To prove their point, the authors introduce a "peer pressure" function $P(*)$. The peer pressure function $P(*)$ is similar to the cost of effort function $C(a)$ except for two differences. First, $P(*)$ *is* a "social" function because it depends on peers' effort and actions, while $C(a)$ does not. Second, $P(*)$ can be subject to manipulation by the group, while $C(a)$ cannot. The agent's utility function is described as additively separable in utility from compensation, disutility from effort, and disutility from peer pressure. Kandel and Lazear (1992) show that $P(*)$ can be interpreted as "implying that workers get utility from effort" (p.805). They use that to prove that with peer pressure, an agent's equilibrium effort is higher than is his effort without peer pressure. The authors point out that this result holds under two necessary conditions. First, the agent's compensation must be tied to peer performance. Otherwise, the agent will have no incentive to monitor and exert peer pressure over the other agents. Second, the agent has to have the means to exert peer pressure. Relative performance information is such a resource. It provides agents with the information they need to be able to monitor their peers.

Varian (1990) proves that it can be valuable to tie an agent's reward to the output of the other agents in the group even when there is no common uncertainty. In such cases, agents may be motivated to take actions that affect each others' cost or utility. The author demonstrates his theory with an example. The Grameen Bank in Bangladesh requires its borrowers to apply for a loan only in groups of five. The bank then accepts or rejects the loan for the entire group, although the projects of the five borrowers are independent of each other. In such cases, the five agents are highly motivated to provide mutual monitoring, insurance and assistance to each other.

Arya et al. (1997) show that even in a situation when the agent's performance measure is informative only for his own action, it can be optimal to condition the agent's pay on both his individual and team performance measures. The use of a team performance measures ties agent's compensation to peer performance and hence provides him with incentives to monitor his peers. Also, it provides the agent with a mechanism to punish peers that shirk by withholding effort in future periods. The authors use a two-period model, where a risk neutral principal employs two risk-averse agents. In period 1, the principal provides incentives based on team output, such that each agent at least weakly prefers both agents working to both shirking. In period 2, the principal uses incentives that ensure that both agents have the ability to punish each other. In fact, punishment is sufficiently large to assure that the agent prefers to work in both periods rather than to free-ride in the first period and be punished in the second period. Importantly, the model assumes that each agent can observe the other agent's effort costlessly. The authors point out that if the cost of observing the other agent's is sufficiently high, tying compensation to each other's performance is not optimal. Here, as with Kandel and Lazear (1992), RPI can play an important role by providing the agents with means to monitor each other.

The research reviewed so far has one thing in common. It examines the effect of RPI under incentive systems that tie an agent's compensation to peer performance. Economic theory does not predict that relative performance information will affect performance when employees' compensation does not depend on the performance of their peers. According to Kendel and Lazear (1992, p.806), in such situations, "peers have no incentive to exert pressure because they do not care what action he *(the other agent)* chooses." Their reasoning is summarized in Frederickson (1992) as follows. Economic theory is based on the assumptions that agent's utility function is the sum of utility from compensation and disutility from effort.[5] The agent, who is risk- and effort-averse, will choose the effort level that maximizes his expected utility for a given compensation scheme. When an agent's compensation is not tied to peer performance, RPI does not enter at all in the agent's objective function. Hence, RPI affects neither agent's utility from compensation nor agent's disutility from effort. Therefore, RPI should not affect in any way the agent's effort decision.

2.2 Social Comparison Theory on the Effect of RPI on Employee Effort and Performance

2.2.1 Social Comparison Theory

I use social comparison theory (Festinger 1954) to predict that providing RPI will affect performance even in cases when employees' compensation is not linked to the performance of their peers. The reasoning is as follows.

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[5] Kandal and Lazear (1991) add a third component to the agent's utility function - disutility from peer pressure. However, because they clearly indicate that this peer pressure will play a role only when agent's compensation depends on peer performance, this component does not change the economic theory prediction.

Social comparison theory (Festinger 1954) posits that people have a drive to compare themselves to others in order to evaluate their own abilities.[6] This drive arises from the fundamental human need to reduce uncertainty.[7] When objective, non-social means are not available, people evaluate their abilities by comparison with others (Festinger 1954, p.118). Festinger points out that often one is not able to evaluate her/his ability simply by reference to the physical world. For example, one can easily find out how fast s/he can run a given distance. However, in order to decide on her/his ability to be fast, one must compare her/his result with the results of others. Festinger claims that when objective, non-social means for evaluation are available, people won't evaluate their ability by comparison with others. Subsequent research (Buunk and Gibbons 2007; Seta et al. 2006) shows that people engage in social comparison even when objective or subjective means or standards are available. For example, Seta et al. (2006) provide evidence that people tend to place considerable weight on social comparisons, even when they have subjective information suggesting that they are doing better than average.

The fundamental need to reduce uncertainty motivates people to seek out information about their own abilities. Research demonstrates that uncertainty increases both the value of performance feedback and feedback seeking behavior (Ashford 1986; Ashford and Cummings 1985). For example, in a field survey, administered in a public

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[6] Festinger (1954) argues that this drive exists for opinions and abilities. To the extent that I am interested only in the part of social comparison theory that concerns abilities, I will discuss only social comparison theory predictions related to abilities.

[7] Social comparison serves three main purposes: (1) self-evaluation/uncertainty reduction (Festinger 1954) – the desire to have an accurate view of one's own abilities; (2) self-improvement (Smith and Sach 1997; Major et al. 1991) – the desire to improve one's abilities, and (3) self-enhancement (Thornton and Arrowood 1966; Wills 1981) – the desire to protect/enhance one's attitude towards the self. Importantly, these motives for social comparison are not mutually exclusive. For example, the desire to self-improve implies obtaining an accurate indication of where one currently stands, which provides a standard to compare future performances against. Additionally, self-improvement can also satisfy self-enhancement motives.

utility company, Ashford and Cumming (1985) find that employees experiencing a high degree of contextual uncertainty and role ambiguity seek performance feedback more frequently than those experiencing a low degree of contextual uncertainty and role ambiguity.

People compare their abilities to those of others by comparing performance on a task that speaks to the ability of interest. As acknowledged by Festinger (1954) "abilities are of course manifested only through performance which is assumed to depend upon the particular ability" (p.118). According to social comparison theory, the results of this comparison directly affect self-image. Individuals are highly motivated to maintain a positive self-image (Beach and Tesser 1995; Tesser 1988; Tesser and Smith 1980), meaning that they try to avoid negative feelings about the self and seek positive feelings about the self. For example, Tesser and Smith (1980) conducted an experiment in which participants, in groups of four, performed a word-identification task. Each of the participants in turn attempted to identify several words, while the other three participants chose clues to give to the first participant. The clues were chosen from a set of clues that varied in difficulty. The authors find that when participants are failing on the task (and the task speaks to an ability important to them), they choose to provide the other participants with harder clues than otherwise. This result is attributed to the failing participants feeling their self-esteem threatened and taking measures to protect it by making sure that the other participants fail the task.

Performing better than others leads to positive feelings such as pride, while performing worse than others leads to negative feelings such as shame (Lazarus 1991; Smith 2000). Shame usually results from *upward comparison* (comparison with a superior performer). Such a comparison highlights one's inferior ability, and can cause an unpleasant feeling (Gibbons et al. 1994; Gilbert 1992; Lazarus 1991; Smith 2000). For example, Gibbons et al. (1994) show that when people do poorly compared to others, in order to avoid shame, they change their social comparison strategies by becoming more self-protective. In their study, students who participated in an academic program for gifted students and had performed poorly demoted the importance of the domain of their poor performance (academics) in order to avoid unpleasant feelings. Contrary to shame, pride usually results from *downward comparison* (comparison with an inferior performer). Such a comparison highlights one's superior ability, and can cause a pleasant feeling (Major et al. 1991; Tesser 1991; Weiner 1986). For example, Major et al. (1991) talk about comparing one's publication rate with that of a less prolific colleague. The authors point out that such comparison enhances self-esteem and pride, especially when the comparer can attribute performance superiority to internal causes (e.g. superior intelligence).

Since performing better than others leads to positive feelings such as pride, while performing worse than others leads to negative feelings such as shame, every individual wishes his/her performance to be at least slightly better than that of others.[8] However, individuals realize that it is impossible for everyone's performance to be better than that of others. This realization leads them to exhibit competitive behavior (Festinger 1954; Hoffman et al. 1954). For example, Hoffman et al. (1954) conducted an experiment on competitive bargaining behavior where one participant in each group of three participants was made to initially score significantly higher than the other two on an intelligence test.

[8] Festinger (1954) claims that this is due to the existing in the Western culture value set on "doing better and better, which means that the higher the score of performance, the more desirable it is" (p.124). He warns this may vary across cultures and hence may not apply to other cultures.

The authors provide evidence that upon realizing that, the other two participants exhibited competitive behavior and consciously prevented the participant who initially scored higher from scoring more points later in the experiment.

Competitive behavior that arises from everyone's desire to perform at least slightly better than the others can have a positive effect on effort and performance. The strength of this effect will be determined by three factors, explained next.

2.2.2 Social Comparison and Competitive Behavior

Competitive behavior is a common consequence of the social comparison process (Festinger 1954; Hoffman et al. 1954). This competitive behavior is more pronounced when the following three conditions are met. First, the performed task is similar across individuals (Festinger 1954; Harkins and Jackson 1985). Second, the comparison target (i.e., the other person) is similar on *related attributes* (characteristics of the person that predict performance) (Festinger 1954; Goethals and Darley 1977). Third, the comparison domain is important to the person (Festinger 1954; Tesser 1988).

On the first point, Festinger (1954) notes that tasks performed must be similar across individuals to allow for performance comparison. Harkins and Jackson (1985) provide empirical evidence on this claim. They conducted an experiment where participants performed a brainstorming task in groups of four. Participants were asked to generate as many uses as they could for a given object. The same object, a knife, was given to all participants. However, half of them were told that the object was the same for each participant, and the other half were told that the object was different for each participant. Performance was measured by the number of uses generated for the given object. The authors demonstrate that RPI positively affects performance only when participants believe that the object for each they generate uses is the same for each participant. Otherwise, participants consider the task dissimilar across participants. This leads them to perceive their individual outputs as not comparable, and the setting as not competitive. In this case, providing RPI has no effect on performance.

On the second point, Festinger argues that when comparing one's own performance to the performance of others, one can be highly confident that the difference in performance is due to a difference in abilities only when the others are similar to the comparer on related attributes, such as experience, education, etc. To illustrate his point, Festinger points out that college students do not compare themselves to inmates of an institution for feeble minded in order to evaluate their own intelligence, and chess beginners do not compare themselves to chess masters in order to evaluate their ability to play chess.

A number of studies (Seta 1982; Wheeler et al. 1982; Zanna et al. 1975) provide support for this claim. In Zanna et al. (1975), undergraduate female and male students took a test supposedly designed to measure two underlying abilities – verbal acuity and logical reasoning. Before taking the test, participants were told that typically women did better on the verbal acuity test and men did better on the logical reasoning test. After taking the test, the participants were presented with an ambiguous performance score and given an opportunity to see the performance scores of the other participants. The results showed an overwhelming tendency to choose to compare with the same-sex participants (ninety seven percent of the students chose to compare with same-sex participants). Wheeler et al. (1982) utilize an experiment involving a task, performance on which is indicative for the analytical reasoning ability (Miller Analogies Test – MAT) of the participants. Before performing the task, participants were supposedly given different number of practice items (0, 10, or 20). Then participants were asked to take a test on which performance was either related or unrelated to practice. Once participants completed the test, they were given their own score, rank, and the number of practice items done by each of the others participants. Then subjects were given an opportunity to learn the performance score of two other subjects and asked to indicate how interested they were in getting such information. The results show that when practice was deemed relevant to performance, participants usually chose to compare with those that had the same amount of practice as they did. Also, participants indicated that they were more interested in the comparison when practice was considered relevant to performance than when it was not. These results support the related attributes hypothesis.

Furthermore, there are two types of related attributes: stable and unstable (Goethals and Darley 1977). Goethals and Darley (1977) demonstrate that people clearly regard information about standing on *stable attributes* (performance-related but not easily altered by the comparer or by circumstances, such as long-term training and experience, education, age, sex, ethnic background) as informative of ability. However, they also show that people do not regard information about standing on *unstable attributes* (attributes that are likely to change over a brief period, such as brief practice, fatigue, and minor illnesses) as informative of ability.

On the third point, Festinger (1954) argues that the more important the comparison ability is to the individual, the greater the drive toward engaging in social comparison and competitive behavior. Subsequent research (Hofman et al. 1954; Pleban and Tesser 1981; Tesser 1991) supports this claim. For example, Hofman et al. (1954)

manipulated ability importance by telling half of the participants in their study that the test that they took provided good measure of intelligence, an ability considered important by participants. The other half of the participants were told that the test provided a very poor measure of intelligence. Because intelligence was important for participants, performing well was important to those that were told that the test provided a good measure of intelligence, and not important to those that were told otherwise. The results showed that competition was significantly greater among participants that considered performance important. Pleban and Tesser (1981) utilized an experiment where participants engaged in a question-answering competition with a confederate. The authors show that people involved in a competition exhibit signs of competitive behavior only when they have previously indicated that the task speaks to an ability that is important.

In summary, providing RPI allows for social comparison and results in competitive behavior. This competitive behavior has a positive effect on effort and performance. Importantly, the strength of competitive behavior and, hence, how positive its effect on effort and performance is, will be determined by three factors: task similarity, comparison target similarity, and comparison domain importance.[9]

2.3 Providing RPI under Incentive Systems That Do Not Tie Compensation to Peer Performance

This dissertation is not the first study to examine the effect of RPI on performance under different incentive systems. Using social comparison theory, previous research demonstrates that RPI can positively affect employees' performance when compensation is not tied to peer performance. Hannan et al. (2008) provide empirical evidence that RPI

[9] Importantly, none of the studies described in this chapter ties participants' compensation to the performance of other participants.

causes an improvement in performance under an individual performance-based compensation contract. Kerr et al. (2007) demonstrate the positive effect of RPI under a fixed compensation scheme. Similarly, Murthy (2008) shows that RPI positively affects performance under incentive schemes that do not tie employees' compensation to peer performance. The first two hypotheses aim to replicate this result. This step in the analysis is important, because the interaction, subsequently predicted, will have the expected form only if this prior result is replicated. The first hypothesis predicts an effect of RPI on *effort*:

H1a: Under incentive contracts that do not tie compensation to peer performance, effort will be higher when relative performance information is provided than when relative performance information is not provided.[10]

Hypothesis H1b follows from H1a. In essence, it states that the increase in *effort*, resulting from providing RPI under incentive contracts that do not tie compensation to peer performance (i.e., flat-wage, individual performance-based), will lead to an increase in *performance*. This will hold only for tasks with a positive effort-performance relationship. Formally stated, H1b is:

H1b: Under incentive contracts that do not tie compensation to peer performance, performance will be higher when relative performance information is provided than when relative performance information is not provided.

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[10] Although both Hannan et al. (2008) and Murthy (2008) recognize that RPI affects performance through effort, they both use only performance as a dependant variable. Hannan et al. (2008) attribute that choice to their inability to capture the multiple dimensions of effort: effort duration, effort intensity, and effort toward strategy development (Sprinkle 2000). Although my study does not provide a measure of effort that completely captures all these dimensions, it provides a measure that satisfies all three criteria for a good effort measure (Baiman 1982): one that is controlled by the agent, results in disutility, and positively correlates with output. Because I have such a measure and because studying the effect of RPI on both effort and performance provides a more detailed picture of the question of interest, my first two hypotheses (H1a and H1b) address the effect of RPI on both effort and performance.

2.4 Interaction between the Incentive System and RPI

Hypotheses 2a and 2b extend the existing literature by examining how the positive effect of RPI depends on the type of incentive system.[11] I argue that the positive effect of RPI on performance will be stronger under an individual performance-based contract than under a flat-wage contract for the following two reasons.

First, a primary motive for engaging in social comparison is to understand how one's ability compares to the abilities of others (Festinger 1954). Hence, the stronger the relationship between task performance and ability, the more useful RPI is for social comparison purposes (Martin 2000). Providing performance-based incentives reduces the noise in the ability-performance relationship and increases the validity of making inferences about ability based on performance. The reasoning is as follows. When a similar task is performed by multiple individuals in a similar environment, the two possible explanations for differences in task performance are: differences in abilities and/or differences in effort. Incentives motivate individuals to exert effort (Baiman 1982, 1990; Locke and Latham 1990; Vroom 1964), reducing the probability of the "differences in effort" explanation and therefore increasing the probability that any observed differences in performance are driven by differences in ability. Thus, RPI allows one to draw clearer inferences about abilities under an individual performance-based contract than under a flat-wage contract. As a result, the positive effect of RPI will

[11] Hannan et al. (2008) study the interaction between RPI and the incentive system. However, one of the incentive systems they use is a tournament, where the individual reward depends directly on peer performance. Although lacking a formal prediction, Murthy (2008) tests for a RPI x incentive system interaction in his post-hoc analysis. He does not find a significant one. However, his test has lower power than the one used here, because the task he uses does not satisfy one of the previously discussed three conditions for a strong relation between comparison and competitive behavior – performance of the task speaks to an important ability.

be stronger under an individual performance-based contract than under a flat-wage contract.

Second, research shows that when compensation is not related to performance, providing RPI may have a negative effect on the effort and performance of the best performers (Kerr 1983; Schnake 1991). Upon observing other employees' performance, the best performers suspect that other employees are withholding effort. To avoid being taken advantage of, the best performers withhold effort in future periods, which causes their performance to decline over time. Schnake (1991) shows the existence of this "sucker effect" under a flat-wage contract. I argue that under an individual performance-based compensation contract, the best performers are rewarded with the highest payoffs, thus eliminating the sucker effect. The elimination of the sucker effect will have a positive effect on the motivation and performance of the best performers.

In summary, providing individual performance-based incentives reduces the noise in the ability-performance relationship and eliminates the sucker effect. Therefore, I expect RPI to have a greater effect on effort and performance under an individual performance-based compensation contract than under flat-wage compensation contract. Formally stated, the hypotheses are:

H2a: The extent to which effort is positively affected by relative performance information will be greater under an individual performance-based compensation contract than under a flat-wage compensation contract.

H2b: The extent to which performance is positively affected by relative performance information will be greater under an individual performance-based compensation contract than under a flat-wage compensation contract.

H1 and H2 are graphically presented in Figure 1.

2.5 Public (vs. Private) Disclosure of RPI under Incentive Systems That Do Not Tie Compensation to Peer Performance

Hypotheses 1a and 1b and Hypotheses 2a and 2b address the effect of providing RPI on employees' effort and performance and how this effect is moderated by the incentive system. For these hypotheses, it is important only whether RPI is provided but not how it is provided. In other words, the predicted effects should hold regardless of whether RPI is disclosed privately or publicly. Hypothesis 3a and 3b and Hypotheses 4a and 4b take as a given that RPI is provided and examine the effect of type of RPI disclosure (private or public) on employees' effort and performance and how this effect is moderated by the incentive system. I posit that publicly (vs. privately) disclosing RPI will have a positive effect on effort and performance and that this positive effect will be greater under a performance-based compensation contract than under a flat-wage compensation contract.

Previous research that studies the effect of RPI on performance under different individual incentive systems preserves participants' anonymity (Frederickson 1992; Hannan et al. 2008; Mitchell 2008; Murthy 2008). This is achieved by providing each participant with information that indicates only how his/her relative performance rank compares to those of the other participants. This information is kept confidential from other participants. Frederickson (1992) expresses a concern that anonymity "may have decreased the importance of RPI" (p. 666). Indeed, Smith (2000) suggests that publicity plays an important role in the social comparison process. He points out that "public comparison can bring with it a variety of unpleasant consequences, and the painful emotion of shame is the common marker of these consequences" (p. 182). The author also suggests that "just as our inferior, blameworthy attributes create less shame if they are kept private, our superior praiseworthy attributes create greater pride if they are made public" (p. 188). Empirical research confirms that public comparison, indeed, has a strong effect on comparison choices made by participants (Smith and Insko 1987; Wilson and Benner 1971).

Additionally, impression management theory argues that people are concerned with the impressions other people form about them (Goffman 1959; Tadeschi 1981). This theory posits that individuals will take actions to avoid negative impressions and to create positive impressions. Therefore, I expect that publicly (vs. privately) disclosing RPI will have a positive effect on effort and performance. The next hypotheses formally state this expectation.

H3a: Under incentive contracts that do not tie compensation to peer performance, effort will be higher when public relative performance information is provided than when private relative performance information is provided.

H3b: Under incentive contracts that do not tie compensation to peer performance, performance will be higher when public relative performance information is provided than when private relative performance information is provided.

Lastly, the positive and negative feelings resulting from publicly disclosing RPI will be stronger under a performance-based compensation contract than under a flat-wage compensation contract due to the stronger relationship between ability and performance when performance is rewarded, as explained earlier for H2a and H2b. This will lead to a stronger positive effect of the public RPI under an individual performance-based compensation contract than under a flat-wage compensation contract.

H4a: The extent to which effort is positively affected by public (vs. private) relative performance information will be greater under an individual performance-based compensation contract than under a flat-wage contract.

H4b: The extent to which performance is positively affected by public (vs. private) relative performance information will be greater under an individual performance-based compensation contract than under a flat-wage contract.

H3 and H4 are graphically presented in Figure 2.

III. METHOD

3.1 Experiment Design and Task Description

I use a nested experimental design in which I vary (between subjects) the incentive system (flat-wage or individual performance-based) and the RPI (present or absent). Nested within the RPI present condition, I vary (also between subjects) the type of RPI at two levels (private or public). The nested design results in six main conditions: no RPI/flat-wage, no RPI/individual performance-based, private RPI/flat-wage, private RPI/individual performance-based, public RPI/flat-wage, and public RPI/individual performance-based. Nine rounds are conducted; therefore, round is a within-subjects factor.[12] While performing a task, participants make decisions that affect their earnings, which are measured in *lira* (i.e., experiment currency). At the end of the experiment, *lira* earned by participants is converted to U.S. dollars at a rate of 240 *lira* per U.S. dollar.[13] Each experimental session is conducted with five participants.

[12] Since performance after receiving RPI is of primary interest for accounting, the multi-period setting is necessary.
[13] I also give a $5 show-up fee to each participant.

The task is performed on a computer using z-Tree software (see Appendix A for sample screen shots) (Fischbacher 2007). Each participant solves multiple choice multiplication problems for 9 independent rounds. In each round, the participant gets six multiplication problems. Table 1 shows the multiplication problems given in one of the rounds, listed in the same order they are displayed on the computer screen. For each problem, five possible answers are provided. The participant is asked to choose the answer s/he believes to be correct. Participants are told that in each round, they can choose both the number of problems (0, 1, 2, 3, 4, 5, or 6) and the order of problems to work on.

To satisfy the first condition for a strong relationship between comparison and competitive behavior, comparison task similarity, the same 54 multiplication problems are given in the same order to all participants. This is made clear to participants in the experiment instructions. To satisfy the second condition for a strong relationship between comparison and competitive behavior, comparison target similarity, all participants are recruited from a homogeneous pool – undergraduate business classes at Emory University. To satisfy the third condition for a strong relationship between comparison and competitive behavior, comparison domain importance, I use a task for which performance speaks to an important ability, general problem solving ability (see Appendix B for details). This is achieved by giving participants multiplication problems that can be solved quickly by using different math shortcuts and precluding them from using a calculator, paper or pencil when working on the problems. Banning the use of a calculator, paper or pencil when solving the problems creates a situation where more than mechanical skills, such as knowledge of the multiplication table, are required to successfully perform the task. The ability to rapidly develop different shortcuts that lead to correct solutions requires imagination and general problem-solving ability. This is explained to participants by telling them that solving the given multiplication problems accurately and quickly requires not only mechanical skills, but also general problem-solving ability. Further, it is emphasized to participants that different types of multiplication problems are often used in IQ tests designed to measure general intelligence level.

In each round, participants are given two easy, two moderate, and two difficult problems.[14] Each problem is classified as easy, moderate or difficult based on two criteria: (a) how many digits have to be multiplied (e.g., multiplying two two-digit numbers vs. multiplying two three-digit numbers) and (b) how easy it is to eliminate possible answers (see Appendix B for task details). The order in which the problems are presented (though not necessary solved) is random and varies from round to round, although it is the same for all participants.

The use of easy, moderate and difficult problems allows for the capture of a wide range of effort levels and abilities. On one hand, using only easy problems would result in a strong relationship between effort and performance and a weak relationship between ability and performance. Within a session, where all participants are assigned to the same condition, difficult problems allow participants not only to draw stronger inferences about their own abilities (which according to Festinger (1954) is the main reason to

[14] To test that participants view the problems difficulty the way I expect them to, in the post-experimental questionnaire I give participants three problems of different difficulty levels and ask them to identify the easiest and the most difficult one (I also provide them with the option to answer that all three problems are of equal difficulty). Out of 120 participants, 116 correctly identified the easiest problem and 115 correctly identified the most difficult problem. Additionally, I compared the average numbers of easy, moderate and difficult problems solved correctly by participants. The numbers for easy, moderate, and difficult problems are: 12.29, 8.32, and 4.02. Results of a paired-samples t-test confirm that these numbers are significantly different.

engage in social comparison), but also to distinguish their performance and abilities from those of the other equally motivated participants. On the other hand, using only difficult problems would result in a strong relationship between ability and performance and a weak relationship between effort and performance (Bonner 1994). Easy problems allow for the detection of differences in the effort levels of participants with equal abilities.

To capture the primary measure of effort – effort duration – participants are provided with the option to choose how much of the available time (300 seconds per round) to spend solving problems. As will be described below, any time not spent on solving problems results in a bonus. Thus, time spent solving problems satisfies the three criteria for a measure of task effort (see footnote 10) suggested by Baiman (1982).[15]

At the end of each round, each participant receives *individual* performance information, showing how many problems s/he has solved correctly in the current round, and how many problems s/he has solved correctly in all rounds completed so far.

3.2 Manipulating the Relative Performance Information

In the no RPI condition, participants are not provided with RPI. In the private RPI condition, participants received the rank of their own performance within the group. In the public RPI condition, participants received their own performance rank and the ranks of each of the other four participants. When present, RPI is provided at the end of rounds three, six and nine, immediately after the individual performance information.

Participants in the RPI present conditions (both public and private) know how their performance ranks against others, but they do not receive detailed performance distribution information (i.e., range, frequencies). Providing participants with such

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[15] The results of a mediation analysis (Baron and Kenny 1986) provide evidence that effort mediates the effects of RPI and incentive system on performance.

distributional information could facilitate task learning and, hence, increase the importance of RPI. However, doing so introduces the possibility of emergence of a normative standard for task performance. If this happens, participants may match performance to simply conform to this standard (Jackson and Harkins 1985; Paulus and Dzindolet 1993). Previous research (Wedell and Parducci 2000) demonstrates that the effect of RPI depends on the shape and range of the performance distribution. Providing detailed performance distribution information would expose participants in the study to the above-mentioned effects. Importantly, it would do so only in the conditions where RPI is present and not in the conditions where RPI is absent. Hence, providing detailed performance distribution information would introduce a confound in the experiment. Therefore, in order to control for the social norm effect, such information is not given to the participants.

3.3 Manipulating the Incentive Mechanism

In the individual performance-based condition, participants receive 180 *lira* for each problem solved correctly. In the flat-wage condition, participants receive a fixed payment of 552 *lira* for each of the nine rounds of the experiment.[16] Regardless of the incentive mechanism condition, participants earn a bonus for unused time out of the 45 minutes allotted for task completion (9 rounds x 300 seconds per round). Participants are paid 1 *lira* for every second saved. The use of a time bonus to proxy for disutility of effort is a common practice in accounting experimental research (e.g., Hannan et al. 2008; Hecht et al. 2009, Sprinkle 2000).

[16] Importantly, average compensation did not differ significantly across the two incentive conditions ($F_{1,20} = 0.01$, $p = 0.92$, *two-tailed*).

3.4 Participants and Procedures

Participants were recruited from undergraduate business classes at Emory University. In total, 120 students participated in twenty-four study sessions (five students in each session). The mean age of the participants was 20.3 years. There were 75 (62.5 percent) female and 45 (37.5 percent) male participants. Participants were similar on related attributes such as education, age, and math background, which satisfied the second condition for a strong relationship between comparison and competitive behavior – comparison target similarity.[17] As participants arrived, they were assigned to one of the six conditions and directed to read the written instructions, after which they answered a short quiz. After all misunderstandings were resolved, each participant introduced herself/himself by standing up and reading the number that was prominently displayed on the top of his computer (e.g., “I am participant #1,” “I am participant #2”). Introductions took place in all experimental conditions. The purpose was to remove performance rank anonymity in the public relative performance condition. After that, the computer-based part of the experiment (i.e., the multiplication task) began. Upon completion of that phase, participants received a short post-experimental questionnaire containing demographic and process-related questions. Finally, each participant was paid the money s/he has earned. Participants earned an average of $32.58 for approximately 1.25 hours.

[17] Most participants were accounting (49.9 percent) or finance (24.8 percent) majors and were primarily undergraduates (96.7 percent), although a minority (3.3 percent) were master’s level students enrolled in undergraduate courses. Ninety-four percent of participants were between 18 and 22 years old. Eighty-two percent of participants had taken one or two college-level math classes.

IV. RESULTS

4.1 Validation of Experimental Setting

Recall that there are three conditions for a strong relationship between comparison and competitive behavior. As described earlier, the design of the experiment and recruitment of participants ensure that the first two conditions (comparison task similarity and comparison target similarity) are satisfied. The experimental procedures are designed to satisfy the third condition (comparison domain importance) as well. However, because this condition is more subjective than the others, I take additional steps to verify that this condition is satisfied. To do so, I need to establish that participants believe that (1) general problem solving ability is important and (2) performance on the multiplication task speaks to general problem solving ability.

To test the first requirement, in the post-experimental questionnaire, I asked participants to what degree they think that general problem solving ability is important for succeeding in business and succeeding in life. Participants' mean responses of 6.40, for importance for succeeding in business, and 6.07, for importance for succeeding in life, on a scale ranging from 1 (Not at all) to 7 (To a great degree) are significantly different from the midpoint of four ($t_{20} = 37.68$, $p < 0.01$, *two-tailed,* for importance for succeeding in business and $t_{20} = 27.98$, $p < 0.01$, *two-tailed*, for importance for succeeding in life). The responses reveal that participants considered general problem-solving ability important.

To test the second requirement, I asked participants to what extent they agree with the statement that not only mechanical skills, but also general problem solving ability, was required to successfully perform the experimental task. Participants' mean response of 5.33 on a scale from 1 to 7 is significantly different from the scale's midpoint of four ($t_{20} = 14.87$, $p < 0.01$, *two-tailed)* and reveals that they agree with this statement. Additionally, I tested the second requirement indirectly by asking participants who received RPI (private or public) to compare their general problem solving ability, on a scale ranging from 1 (Inferior) to 7 (Superior), to those of the other participants in their session. Then, I conducted a regression using the answer to this question as a dependent measure and the participants' final rank as an independent measure.[18] This regression finds a significantly negative effect ($t = -2.76$, $p = 0.02$, *two-tailed*) of the final rank on the answer to the above mentioned question. This result reveals that participants believe performance on the task is indicative of general problem solving ability. Thus, by establishing participants' belief that performance on the experimental task speaks to an ability that is important to them, I have verified that the experimental task satisfies the comparison domain importance condition.

To assess whether participants were engaged in a social comparison process while performing the task, in the post-experimental questionnaire, I asked participants to report how often they thought about how their performance ranked relative to those of the other participants in the experiment (*rank thinking*); to what extent they were nervous or concerned about how well they were performing relative to other participants in the experiment (*rank nervousness*); and to what extent thinking about performance comparison interfered with their ability to concentrate on the problems (*rank interference*). Participants responded on a scale ranging from 1 (Not at all) to 7 (To a great extent) (see Table 3).

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[18] I used the Huber-White sandwich estimator (Huber 1967, Rogers 1993, White 1980) and clustered the data by session.

A factor analysis using the three Likert scale responses reveals that one factor, with Eigenvalue of 2.43, explains 81% of the variance in the measures. A regression using the resulting factor score as a dependent measure and RPI as an independent measure reveals that while performing the task, participants who received RPI were more engaged in a social comparison process relative to participants who did not receive RPI ($t_{20} = 2.67$, $p = 0.02$, *two-tailed*). This result provides evidence that participants were engaged in a social comparison process while performing the task.

4.2 Hypotheses 1 and 2

Hypotheses 1a and 1b predict a main effect of RPI, such that effort (H1a) and performance (H1b) are greater when participants receive RPI than when they do not receive RPI. Hypotheses 2a and 2b predict an interaction between RPI and incentive system, such that the effect of RPI on effort (H2a) and performance (H2b) will be greater under a performance-based compensation contract than under a flat-wage compensation contract. Figure 1 shows that the predicted interaction is ordinal. Comparing the predicted pattern of results in Figure 1 with the actual results for effort (Figure 3, Table 2) and for performance (Figure 4, Table 2) shows that the two patterns are similar.

To formally test whether the results fall in the predicted by H1a,b and H2a,b pattern, I pool the private and public RPI conditions. I do so because H1a,b and H2a,b are concerned only with whether RPI is present or absent and not with the specifics of how RPI is provided. I use a planned contrast (Buckless and Ravenscoft 1990) to compare the pooled RPI data with the data from the RPI condition.[19] Importantly, for this and all subsequent tests, I take the conservative approach of treating each session as

[19] I use planned contrast to test for the Figure 1 pattern because the data provides limited degrees of freedom and I predict a specific, non-symmetric pattern.

one independent observation.[20] The contrast coefficients for the test of H1a,b and H2a,b are -3 for the no RPI/flat-wage condition, -2 for the no RPI/performance-based incentive condition, -1 for the RPI/flat-wage condition, and +6 for the RPI/performance-based incentive condition.

The contrast coding reflects the specific pattern for effort and performance predicted by H1a,b and H2a,b collectively. First, the contrast coding shows that participants provided with RPI exert more effort and perform better than participants not provided with RPI (H1a,b). Thus, the coefficient for the RPI/flat-wage condition (-1) is greater than that for the no RPI/flat-wage condition (-3), and the coefficient for the RPI/performance-based incentive condition (+6) is greater than that for the no RPI/performance-based incentive condition (-2). Second, the contrast coding shows that the extent to which participants' effort and performance are positively affected by RPI is greater under the individual performance-based compensation contract than under the flat-wage compensation contract (H2a,b). Hence, the difference between the coefficients for the RPI conditions (+6 for performance-based; -1 for flat-wage) is greater than the difference between the coefficients for the no RPI conditions (-2 for performance-based; -3 for flat-wage).[21]

Table 4, Panel A and Panel B, presents the results of the planned contrast total testing H1a,b and H2a,b collectively. The dependent variables are time spent and

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[20] I also test the hypotheses by using the Huber-White sandwich estimator (Huber 1967; Rogers 1993; White 1980) and cluster the data by session. The results are inferentially identical to the ones reported here. The only difference is that when using the Huber-White sandwich estimator, the effect of public (vs. private) RPI on effort and performance under flat-wage contract is not significant.

[21] Although not explicitly hypothesized, the positive effect of incentives on participants' effort and performance is a necessary condition for the incentive system x RPI interaction hypothesized in H2a,b. Thus, the coefficient for the no RPI/performance-based incentive condition (-2) is greater than that for the no RPI/flat-wage condition (-3), and the coefficient for the RPI/performance-based incentive condition (+6) is greater than that for the RPI/flat-wage condition (-1).

problems solved.[22] The independent variables are RPI (present or absent) and incentive system (flat-wage or individual performance-based). As shown in Table 4, Panel A, effort is consistent with the pattern hypothesized by H1a and H2a ($F_{1,20} = 70.06$, $p < 0.01$, *one-tailed*). Table 4, Panel B shows performance is also consistent with the pattern hypothesized by H1b and H2b ($F_{1,20} = 50.27$, $p < 0.01$, *one-tailed*).[23] These results suggest that RPI positively affects employees' effort and performance. Further, this positive effect is greater under an individual performance-based contract than under a flat-wage contract.

To demonstrate the robustness of my results, I conduct an ANOVA with time spent as the dependent variable. The between-subjects variables are RPI (no RPI, RPI) and incentive system (flat-wage, individual performance-based). I find a significant RPI x incentive system interaction ($F_{1,20} = 4.96$, $p = 0.02$, *one-tailed)*. Specifically, I find that the positive effect of RPI on effort is greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Simple effect analysis indicates that RPI has a significant positive effect on effort in the flat-wage condition ($F_{1,20} = 4.02$, $p = 0.03$*, one-tailed*), and a significant positive effect in the individual performance-based condition ($F_{1,20} = 26.54$, $p < 0.01$*, one-tailed).*

Lastly, I conduct an ANOVA with problems solved as the dependent variable. The between-subjects variables are RPI (no RPI, RPI) and incentive system (flat-wage, individual performance-based). I find a significant RPI x incentive system interaction

[22] Time spent is the average time spent solving problems by the participants in each session. Problems solved is the average number of problems solved correctly by the participants in each session.

[23] H1a,b and H2a,b do not distinguish between private and public RPI. This means that the pattern predicted by H1a,b and H2a,b should hold for both types of RPI. In order to see whether this is the case, I repeat the planned contrast described above using RPI (No, Private) and RPI (No, Public) instead of RPI (No, Yes). The obtained results demonstrate that pattern predicted by H1 and H2 holds for both private and public RPI.

($F_{1,20}$ = 3.00, p = 0.05, *one-tailed)*. Specifically, I find that the positive effect of RPI on performance is greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Simple effect analysis indicates that RPI has a significant positive effect on performance in the flat-wage condition ($F_{1,20}$ = 3.78, p = 0.03*, one-tailed*), and a significant positive effect in the individual performance-based condition ($F_{1,20}$ = 19.30, p < 0.01*, one-tailed)*.

4.3 Hypotheses 3 and 4

Hypotheses 3a and 3b predict a main effect of type of RPI disclosure, such that effort (H3a) and performance (H3b) are greater when participants receive public RPI than when they receive private RPI. Hypotheses 4a and 4b predict an interaction between type of RPI and incentive system, such that the positive effect of public (vs. private) RPI on effort (H4a) and performance (H4b) will be greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Figure 2 shows that the predicted interaction is ordinal. The predicted pattern of results in Figure 2 is similar to the actual pattern of results for effort (Figure 5, Table 2) and for performance (Figure 6, Table 2).

To formally test whether the results fall in the pattern predicted by H3a,b and H4a,b, I discard the no RPI condition. I do so because H3a,b and H4a,b are concerned only with the effect of public (vs. private) RPI. The main positive effect of present (vs. absent) RPI has already been demonstrated by H1a,b. I test H3a,b and H4a,b using a planned contrast. The contrast coefficients for the test of H3a,b and H4a,b are -3 for the private RPI/flat-wage condition, -2 for the private RPI/performance-based incentive condition, -1 for the public RPI/flat-wage condition, and +6 for the public

RPI/performance-based incentive condition. The contrast coefficients reflect the specific pattern for effort and performance predicted by H3a,b and H4a,b collectively and are derived using similar logic to the one used for H1a,b and H2a,b.

Table 4, Panel C and Panel D present the results of a planned contrast total testing H1a,b and H2a,b collectively. The dependent variables are effort, measured as the total time spent solving problems, and performance, measured as the total number of problems solved correctly. The independent variables are RPI (private or public) and incentive system (flat-wage or individual performance-based). As shown in Table 4, Panel C and D, both effort and performance fall into the pattern hypothesized by H3a,b and H4a,b ($F_{1,20} = 114.92$, $p < 0.01$, *one-tailed,* for effort and $F_{1,20} = 27.14$, $p < 0.01$, *one-tailed*, for performance). These results suggest that when present, pubic RPI (vs. private RPI) positively affects employees' effort and performance. Further, this positive effect is greater under an individual performance-based compensation contract than under a flat-wage compensation contract.

To demonstrate the robustness of my results, I conduct an ANOVA with time spent as the dependent variable. The between-subjects variables are type of RPI disclosure (private RPI, public RPI) and incentive system (flat-wage, individual performance-based). I find a significant type of RPI disclosure x incentive system interaction ($F_{1,20} = 7.46$, $p = 0.01$, *one-tailed)*. Specifically, I find that the positive effect of type of RPI disclosure on effort is greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Simple effect analysis indicates that type of RPI disclosure has only a marginally significant positive effect on effort in the flat-wage condition ($F_{1,20} = 2.40$, $p = 0.07$*, one-tailed*), and a significant positive effect in the individual performance-based condition ($F_{1,20} = 29.32$, $p < 0.01$, *one-tailed)*.

Lastly, I conduct an ANOVA with problems solved as the dependent variable. The between-subjects variables are type of RPI disclosure (private RPI, public RPI) and incentive system (flat-wage, individual performance-based). I find a marginally significant type of RPI disclosure x incentive system interaction ($F_{1,20} = 2.23$, $p = 0.08$ *one-tailed)*. Specifically, I find that the positive effect of type of RPI disclosure on performance is greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Simple effect analysis indicates that type of RPI disclosure has no significant effect on performance in the flat-wage condition ($F_{1,20} = 0.14$, $p = 0.32$, *one-tailed*), and a significant positive effect in the individual performance-based condition ($F_{1,20} = 6.17$, $p = 0.01$, *one-tailed)*.

4.4 Process Analysis

4.4.1 Performance-Ability Relationship

The first supplemental analysis relates to participants' perceptions of the performance-ability relationship. If the theory is correct, participants in the individual performance-based compensation condition will perceive the relationship between performance and ability as stronger than will participants in the flat-wage compensation condition. This will cause participants working under an individual performance-based compensation contract to be more prone to attribute differences in performance to differences in abilities than participants working under a flat-wage contract. To see if this is the case, in the post-experimental questionnaire, participants are asked whether they thought that the differences in performance in their session were due more to differences in individual effort levels or more to differences in individual problem solving abilities. Participants responded on a scale ranging from 1 (Entirely due to differences in effort) to 7 (Entirely due to differences in ability). As predicted, participants in the individual performance-based condition attributed differences in performance as more due to differences in abilities than did participants in the flat-wage condition (5.32 vs. 3.29). This difference is statistically significant ($F_{1,20} = 9.07$, $p < 0.01$, *two-tailed*). Thus, I show that incentives reduce perceived noise in the ability-performance relationship and increase the validity of making inferences about ability based on performance.

4.4.2 Exacerbation of Pride and Shame

The second supplementary analysis relates to participants' feelings about their performance. Specifically, the theory predicts that the worst performers will feel more ashamed of their own performance when RPI is present than when RPI is absent. Similarly, it predicts that the best performers will feel more proud of their own performance when RPI is present than when RPI is absent. Furthermore, when RPI is present, I expect feelings of shame and pride to be stronger when RPI is disclosed publicly than when it is disclosed privately. To see if this is the case, in the post-experimental questionnaire, participants were asked how they felt about their own performance. Participants responded on a scale ranging from 1 (Very ashamed) to 7 (Very proud). To test the prediction, answers equal to 1 and 7 are recoded as *Extreme* and answers equal to 2,3,4,5, and 6 as *Moderate*.[24] As predicted, the number of extreme answers is significantly higher when RPI is present than when RPI is absent ($F_{1,20} = 5.54$,

[24] The results are identical if answers equal to 1, 2, 6, and 7 are coded as *Extreme* and answers equal to 3, 4, and 5 as *Moderate*.

p = 0.02, *two-tailed*).[25] Also as predicted, when RPI is present, the number of extreme answers is significantly higher when RPI is disclosed publicly than when RPI is disclosed privately ($F_{1,20}$ = 7.60, p = 0.01, *two-tailed*). Thus, RPI, especially when provided publicly, exacerbates both positive and negative performance-related feelings.[26] Surprisingly, this effect does not depend on the incentive system ($F_{1,20}$ = 1.32, p = 0.87, *two-tailed*). A possible reason for this result is that participants' feelings about their performance are primarily driven by the outcome and not by the reasons to which the outcome was attributed (due to effort or ability).

4.4.3 Sucker Effect

The third supplementary analysis relates to the effect RPI has on the effort and performance of the best performers in a flat-wage condition. If a sucker effect exists, I would expect RPI to have a negative effect on the effort and performance of the best performers in the flat-wage condition but not in the individual performance-based condition. I use ANOVA to test for the sucker effect. The dependent variables are the percentage change in time spent solving problems and the percentage change in problems solved between the first three rounds and the second three rounds, and between the second three rounds and the last three rounds. The dependent variables are calculated and averaged only for participants ranked first in their session at the end of round three.[27]

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[25] This significance is driven entirely by the public RPI condition. The number of extreme answers is: 4 out of 40 in the no RPI condition, 6 out of 40 in the private RPI condition, and 17 out of 40 in the public RPI condition. Only 4 of the extreme answers are due to answers equal to 1 (Very ashamed). All come from participants in public RPI condition.

[26] I also regress the answers to the above-mentioned question on the participants' final rank. The regression shows that participants' final rank was negatively (i.e., the smaller the rank the more proud one feels and vice versa) related to participants' feelings (t = -3.74, p = 0.01, *two-tailed*) when the rank was disclosed to participants (RPI present) and not related to participants' feelings (t = -0.19, p = 0.86, *two-tailed*) when it was not disclosed to participants (RPI absent).

[27] Remember that RPI is given after rounds 3, 6, and 9. Also, I conducted separate analyses for the percentage change in time spent and problems solved by the best performers in each session, between

The independent variables are RPI (present, absent) and incentive (flat-wage, individual performance-based). The preceding discussion predicts an interaction, such that the effect of RPI on effort and performance of the best performers is negative in the flat-wage condition but not in the individual performance-based condition. While the results do not follow the predicted pattern for effort ($F_{1,20} = 1.17$, $p = 0.30$, *two-tailed*), they do so for performance ($F_{1,20} = 10.15$, $p = 0.01$, *two-tailed*). Simple effects analysis indicates that RPI has no significant effect on the percentage change in problems solved over the last six rounds by the best performers in the individual performance-based incentive condition ($F_{1,20} = 1.82$, $p = 0.20$, *two-tailed*). However, simple effects analysis indicates that RPI has a significantly negative effect on the percentage change in problems solved over the last six rounds by the best performers in the flat-wage condition ($F_{1,20} = 9.97$, $p = 0.01$, *two-tailed*). Taken together, the results suggest that RPI has a negative effect on the performance of the best performers under a flat-wage compensation contract, which is consistent with the sucker effect. The results also indicate that the negative effect cannot be attributed to effort duration but to the other dimensions of effort mentioned earlier – effort intensity and/or effort toward strategy development.

4.4.4 Performance over Time

The final supplemental analysis addresses the trend in performance over time. I conduct an ANOVA with problems solved as the dependent variable. The between-subjects variables are RPI (no RPI, private RPI, public RPI) and incentive system (flat-

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rounds 1, 2, 3 and rounds 4, 5, 6, and between rounds 4, 5, 6 and rounds 7, 8, 9. The results are inferentially identical to the results reported above, which are based on the average of the two percentage changes.

wage, individual performance-based).[28] The within-subjects variable is round. I use the method of orthogonal polynomial contrasts to detect the linear trend in performance.[29,30]

I find a statistically significant three-way interaction among the independent variables ($F_{1,20} = 4.04$, $p = 0.04$, *two-tailed*), suggesting that the linear trend in performance is affected by the interaction between RPI and incentive system. I follow up on the three-way interaction by conducting three independent ANOVAs, one for no RPI condition and one for each of the RPI conditions (private and public). In each of the RPI conditions, I find a significant interaction between the incentive system and the linear trend across rounds (no RPI: $F_{1,20} = 12.92$, $p < 0.01$, *two-tailed;* private RPI: $F_{1,20} = 34.72$, $p < 0.01$, *two-tailed;* public RPI: $F_{1,20} = 57.78$, $p < 0.01$, *two-tailed*). These interactions are due to a more positive linear trend in the individual performance-based incentive condition than in the flat-wage condition. Simple effects analysis indicates that the linear trend in performance in the flat-wage condition is significantly positive in no RPI condition ($F_{1,20} = 7.55$, $p = 0.01$, *two-tailed*), only marginally significantly positive in private RPI condition ($F_{1,20} = 3.89$, $p < 0.06$, *two-tailed)*, and not significant in public RPI condition ($F_{1,20} = 0.15$, $p < 0.70$, *two-tailed)*. In contrast, the linear trend in performance in the individual performance-based incentive condition is significantly positive regardless of the type of RPI (no RPI: $F_{1,20} = 61.34$, $p < 0.01$, *two-tailed*; private RPI: $F_{1,20} = 106.20$, $p < 0.01$, *two-tailed* ; public RPI: $F_{1,20} = 124.07$, $p < 0.01$, *two-tailed*).

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[28] Recall that I have a nested design (RPI (present or absent) and, nested within the RPI present condition, type of RPI disclosure (private or public)). In essence, this means that there are three conditions: no RPI, private RPI, and public RPI. I use this simplified representation of the RPI variable in the ad hoc analysis in the current section.

[29] The method of orthogonal polynomial contrasts is appropriate when means are based on equal numbers of observations and the levels of the independent variable are equally spaced on some continuum. This is the case here, where I have 9 observations rounds per subject that are equally spaced (i.e., all rounds are equal in terms of number of available problems to solve).

[30] I also use this method to detect the linear trend in effort. The main pattern emerging from the results is that effort decreases over the course of the session, likely due to fatigue or boredom.

Although the three-way interaction suggests that the linear trend in performance is affected by the interaction between RPI and incentive system, the main pattern emerging from these results is that performance in the individual performance-based incentive condition improved significantly more over time than performance in the flat-wage condition. These results are consistent with incentives having a positive effect on effort directed towards strategy development, leading to an accelerated learning process (Sprinkle 2000). In other words, as argued by Sprinkle (2000), the incentive-based compensation contract motivates individuals to engage in search behavior designed to discover the optimal performance strategy. The learning process can account for the opposite trends in effort and performance over time.

4.5 Additional Analysis

4.5.1 Separate Analysis for Easy, Moderate, and Difficult Problems

As mentioned earlier, I use problems with three different difficulty levels: easy, moderate, and difficult. Specifically, participants are given 18 easy, 18 moderate, and 18 difficult problems over the course of the experiment. This analysis explores the effects of RPI and the incentive system on effort and performance by looking separately at the easy, moderate, and difficult problems (see Table 5).

First, I conduct three ANOVAs with time spent (solving easy, moderate, and difficult problems) as the dependent variable. The between-subjects variables are RPI (no RPI, private RPI, and public RPI) and incentive system (flat-wage, individual performance-based).[31] For easy problems, I find no significant RPI x incentive system

[31] As mentioned in f.n. 28, I have a nested design RPI (present or absent) and, nested within the RPI present condition, type of RPI disclosure (private or public). In essence, this means that there are three conditions: no RPI, private RPI, and public RPI. I use this simplified representation of the RPI variable in the ad hoc

interaction ($F_{1,20}$ = 0.09, p = 0.91, *two-tailed*) and significant main effects for RPI ($F_{1,20}$ = 3.70, p = 0.05, *two-tailed)* and incentive system($F_{1,20}$ = 58.80, p < 0.01, *two-tailed).* Specifically, I find that RPI and the incentive system positively affect effort on easy problems. For moderate problems, I find a significant RPI x incentive system interaction ($F_{1,20}$ = 6.77, p = 0.01, *two-tailed).* Specifically, I find that the positive effect of RPI on effort is greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Simple effect analysis indicates that the incentive system has only a marginally significant positive effect of effort in the no RPI condition ($F_{1,20}$ = 3.24, p = 0.09*, two-tailed*), a significant positive effect in the private RPI condition ($F_{1,20}$ = 11.12, p < 0.01*, two-tailed)*, and a significant positive effect in the public RPI condition *(*$F_{1,20}$ = 47.25, p < 0.01*, two-tailed).* For difficult problems, I find a significant RPI x incentive system interaction ($F_{1,20}$ = 18.47, p < 0.01, *two-tailed).* Specifically, I find that the positive effect of RPI on effort is greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Simple effect analysis indicates that the incentive system has no significant effect on effort in the no RPI condition ($F_{1,20}$ = 0.13, p = 0.72*, two-tailed*), a significant positive effect in the private RPI condition ($F_{1,20}$ = 15.27, p < 0.01*, two-tailed)*, and a significant positive effect in the public RPI condition *(*$F_{1,20}$ = 79.52, p < 0.01*, two-tailed).*

Next, I conduct three ANOVAs with problems solved (easy, moderate, difficult) as the dependent variable. The between-subjects variables are RPI (no RPI, private RPI, public RPI) and incentive system (flat-wage, individual performance-based). For easy problems, I find no significant RPI x incentive system interaction ($F_{1,20}$ = 0.14, p = 0.87, *two-tailed*) and significant main effects for RPI ($F_{1,20}$ = 7.10, p = 0.01, *two-tailed)* and

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analysis in the *supplemental analysis* section.

incentive system($F_{1,20} = 63.41$, $p < 0.01$, *two-tailed)*. Specifically, I find that RPI and the incentive system positively affect performance on easy problems. For moderate problems, I find a significant RPI x incentive system interaction ($F_{1,20} = 3.86$, $p = 0.04$, *two-tailed)*. Specifically, I find that the positive effect of RPI on performance is greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Simple effect analysis indicates that the incentive system has no significant effect on performance in the no RPI condition ($F_{1,20} = 0.50$, $p = 0.49$, *two-tailed*), only a marginally significant positive effect in the private RPI condition ($F_{1,20} = 4.10$, $p < 0.06$, *two-tailed)*, and a significant positive effect in the public RPI condition ($F_{1,20} = 20.90$, $p < 0.01$, *two-tailed)*. For difficult problems, I find a significant RPI x incentive system interaction ($F_{1,20} = 9.47$, $p < 0.01$, *two-tailed)*. Specifically, I find that the positive effect of RPI on performance is greater under an individual performance-based compensation contract than under a flat-wage compensation contract. Simple effect analysis indicates that the incentive system has no significant effect on performance in the no RPI condition ($F_{1,20} = 0.04$, $p = 0.84$, *two-tailed*), a significant positive effect in the private RPI condition ($F_{1,20} = 6.947$, $p = 0.02$, *two-tailed)*, and a significant positive effect in the public RPI condition ($F_{1,20} = 39.96$, $p < 0.01$, *two-tailed)*. Taken together, the results suggest that the predicted effects of RPI and the incentive system on effort and performance hold for easy, moderate, and difficult problems. Further, the results suggest that providing RPI is more beneficial when the performed task is non-trivial.

4.5.2 Effort Intensity

As mentioned earlier, effort has multiple dimensions: effort duration, effort intensity, and effort toward strategy development (Sprinkle 2000). Higher motivation to perform may affect one, two, or all three dimensions of effort. To explore the effects of RPI and the incentive system on effort intensity, I compute a measure called *time per problem* by dividing time spent on the problems solved. In essence, this measure captures the average time spent per problem solved. That is, the smaller this measure, the more efficiently a participant utilizes time spent (via, for example, attention and concentration) to achieve higher performance. Because solving a difficult problem correctly required more time than solving an easy one correctly, I compute time per problem separately for easy, moderate, and difficult problems.

I conduct three ANOVAs with time per problem (easy, moderate, difficult) as the dependent variable. The between-subjects variables are RPI (no RPI, private RPI, public RPI) and incentive system (flat-wage, individual performance-based). I find no significant RPI x incentive system interaction (easy problems: $F_{1,20} = 0.60$, $p = 0.95$, *two-tailed;* moderate problems: $F_{1,20} = 0.44$, $p = 0.65$, *two-tailed;* difficult problems: $F_{1,20} = 0.25$, $p = 0.78$, *two-tailed*). Further, I find no main effects of RPI and the incentive system.

The lack of effect of RPI and the incentive system on effort intensity is surprising, given their strong effect on effort duration. One possible explanation is that the measure of effort intensity is too noisy. The measure does not distinguish between problems solved by guessing and problems solved by working (remember that all the problems are multiple-choice with five possible answers). In order to remedy that, I compute a new measure called *time per problem no guessing* by dividing time spent on the problems solved. This time, however, I exclude problems solved by pure guessing - problems worked for 5 or less than 5 seconds.[32]

Next, I conduct three ANOVAs with time per problem no guessing (easy, moderate, difficult) as the dependent variable. The between-subjects variables are RPI (no RPI, private RPI, public RPI) and incentive system (flat-wage, individual performance-based). I find no significant RPI x incentive system interaction (easy problems: $F_{1,20} = 0.50$, $p = 0.96$, *two-tailed;* moderate problems: $F_{1,20} = 0.10$, $p = 0.91$, *two-tailed;* difficult problems: $F_{1,20} = 0.33$, $p = 0.72$, *two-tailed*). Further, I find no main effect of RPI (easy problems: $F_{1,20} = 0.01$, $p = 0.99$, *two-tailed;* moderate problems: $F_{1,20} = 0.21$, $p = 0.82$, *two-tailed;* difficult problems: $F_{1,20} = 0.93$, $p = 0.42$, *two-tailed*). Lastly, I find no main effect of the incentive system on the dependent variable for the easy problems ($F_{1,20} = 0.44$, $p = 0.51$, *two-tailed)*, a marginally significant negative effect for the moderate problems ($F_{1,20} = 3.36$, $p = 0.08$, *two-tailed)*, and a negative effect for the difficult problems ($F_{1,20} = 4.81$, $p = 0.05$, *two-tailed)*. The results demonstrate that participants in the individual performance-based incentive condition worked longer and harder than participants in the flat-wage incentive condition. This is consistent with incentives having a positive effect on effort intensity. Further, the results suggest that in my study RPI affected performance primarily through effort duration.

4.5.3 Problems Attempted

I can obtain greater insight into the processes responsible for my findings by considering the effects of RPI and the incentive system on *problems attempted*. Problems attempted represents the average number of problems attempted to be solved (including

[32] The results are inferentially identical if I use 3 or 4 seconds as the exclusion criteria.

by guessing) by the participants in each session. Figure 7 and Table 2 show that the average number of problems attempted is higher for the participants in the individual performance-based incentive condition (48.80) than is for participants in a flat-wage condition (32.52). The results of ANOVA with problems attempted as a dependent variable and RPI and incentive system as between-subjects variables support this observation *(*$F_{1,20} = 72.97$, $p < 0.01$*, two-tailed)*.[33] Participants in the individual performance-based incentive condition attempted to solve almost all of the problems (49 out of 54), which is consistent with them trying to maximize their payoff. For this condition, the expected payoff of a pure guess is 36 *lira* (20% chance to earn 180 *lira*) and the cost is only a loss of few seconds. The result suggests that participants devoted some effort toward strategy development.

4.5.4 Time Spent Choosing

To acquire further insight into the processes responsible for my findings, I explore the effects of RPI and the incentive system on the *time spent choosing*. Time spent choosing represents the average time spent choosing a problem to tackle by the participants in each session (see Figure 8 and Table 5).

I conduct an ANOVA with time spent choosing as the dependent variable and RPI and incentive system as between-subjects variables. I find no significant RPI x incentive system interaction ($F_{1,20} = 1.95$, $p = 0.17$*, two-tailed).* However, I find that RPI and the incentive system have a positive effect on the dependent variable (RPI: $F_{1,20} = 13.26$, $p < 0.01$*, two-tailed;* incentive system: $F_{1,20} = 21.88$, $p < 0.01$*, two-tailed).* This result can be explained by RPI and incentives having a positive effect on another dimension of effort - the effort toward strategy development (higher motivation to perform is leading to a more

[33] RPI does not interact with incentive system and does not have a significant effect on problems attempted.

deliberate choice of a problem to work on).[34] Alternatively, the result can be due to the hardworking participants needing a short break between problems.

4.5.5 Dominated vs. Not Dominated Choices

I perform one additional analysis to obtain deeper insight into participants' strategies. I code each participant's answer choice to an easy or a moderate problem as 1(0) if the answer choice is not dominated (dominated). The reason is that for easy (moderate) problems, participants can eliminate three (two) of the five possible answers provided just by looking at the last digit of the possible answer (e.g., the right answer to the problem 33 x 22 has to end on 6).[35] Given that, some answer choices are economically dominated (e.g., the answer choices to the problem 33 x 22 that do not end on 6 are dominated by the ones that end on 6). For each session, I sum this measure, which I label *dominating choice.* I conduct an ANOVA with dominating choice as the dependent variable and RPI and incentive system as between-subjects variables. The problems attempted (easy and moderate) is my covariate factor. I find a significantly positive main effect of incentive system ($F_{1,20} = 78.38$, $p < 0.01$, *two-tailed*).[36] Thus, it appears that participants in an individual performance-based incentive condition have a stronger appreciation for non-dominated answer choices than participants in a flat-wage condition. The result is consistent with incentives having a positive effect on strategy development.

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[34] Before attempting a problem, participants could be weighting the cost of working the problem (expected time bonus loss) against the benefit of doing so (expected reward for correct answer).

[35] For difficult problems, this technique will be of no help, because all answers end on the right digit.

[36] RPI does not interact with incentive system and does not have a significant effect on dominating choice.

V. CONCLUSION

In this study, I examine the effect of RPI on effort and performance under two different incentive systems that do not tie employees' compensation to peer performance (flat-wage or individual performance-based). I expect and find that although RPI has a positive effect on effort and performance under both incentive systems, this effect is greater under the individual performance-based incentive system. Furthermore, given that RPI is present, I study the effect of type of RPI disclosure (private or public) on effort and performance under the above-mentioned incentive systems. As predicted, I find that publicly (vs. privately) disclosing RPI has a positive effect on effort and performance under both incentive systems, and also that this positive effect is greater under the individual performance-based incentive system. Thus, I demonstrate that it is important to know not only whether RPI is provided, but also how it is provided.

This study provides useful insights for firms that strive to design effective information and incentive systems. Prior research has shown that, in addition to shame and pride, RPI may also lead to negative feelings of resentment and envy (Smith 2000). Such feelings that can reduce cooperation among employees are probably stronger under an individual performance-based incentive system when superior performance results in higher pay. This study demonstrates that although the costs of RPI might be higher under an individual performance-based incentive system than under a flat-wage incentive system, the benefits are also higher. Companies gain from knowing the benefits of RPI under different incentive systems so they can weigh these benefits against the costs of RPI under different incentive systems.

Further, publicly (vs. privately) disclosing RPI can help identify potential targets of resentment and envy and hence exacerbate these negative feelings among employees, creating an unhealthy work environment. However, as this study shows, publicly (vs. privately) disclosing RPI can also positively affect employees' effort and performance. This study therefore helps explain why some companies provide RPI publicly and other companies provide RPI privately (Nordstrom et al. 1990).

As demonstrated by Wedell and Parducci (2000), the effect of RPI depends on the distribution and range of performance. Future research should examine the effect of providing employees with detailed performance distribution information under different incentive systems. Also, future research should study the effect of disclosing only selected parts of performance distribution (e.g., only disclosing performance of the best performers or only disclosing performance of the worst performers).

Lastly, the experimental setting employed in the current study is one in which participants are able to see each other. This high physical proximity probably increases the power of RPI. However, in recent years we have seen the emergence of the virtual work environment, in which employees work in physically distant locations (Webster and Staples 2006). Future research should examine whether the RPI effects observed in the current study also hold in situations in which participants work in a low physical proximity environment.

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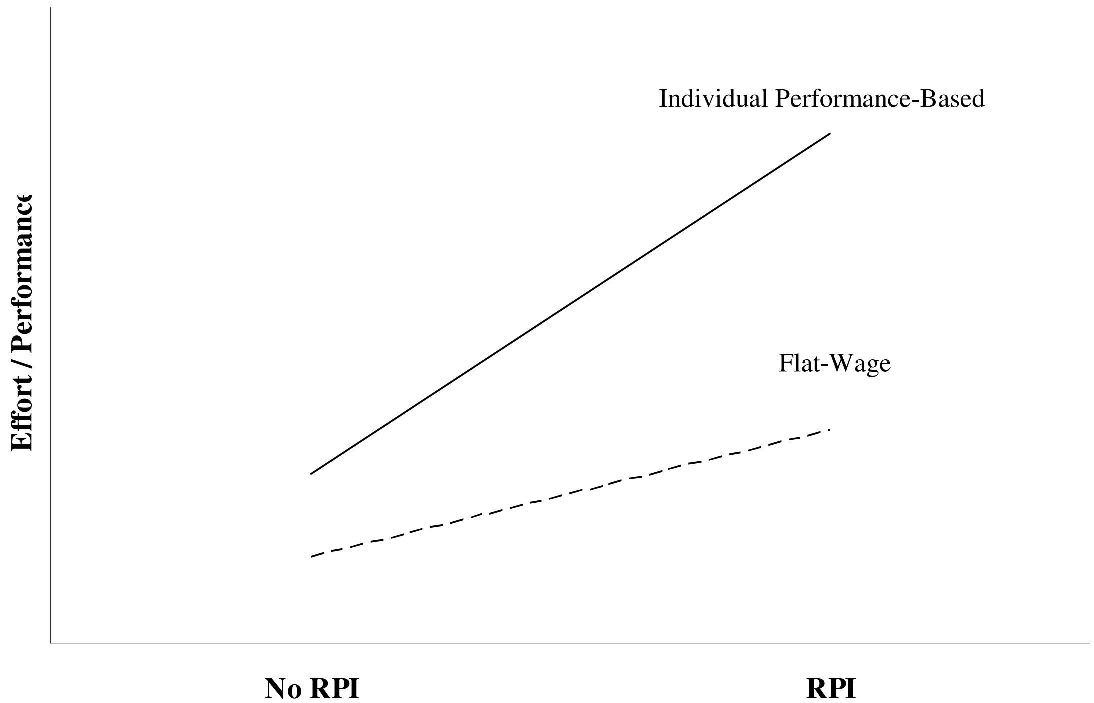
FIGURE 1
Predicted Effects of RPI and Incentive System on Effort and Performance (H1 and H2)

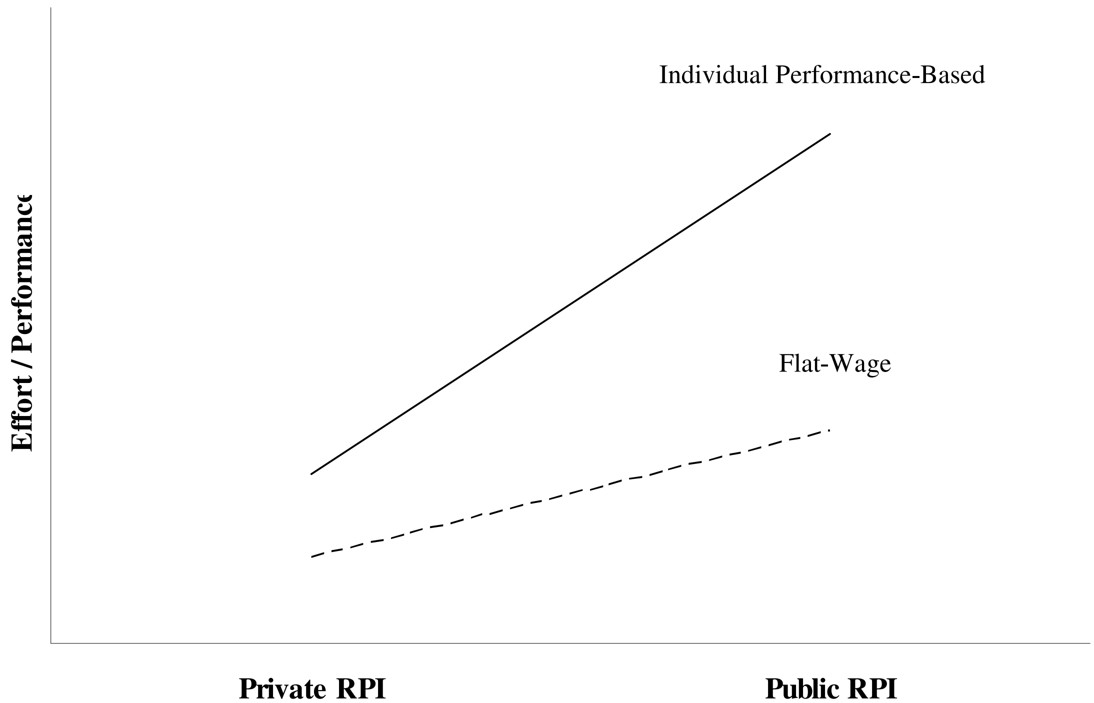


This figure depicts the predicted pattern of participants' mean levels of effort and performance by RPI and incentive system conditions.

Per Hypothesis 1, RPI positively influences effort and performance under both incentive systems.

Per Hypothesis 2, the extent to which RPI influences effort and performance depends on the type of incentive system. Specifically, the extent to which effort/performance is affected by RPI is greater under an individual performance-based compensation contract than under a flat-wage compensation contract.

FIGURE 2
Predicted Effects of Type of RPI Disclosure and Incentive System on Effort and Performance (H3 and H4)

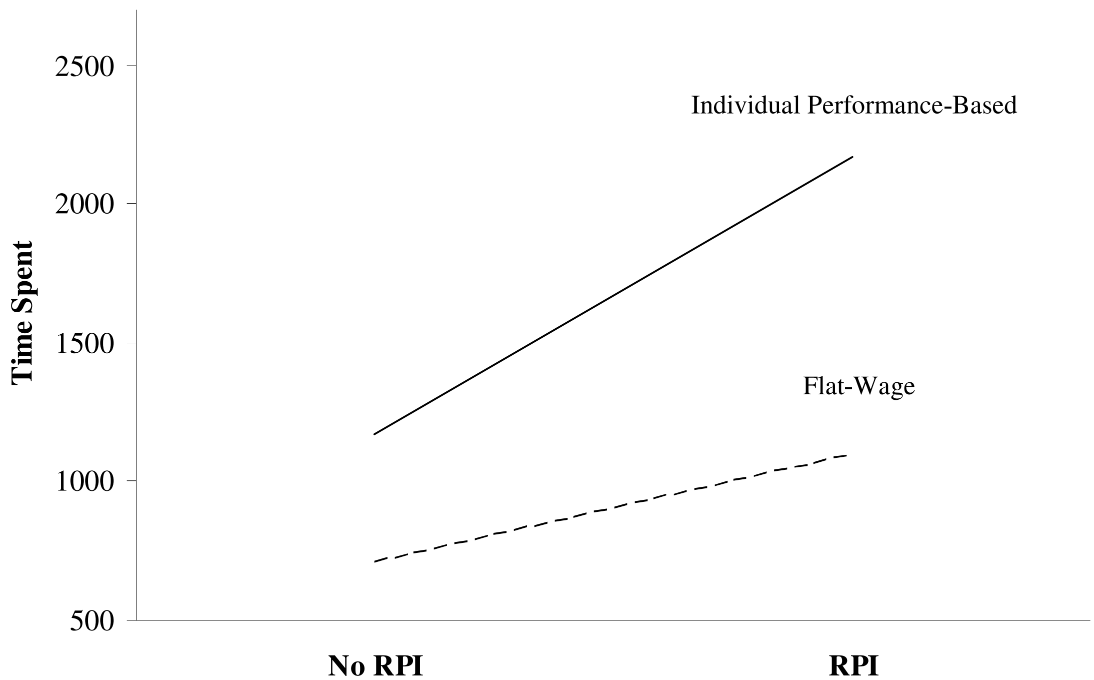


This figure depicts the predicted pattern of participants' mean levels of effort and performance by type of RPI disclosure (given that RPI is provided) and incentive system condition.

Per Hypothesis 3, publicly (vs. privately) disclosing RPI positively influences effort and performance under both incentive systems.

Per Hypothesis 4, the extent to which publicly (vs. privately) disclosing RPI influences effort and performance depends on the type of incentive system. Specifically, the extent to which effort/performance is affected by publicly (vs. privately) disclosing RPI is greater under an individual performance-based compensation contract than under a flat-wage compensation contract.

FIGURE 3
Effect of RPI [a] and Incentive System [b] on Time Spent [c] (H1a and H2a)



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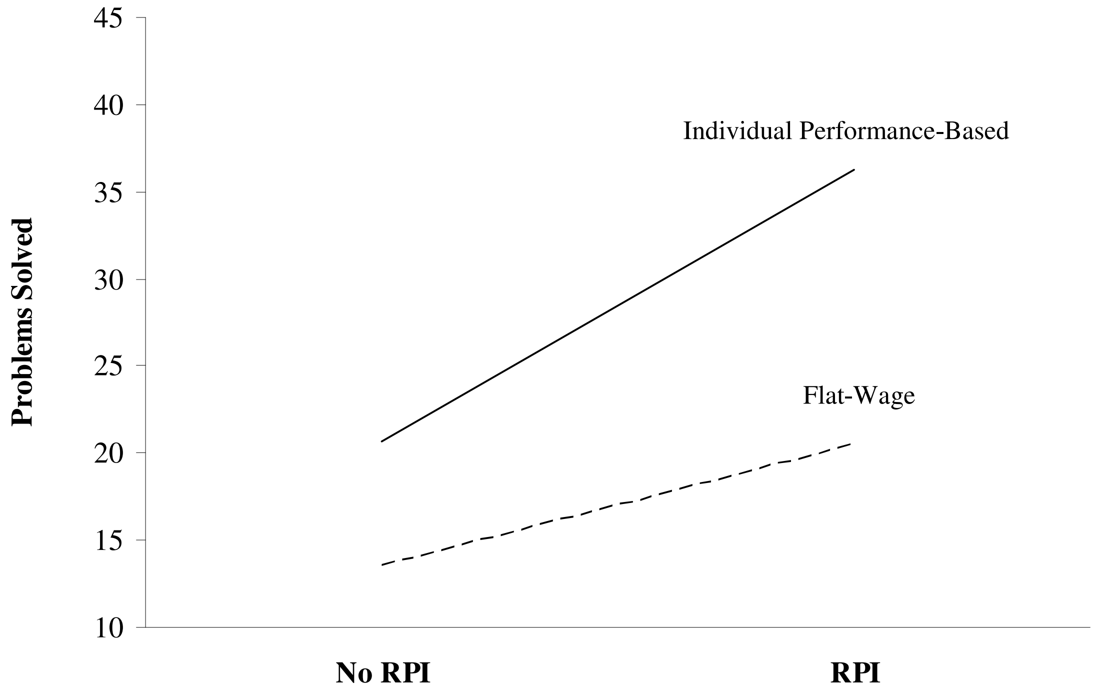
[a] *RPI* is manipulated as a between-subjects factor at two levels, *No RPI,* and *RPI*. Participants in the *No RPI* condition are not provided with any RPI. Participants in the *RPI* are provided with RPI ranking, at the end of rounds 3, 6, and 9.

[b] *Incentive System* is manipulated as a between-subjects factor at two levels, *Flat-Wage and Individual Performance-Based*. Participants in the *flat-wage* condition received 552 *lira* for each of the 9 rounds of the experiment, regardless of the number of problems they solved correctly. Participants in the *individual performance-based incentive* condition received 180 lira for each problem they solved correctly.

[c] *Time Spent* represents the average number of seconds spent solving problems by the participants in each session.

FIGURE 4
Effect of RPI [a] and Incentive System [b] on Problems Solved [c] (H1b and H2b)



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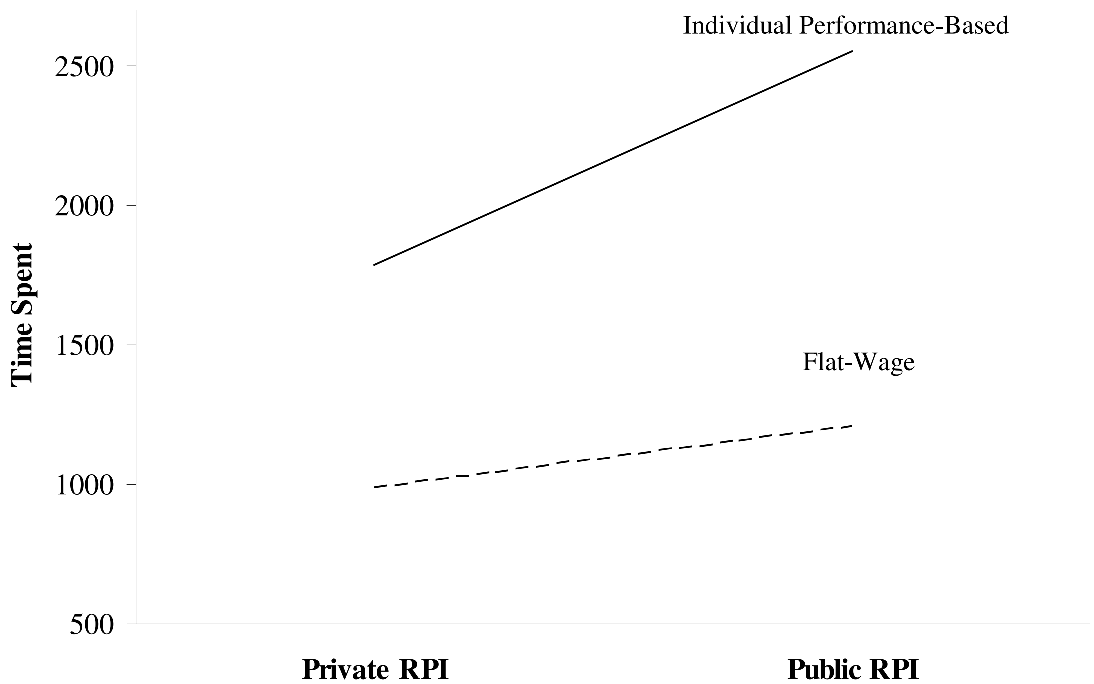
[a] *RPI* is manipulated as a between-subjects factor at two levels, *No RPI* and *RPI*. Participants in the *No RPI* condition are not provided with any RPI. Participants in the *RPI* condition are provided with RPI ranking at the end of rounds 3, 6, and 9.

[b] *Incentive System* is manipulated as a between-subjects factor at two levels, *Flat-Wage and Individual Performance-Based*. Participants in the *flat-wage* condition received 552 *lira* for each of the 9 rounds of the experiment, regardless of the number of problems they solved correctly. Participants in the *individual performance-based incentive* condition received 180 lira for each problem they solved correctly.

[c] *Problems Solved* represents the average number of problems solved correctly by the participants in each session.

FIGURE 5
Effect of Type of RPI Disclosure [a] and Incentive System [b] on Time Spent [c] (H3a and H4a)



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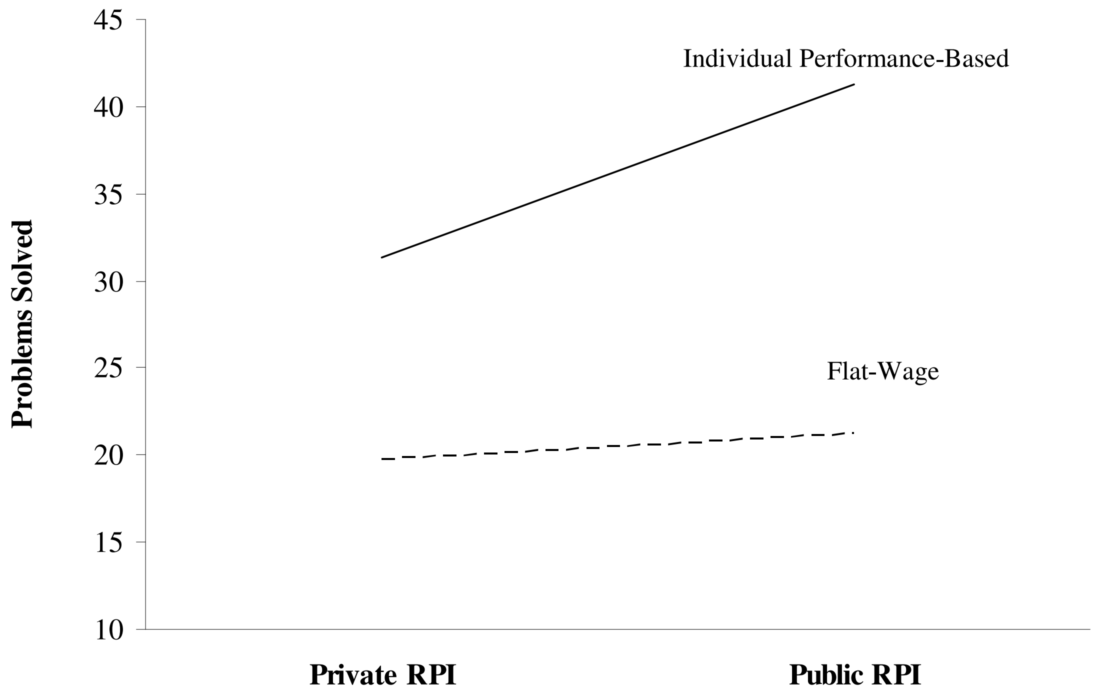
[a] *Type of RPI Disclosure* is manipulated as a between-subjects factor at two levels, *Private RPI* and *Public RPI*. Participants in the *Private RPI* condition are provided only with their own performance rank at the end of rounds 3, 6, and 9. Participants in the *Public RPI* condition are provided not only with their own performance rank, but also with the performance ranks of the other four participants in the session at the end of rounds 3, 6, and 9.

[b] *Incentive System* is manipulated as a between-subjects factor at two levels, *Flat-Wage and Individual Performance-Based*. Participants in the *flat-wage* condition received 552 *lira* for each of the 9 rounds of the experiment, regardless of the number of problems they solved correctly. Participants in the *individual performance-based incentive* condition received 180 lira for each problem they solved correctly.

[c] *Time Spent* represents the average number of seconds spent solving problems by the participants in each session.

FIGURE 6
Effect of Type of RPI Disclosure [a] and Incentive System [b] on Problems Solved [c] (H3b and H4b)



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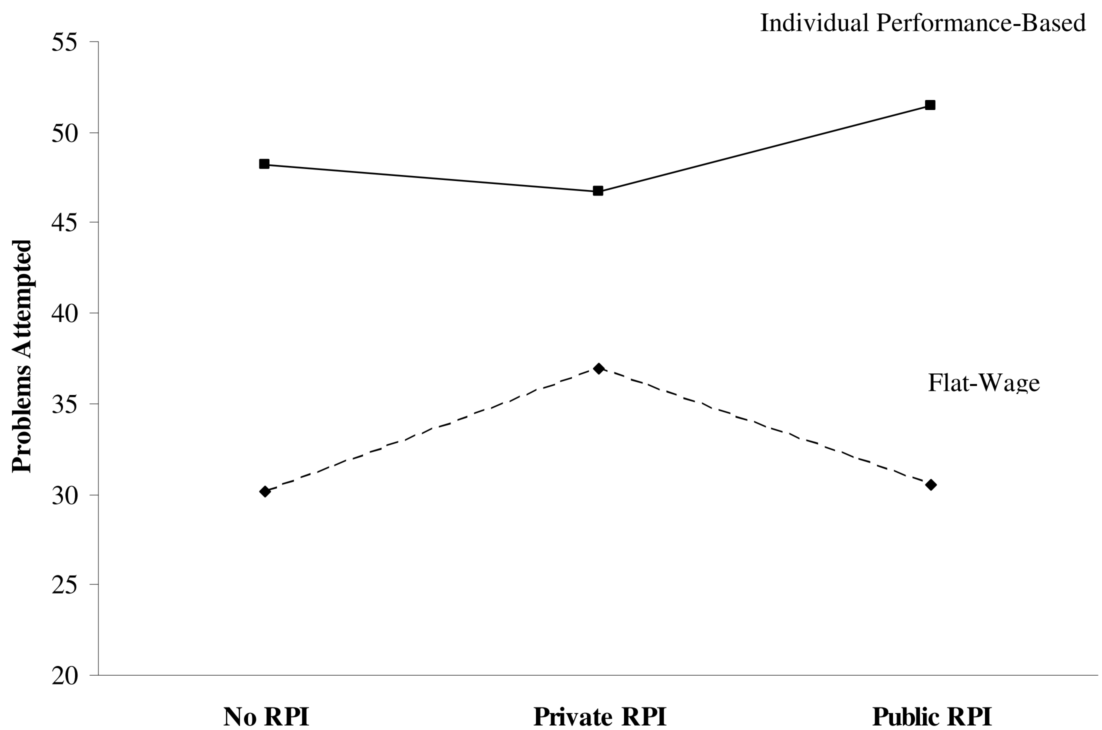
[a] *Type of RPI Disclosure* is manipulated as a between-subjects factor at two levels, *Private RPI* and *Public RPI*. Participants in the *Private RPI* condition are provided only with their own performance rank at the end of rounds 3, 6, and 9. Participants in the *Public RPI* condition are provided not only with their own performance rank, but also with the performance ranks of the other four participants in the session at the end of rounds 3, 6, and 9.

[b] *Incentive System* is manipulated as a between-subjects factor at two levels, *Flat-Wage and Individual Performance-Based*. Participants in the *flat-wage* condition received 552 *lira* for each of the 9 rounds of the experiment, regardless of the number of problems they solved correctly. Participants in the *individual performance-based incentive* condition received 180 lira for each problem they solved correctly.

[c] *Problems Solved* represents the average number of problems solved correctly by the participants in each session.

FIGURE 7
Effect of RPI [a] and Incentive System [b]
on Problems Attempted [c]



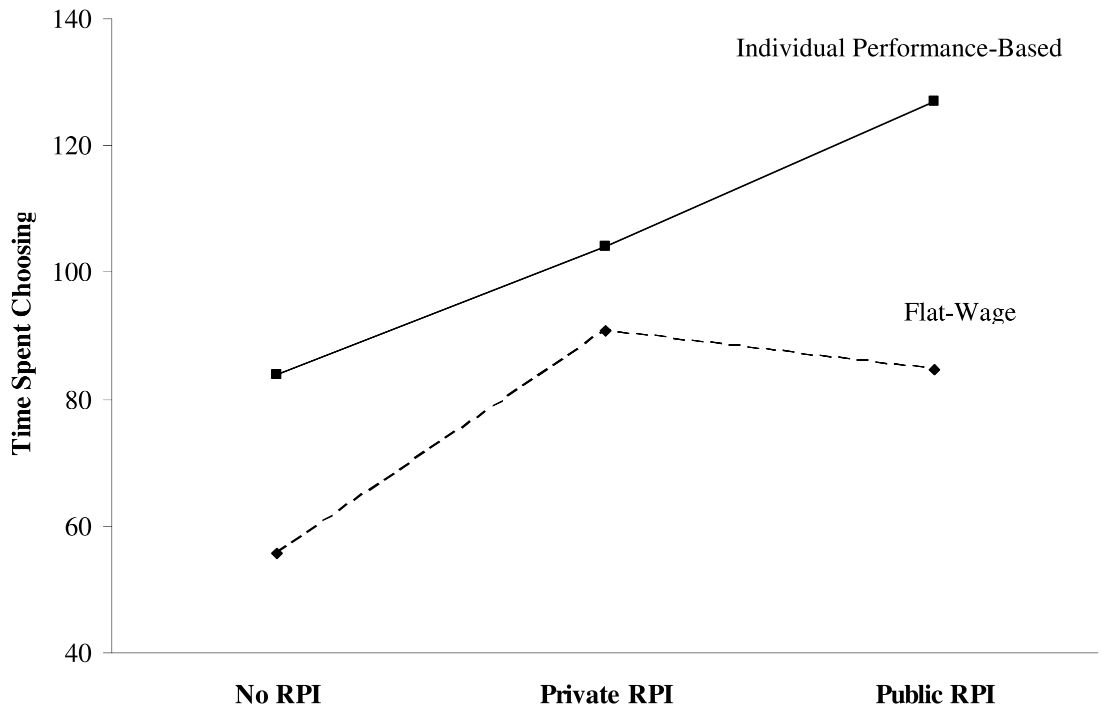
[a] *RPI* is manipulated as a between-subjects factor at two levels, *No RPI,* and *RPI*. Participants in the *No RPI* condition are not provided with any RPI. Participants in the *RPI* are provided with RPI ranking, at the end of rounds 3, 6, and 9.

[b] *Incentive System* is manipulated as a between-subjects factor at two levels, *Flat-Wage and Individual Performance-Based*. Participants in the *flat-wage* condition received 552 *lira* for each of the 9 rounds of the experiment, regardless of the number of problems they solved correctly. Participants in the *individual performance-based incentive* condition received 180 lira for each problem they solved correctly.

[c] *Problems Attempted* represents the average number of problems attempted to be solved (including by guessing) by the participants in each session.

FIGURE 8

Effect of RPI [a] and Incentive System [b]
on Time Spent Choosing [c]



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[a] *RPI* is manipulated as a between-subjects factor at two levels, *No RPI,* and *RPI*. Participants in the *No RPI* condition are not provided with any RPI. Participants in the *RPI* are provided with RPI ranking, at the end of rounds 3, 6, and 9.

[b] *Incentive System* is manipulated as a between-subjects factor at two levels, *Flat-Wage and Individual Performance-Based*. Participants in the *flat-wage* condition received 552 *lira* for each of the 9 rounds of the experiment, regardless of the number of problems they solved correctly. Participants in the *individual performance-based incentive* condition received 180 lira for each problem they solved correctly.

[c] *Time Spent Choosing* represents the average number of seconds spent choosing a problem to tackle by the participants in each session.

TABLE 1
Multiplication Problems

33 x 214

a) 6,632	b) 7,062	c) 7,194	d) 7,292	e) 7,414

33 x 22

a) 656	b) 704	c) 726	d) 744	e) 882

41 x 11

a) 399	b) 401	c) 427	d) 443	e) 451

311 x 714

a) 211, 154	b) 214,124	c) 215,054	d) 220,424	e) 222,054

688 x 886

a) 609,568	b) 611, 128	c) 619, 328	d) 622, 728	e) 628,768

34 x 187

a) 6,358	b) 6,424	c) 6, 538	d) 6,764	e) 6,828

These multiplication problems are assigned in one of the 9 rounds of the study. Problems are listed in the order they are displayed on the computer screen.

In each round, participants are given two easy, two moderate, and two difficult problems. The order in which the problems are presented (though not necessary solved) is random and varies from round to round, although is the same for all participants.

Participants are precluded from using a calculator, paper or pencil while solving the problems. In each round, participants may choose the number and order of problems to work on.

TABLE 2
Descriptive Statistics

	RPI [a]					
	No RPI		**Private RPI**		**Public RPI**	
	Incentive System [b]		**Incentive System [b]**		**Incentive System [b]**	
	Flat-Wage	**Performance-Based**	**Flat-Wage**	**Performance-Based**	**Flat-Wage**	**Performance-Based**
Time Spent [c]	708.77 (34.83)	1,167.58 (304.20)	989.26 (126.27)	1788.06 (246.65)	1207.72 (266.67)	2550.84 (104.36)
Problems Solved [d]	13.55 (2.14)	20.70 (4.68)	19.70 (7.59)	31.30 (6.45)	21.20 (4.38)	41.30 (3.32)
Problems Attempted [e]	30.15 (4.08)	48.20 (3.45)	36.90 (4.44)	46.70 (4.34)	30.50 (7.96)	51.50 (0.62)

[a] *RPI* is manipulated via nested design as a between-subjects factor at three levels, *No RPI, Private RPI, and Public RPI*. Participants in the *No RPI* condition are not provided with any RPI. Participants in the *Private RPI* condition are provided only with their own performance rank at the end of rounds 3, 6, and 9. Participants in the *Public RPI* condition are provided not only with their own performance rank, but also with the performance ranks of the other four participants in the session at the end of rounds 3, 6, and 9.

[b] *Incentive System* is manipulated as a between-subjects factor at two levels, *Flat-Wage* and *Individual Performance-Based*. Participants in the *flat-wage* condition received 552 *lira* for each of the 9 rounds of the experiment, regardless of the number of problems they solved correctly. Participants in the *individual performance-based* incentive condition received 180 lira for each problem they solved correctly.

[c] *Time Spent* represents the average number of seconds spent solving problems by the participants in each session.

[d] *Problems Solved* represents the average number of problems solved correctly by the participants in each session.

[e] *Problems Attempted* represents the average number of problems attempted to be solved (including by guessing) by the participants in each session.

TABLE 3
Descriptive Statistics

	RPI [a]					
	No RPI		Private RPI		Public RPI	
	Incentive System [b]		Incentive System [b]		Incentive System [b]	
	Flat-Wage	Performance-Based	Flat-Wage	Performance-Based	Flat-Wage	Performance-Based
Time pressure early [c]	2.30 (0.38)	3.95 (0.60)	2.30 (0.90)	3.85 (0.47)	3.15 (0.68)	5.85 (0.50)
Time pressure late [d]	1.90 (1.04)	2.70 (0.26)	3.55 (0.66)	2.72 (1.04)	2.05 (0.10)	5.20 (0.57)
Problems difficulty [e]	4.20 (0.35)	5.35 (0.53)	5.10 (0.53)	5.02 (0.80)	4.50 (0.84)	5.50 (0.50)
Comp. method complexity [f]	2.60 (0.33)	2.75 (0.72)	2.65 (0.34)	2.80 (0.85)	2.25 (0.38)	2.80 (0.28)
Task interest [g]	2.65 (0.30)	3.45 (0.85)	3.00 (0.28)	3.35 (0.77)	2.90 (0.26)	3.40 (1.03)
Strategy change [h]	4.00 (1.21)	4.35 (0.47)	5.10 (0.50)	4.62 (0.95)	3.75 (0.81)	4.90 (1.09)
Performance comparison [i]	1.90 (0.26)	3.70 (0.48)	2.85 (0.30)	4.50 (0.90)	3.05 (0.62)	6.05 (0.25)
Nervousness [j]	1.75 (0.34)	3.40 (0.16)	2.95 (0.55)	3.30 (1.07)	2.90 (0.90)	5.20 (0.33)
Performance interference [k]	2.20 (0.43)	2.80 (0.71)	2.25 (0.60)	2.05 (0.66)	2.35 (0.44)	3.80 (0.69)
Rank attention [l]	NA	NA	3.55 (0.77)	4.05 (0.41)	3.70 (0.70)	5.45 (0.72)
Rank effect [m]	NA	NA	2.60 (0.95)	2.55 (1.00)	2.70 (1.01)	3.25 (0.70)
Effort/ability [n]	3.07 (0.81)	5.00 (0.43)	3.50 (1.19)	5.35 (0.47)	3.25 (0.60)	5.60 (0.28)

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[a] *RPI* is manipulated via nested design as a between-subjects factor at three levels, *No RPI, Private RPI,* and *Public RPI*. Participants in the *No RPI* condition are not provided with any RPI. Participants in the *Private RPI* condition are provided only with their own performance rank at the end of rounds 3, 6, and 9. Participants in the *Public RPI* condition are provided not only with their own performance rank, but also with the performance ranks of the other four participants in the session at the end of rounds 3, 6, and 9.

[b] *Incentive System* is manipulated as a between-subjects factor at two levels, *Flat-Wage* and *Individual Performance-Based*. Participants in the *flat-wage* condition received 552 *lira* for each of the 9 rounds of the experiment, regardless of the number of problems they solved correctly. Participants in the *individual performance-based* incentive condition received 180 lira for each problem they solved correctly.

[c] *Time Pressure Early* represents participants' assessments of the extent to which they felt time pressure in the early rounds of the session, using a 7-point Likert scale (1 – not at all, 4 – to a moderate extent, 7 – to a great extent).
[d] *Time Pressure Late* represents participants' assessments of the extent to which they felt time pressure in the late rounds of the session, using a 7-point Likert scale (1 – not at all, 4 – to a moderate extent, 7 – to a great extent).
[e] *Problems Difficulty* represents participants' assessments of how difficult the problems were, using a 7-point Likert scale (1 – very easy, 4 – moderately difficult, 7 – very difficult).
[f] *Compensation Method Complexity* represents participants' assessments of compensation method complexity, using a 7-point Likert scale (1 – very simple, 4 – moderately complex, 7 – very complex).
[g] *Task Interest* represents participants' assessments of how interesting the task was, using a 7-point Likert scale (1 – not at all interesting, 4 – moderately interesting, 7 – very interesting).
[h] *Strategy Change* represents participants' assessments of the extent to which their strategy changed throughout the session, using a 7-point Likert scale (1 – not at all, 4 – to a moderate extent, 7 – to a great extent).
[i] *Performance Comparison* represents participants' assessments of how often they thought of how their performance compares to those of the other participants, using a 7-point Likert scale (1 – never, 4 – sometimes, 7 – very often).
[j] *Nervousness* represents participants' assessments of how nervous or concerned they were about how well they were performing relative to the other participants, using a 7-point Likert scale (1 – not at all nervous or concerned, 4 – somewhat nervous or concerned, 7 – very nervous or concerned).
[k] *Performance Interference* represents participants' assessments of the extent to which thinking about how their performance compared to those of the other participants interfered with their ability to concentrate on the problems, using a 7-point Likert scale (1 – not at all, 4 – to a moderate extent, 7 – to a great extent).
[l] *Rank Attention* represents participants' assessments of the extent to which they paid attention to the performance rank (only for Private RPI and Public RPI condition), using a 7-point Likert scale (1 – not at all, 4 – to a moderate extent, 7 – to a great extent).
[m] *Rank Effect* represents participants' assessments of the extent to which performance rank affected their strategy (only for Private RPI and Public RPI condition), using a 7-point Likert scale (1 – not at all, 4 – to a moderate extent, 7 – to a great extent).
[n] *Effort/Ability* represents participants' assessments of whether differences in performance in their session were due to difference in individual effort levels or differences in general problem-solving abilities, using a 7-point Likert scale (1 – entirely due to differences in effort, 4 – equally due to differences in effort and ability, 7 – entirely due to differences in ability).

TABLE 4

Contrast Coding Summary Tables for Planned Contrasts Used to Test H1, H2, H3, and H4

Panel A: H1a and H2a: Dependent Variable – Time Spent

Source of Variation	*df*	*MS*	*F-statistic*	*p-value*
Model Contrast[a] (Tests for Fig.1 pattern)	1	7,062,263.01	70.06	$p < 0.01$[*]
Residual[c]	2	175,397.34	1.74	$p = 0.19$[**]
Error	20	100,803.07		

Panel B: H1b and H2b: Dependent Variable – Problems Solved

Source of Variation	*df*	*MS*	*F-statistic*	*p-value*
Model Contrast[a] (Tests for Fig.1 pattern)	1	1,686.06	50.27	$p < 0.01$[*]
Residual[c]	2	30.52	0.91	$p = 0.46$[**]
Error	20	33.54		

Panel C: H3a and H4a: Dependent Variable – Time Spent

Source of Variation	*df*	*MS*	*F-statistic*	*p-value*
Model Contrast[b] (Tests for Fig.2 pattern)	1	5,888,943.43	114.92	$p < 0.01$[*]
Residual[c]	2	107,099.65	2.09	$p = 0.16$[**]
Error	20	51,243.85		

Panel D: H3b and H4b: Dependent Variable – Problems Solved

Source of Variation	*df*	*MS*	*F-statistic*	*p-value*
Model Contrast[b] (Tests for Fig.2 pattern)	1	1,148.93	27.14	$p < 0.01$[*]
Residual[c]	2	82.55	1.95	$p = 0.18$[**]
Error	20	42.33		

[*] The p-value is reported on a one-tailed basis, given the directional prediction for this effect.
[**] The p-value is reported on a two-tailed basis, given the lack of directional prediction for this effect.

[a] Contrast coefficients are -3 for the no RPI/flat-wage condition, -2 for the no RPI/ performance-based incentive condition, -1 for the RPI/flat-wage condition, and +6 for the RPI/ performance-based incentive condition.
[b] Contrast coefficients are -3 for the private RPI/flat-wage condition, -2 for the private RPI/performance-based incentive condition, -1 for the public RPI/flat-wage condition, and +6 for the public RPI/performance-based incentive condition.
[c] The residual sum of squares represents the between-group variance unexplained by the model contrast used to test the hypotheses. An insignificant p-value indicates that the model contrast explains all of the between-group variance in the data.

TABLE 5
Descriptive Statistics

	RPI [a]					
	No RPI		**Private RPI**		**Public RPI**	
	Incentive System [b]		**Incentive System** [b]		**Incentive System** [b]	
	Flat-Wage	**Performance-Based**	**Flat-Wage**	**Performance-Based**	**Flat-Wage**	**Performance-Based**
Time Spent Choosing [c]	55.79 (7.56)	83.91 (7.39)	90.80 (10.09)	104.17 (23.08)	84.67 (21.19)	126.95 (9.35)
Time Spent Easy [d]	274.55 (42.36)	554.92 (151.67)	288.70 (61.48)	606.79 (133.78)	394.52 (72.49)	681.65 (40.27)
Time Spent Moderate [e]	280.27 (75.39)	409.34 (132.35)	377.11 (93.70)	616.15 (143.93)	424.85 (77.96)	917.59 (53.79)
Time Spent Difficult [f]	98.17 (47.73)	119.41 (33.49)	232.65 (73.27)	460.95 (92.96)	303.68 (131.74)	824.95 (78.67)
Problems Solved Easy [g]	7.65 (1.15)	12.45 (2.32)	9.35 (2.66)	15.15 (1.99)	10.75 (1.79)	17.40 (0.28)
Problems Solved Moderate [h]	4.90 (1.27)	6.05 (2.16)	7.15 (3.24)	10.45 (3.27)	6.95 (1.34)	14.40 (1.61)
Problems Solved Difficult [i]	1.00 (0.23)	2.2 (0.49)	3.20 (1.99)	5.70 (1.31)	3.50 (1.60)	9.50 (1.51)

[a] *RPI* is manipulated via nested design as a between-subjects factor at three levels, *No RPI, Private RPI,* and *Public RPI*. Participants in the *No RPI* condition are not provided with any RPI. Participants in the *Private RPI* condition are provided only with their own performance rank at the end of rounds 3, 6, and 9. Participants in the *Public RPI* condition are provided not only with their own performance rank, but also with the performance ranks of the other four participants in the session at the end of rounds 3, 6, and 9.

[b] *Incentive System* is manipulated as a between-subjects factor at two levels, *Flat-Wage* and *Individual Performance-Based*. Participants in the *flat-wage* condition received 552 *lira* for each of the 9 rounds of the experiment, regardless of the number of problems they solved correctly. Participants in the *individual performance-based* incentive condition received 180 lira for each problem they solved correctly.

[c] *Time Spent Choosing* represents the average number of seconds spent choosing a problem to tackle by the participants in each session.

[d] *Time Spent Easy* represents the average number of seconds spent solving easy problems by the participants in each session.

[e] *Time Spent Moderate* represents the average number of seconds spent solving moderate problems by the participants in each session.

[f] *Time Spent Difficult* represents the average number of seconds spent solving difficult problems by the participants in each session.

[g] *Problems Solved Easy* represents the average number of easy problems solved correctly by the participants in each session.

[h] *Problems Solved Moderate* represents the average number of moderate problems solved correctly by the participants in each session.
[i] *Problems Solved Difficult* represents the average number of difficult problems solved correctly by the participants in each session.

APPENDIX A
PROCEDURES, INSTRUCTIONS, AND SCREEN SHOTS

Participants first read (printed paper) informed consent forms and task instructions. Next, a short quiz is given to check how well participants understand the instructions. Quizzes and incorrect answers are reviewed with participants privately. Next, after all misunderstandings are resolved, each participant introduces herself/himself by standing up and reading the number that is prominently displayed on the top of his computer (i.e., "I am participant #1," "I am participant #2,, etc.). Then participants complete a z-Tree-based computer task (Fischbacher 2007), sample screen shots from which are provided below.

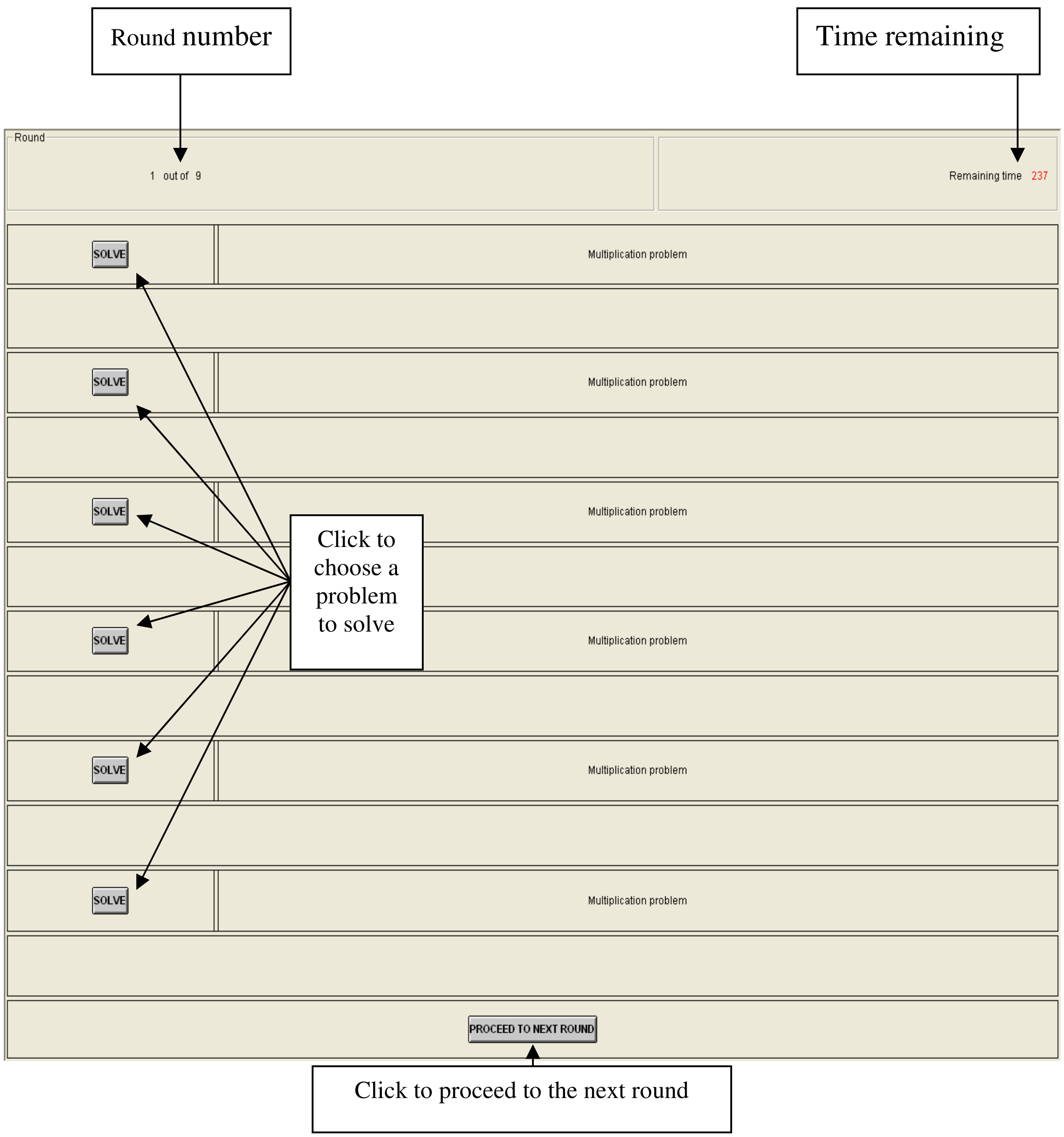
<u>Steps within a Round</u>

On each screen, participants are provided with the round number and time remaining within the current round.

Below is the first screen participants see once the task begins.

At this time, participants need to choose which problem, if any, they wish to solve by clicking the "*Solve*" button for that problem.

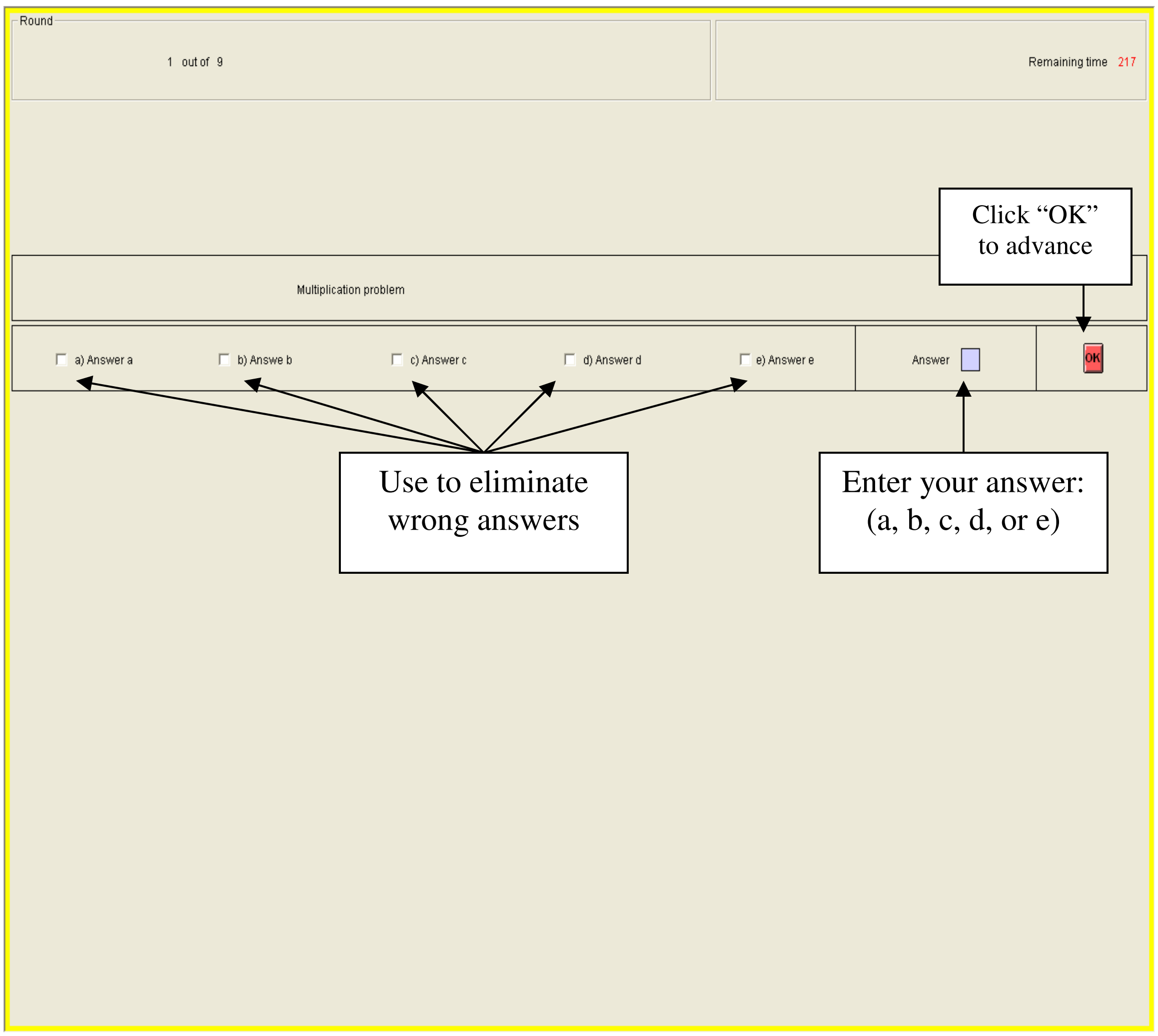
If participants do not wish to solve any problem, they may click the "*Proceed to next round*" button.



Once participants have chosen a problem to work on, if any, they are given five possible answers to the problem. At this point, they need to choose the answer they believe is correct and then click "OK."

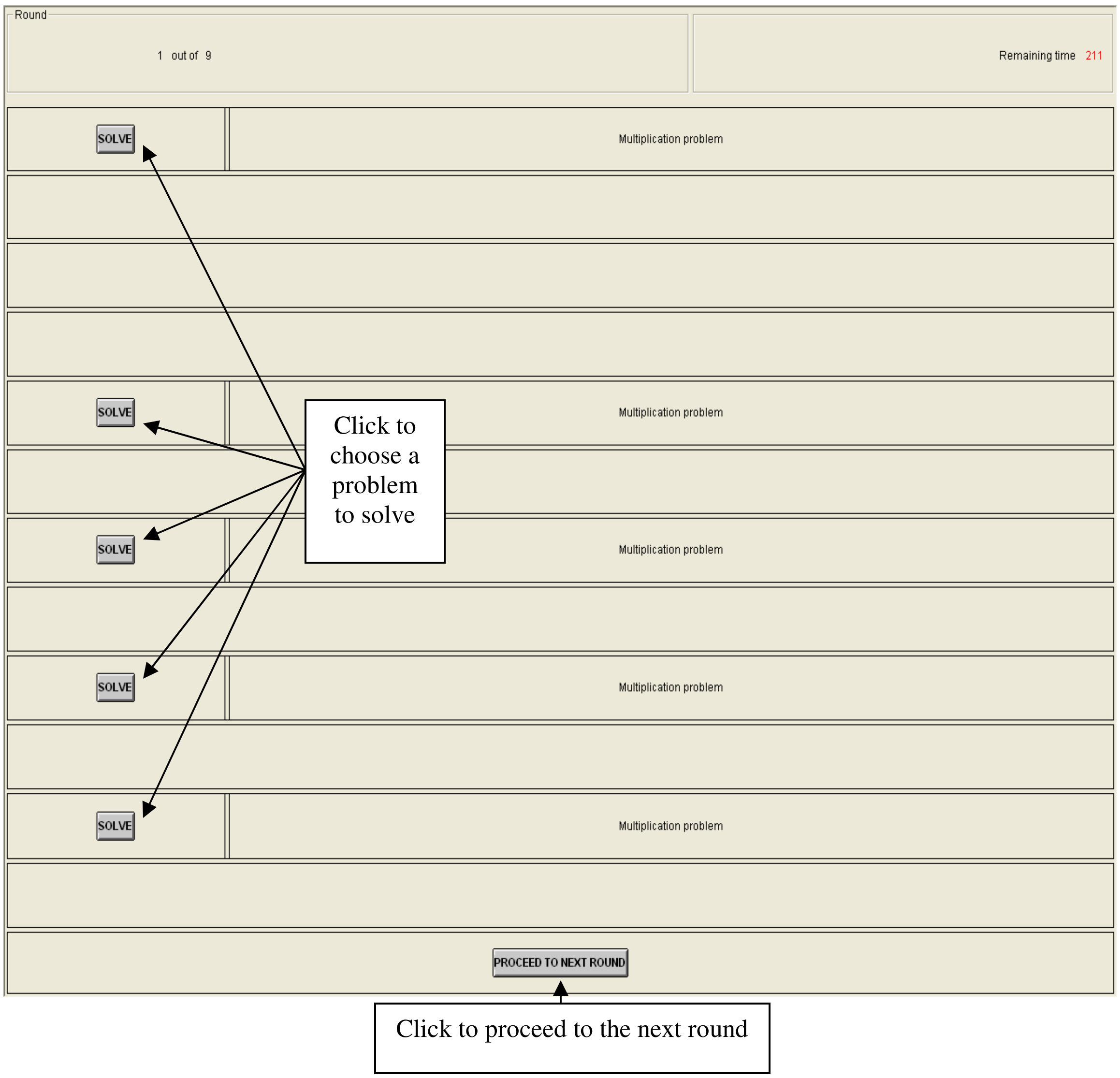
Participants may eliminate an answer they consider wrong by checking the box in front of the answer.

Note that once they choose a problem to work on, all other problems and the "*Proceed to next round*" button disappear from the screen.



Once participants have provided an answer to the problem, all the other problems (except the ones already answered) and the "*Proceed to next round*" button reappear on the screen again.

At this time, participants need to choose another problem, if any, they wish to solve, or click the "*Proceed to next round*" button.



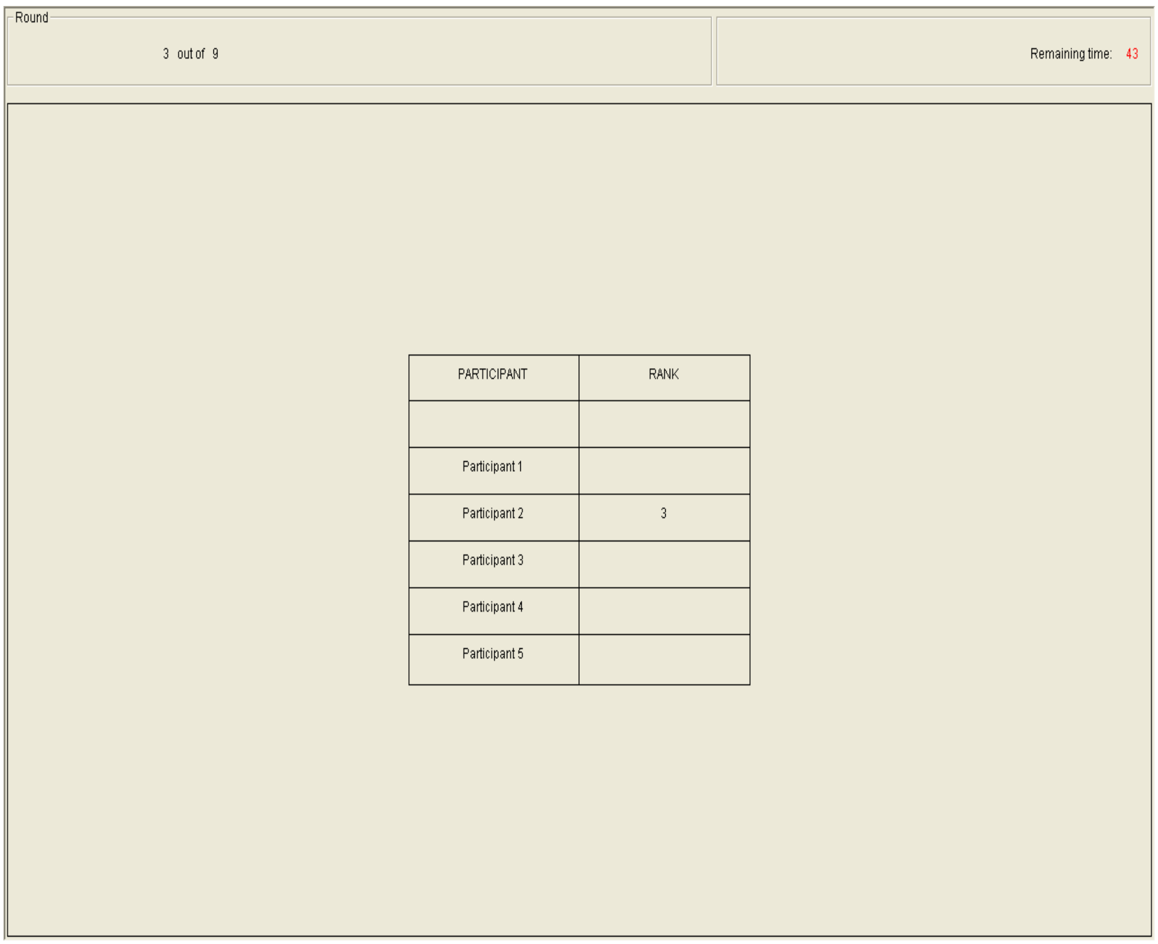
These steps repeat until they have clicked on the "*Proceed to next round*" button or run out of time.

At the end of each round, an “End of Round History” screen appears. This screen shows to participants how many problems they have solved correctly in the current round, and how many problems they have solved correctly in all rounds they have completed so far in the study.

<u>Private RPI Condition</u>

At the end of rounds 3, 6, and 9, immediately after the “End of Round History” screen disappears, each participant receives feedback comparing his/her performance to that of the other 4 participants in the session. Specifically, participants are told the rank of their performance.

Example: If the total number of problems *Participant 2* has solved correctly so far is the 3rd largest number in her/his session, s/he receives the following feedback:



PARTICIPANT	RANK
Participant 1	
Participant 2	3
Participant 3	
Participant 4	
Participant 5	

<u>Public RPI Condition</u>

At the end of rounds 3, 6, and 9, immediately after the “End of Round History” screen disappears, participants receive feedback comparing their performance to that of the other 4 participants in the session. Specifically, participants are able to see the individual performance ranking within their session.

PARTICIPANT	RANK
Participant 1	3
Participant 2	1
Participant 3	4
Participant 4	4
Participant 5	2

APPENDIX B
TASK DESCRIPTION

Difficulty manipulation

Participants have the opportunity to solve a total of 54 multiple choice multiplication problems (9 rounds x 6 problems). These problems are of three different difficulty levels – easy, moderate, and difficult. Two factors determine the difficulty level: (1) the number of digits to be multiplied, and (2) the solution choices provided.

On the first point: to solve an easy problem, one must multiply two two-digit numbers (e.g., 33 x 22); to solve a moderate problem, one must multiply a two-digit number with a three digit number (e.g., 34 x 187); to solve a difficult problem, one must multiply two three-digit numbers (e.g., 688 x 886). Additionally, the higher the difficulty level of a problem, the further away the numbers multiplied are from round numbers. For example, the easy problem 33 x 22 can be presented as: (30 + 2) x (20 + 2); the moderate problem 34 x 187 can be presented as: (30 + 4) x (200 – 13); and the difficult problem 688 x 886 can be presented as: (700 – 12) x (900 – 14). Because shortcut math techniques usually involve some rounding transformation, the further away the multiplied numbers are from round numbers, the more difficult it is to do the multiplication using math shortcuts (e.g., 299 x 399 is easier to solve that 289 x 389).

On the second point, the higher the difficulty level of the problem, the more difficult it is to eliminate possible answers. For example, for easy problems one can eliminate three of the five possible answers provided just by looking at the last digit of the possible answer. For moderate problems, one can eliminate only two of the five possible answers by using this technique. For difficult problems, the technique will be of no help.

To demonstrate, see Table 1. One of the easy problems is 33 x 22. By multiplying the last digits of the two numbers (3 and 2), we can determine that a correct answer to this problems must end with 6. Only two of the possible answers (656 and 726) satisfy this requirement. Now see one of the moderate problems: 34 x 187. By multiplying the last two numbers (4 and 7), we can determine that the correct answer to this problem must end with 8. Three of the possible answers (6,358, 6,538, and 6,828) satisfy that requirement. Lastly, all five of the possible answers to a difficult problem (688 x 886) end with 8.

Additional Details

Multiplication problems involving two two-digit numbers may have three-digit or four-digit answers (e.g., 32 x 22 = 726 vs. 72 x 62 = 4,462). Similarly, multiplication problems involving multiplying a two-digit with three-digit number (two three digit numbers) may have four-digit or five digit (five-digit or six digit) answers. Because problem difficulty may be affected by the number of digits in the answer, all easy/moderate/difficult problems in the experiment have three/four/six digit-answers.

Now, see three easy (17 x 19, 41 x 11, 38 x 22), three moderate (47 x 184, 34 x 187, 33 x 214), and three difficult (688 x 886, 311 x 714, and 389 x 414) problems. Within each group of problems, participants may find some problems easier to solve than others. Further, they may disagree on which are the easiest problems within a difficulty level group. What is important for this task is that participants agree on the between-groups difficulty levels (e.g., one difficult problem may be perceived as easier to solve than another difficult problem, but never as easier to solve than a moderate problem). As discussed in footnote 14, I have achieved this requirement in my experiment.

Strategies for Solving Problems

Easy problem example:

17 x 19

a) 294 b) 323 c) 337 d) 353 e) 369

- Solve directly: 17 x 19 = 323
- Solve by rounding: (17 x 20) – 17 = 340 – 17 = 323
- Multiply (17 x 20) = 340 > (17 x 19). Now you can eliminate 369 > 340, and 353 > 340. Next, stop and guess among the remaining three answers (294, 323, and 337) or continue and eliminate an additional answer (337) as being too close to 340. Next, stop and guess between the remaining two answers (294, 323),or continue and eliminate 294 by multiplying the last digits of the two numbers (7 x 9).
- Eliminate 3 possible answers by multiplying the last digits of the two numbers (7 x 9 = 63, ends on 3). Next, guess between the remaining two answers (323 and 353) or continue by multiplying (17 x 20) = 340 > (17 x 19). Eliminate 353 > 340.

Moderate problem example:

23 x 384

a) 8,696 b) 8,832 c) 8,986 d) 9,182 e) 9,336

- Solve directly: 23 x 384 = 8,832
- Solve by rounding: (23 x 400) – (16 x 23) = 8,832
- Solve by rounding: (23 x 400) – (16 x 20) = 8,880 and adjusting (realize that the actual number should be slightly smaller because (16 x 20) < (16 x 23)).

- Solve by rounding: (23 x 400) – (16 x 30) = 8,810 and adjusting (realize that the actual number should be slightly larger because (16 x 30) > (16 x 23)).
- Multiply (23 x 400) = 9,200 > (23 x 384). Now you can eliminate 9,336 > 9,200. Next, stop and guess among the remaining four answers or continue and eliminate an additional answer (9,182) as being too close to 9,200. Next, stop and guess among the remaining three answers or continue and eliminate 8,696 and 8,986 by multiplying the last digits of the two numbers (3 x 4 = 12, ends on 2).
- Eliminate four answers by figuring out the last two digits of the answer (xx32).
- Eliminate 2 possible answers by multiplying the last digits of the two numbers (3 x 4 = 12, ends on 2). Next, guess among the remaining three answers or continue by multiplying (23 x 400) = 9,200 > (23 x 384). Eliminate another answer (9,182) as being too close to 9,200.

Difficult problem example:

311 x 714

a) 211,154 b) 214,124 c) 215,054 d) 220,424 e) 222,054

- Solve directly: 311 x 714 = 222,054
- Solve by rounding: (300 x 700) + (11 x 714) + (14 x 300) = (300 x 700) + (11 x 700) + (14 x 311) = 222,054.
- Solve by rounding (300 x 700) + (11 x 700) + (14 x 300) = 221,900 and adjusting (realize that the actual number should be slightly larger because (11 x 700) < (11 x 714)).
- Multiply (300 x 700) = 210,000 < (311 x 714). Now you can eliminate 211,154 as being too close to 210,000. Next, stop and guess among the remaining four answers or eliminate two more answers (214,124 and 220,424) by figuring the last

two digits of the answer (xxxx54). Next, guess between the remaining two answers (215,054 and 222,054).

- Multiply (311 x 700) = 217,700 < (311 x 714). Eliminate the first three answers as smaller than 217,700. Next, stop and guess between the remaining two answers (220,424 and 222,054) or continue by figuring the last two digits of the answer (xxxx54).
- Multiply (300 x 714) = 214,200 < (311 x 714). Eliminate 211,154 and 214,124 as being smaller than 214,200 and 215,054 as being too close to 214,200. Next, stop and guess between the remaining two answers (220,424 and 222,054) or continue by figuring the last two digits of the answer (xxxx54).

These three examples demonstrate the following. All problems can be solved either by directly deriving the right answer or by getting to it by eliminating all wrong answers. The optimal strategy depends on individual problem-solving ability. However, holding the ability constant, the more difficult the problem, the more useful the later approach becomes. Additionally, the more effort one exerts, the more wrong answers one can eliminate and the better the odds of getting the right answer. Each eliminated wrong answer increases one’s chance of getting the right answer. The complexity of the calculation required to eliminate a wrong answer increases with each eliminated wrong answer. This means that when working on a difficult problem, one may realize that eliminating three out of five possible answers and then guessing is sometimes a better strategy than trying to eliminate the last wrong answer.

APPENDIX C
INSTRUCTIONS, QUIZ, AND POST EXPERIMENTAL QUESTIONNAIRE

Instructions

Note: Please raise your hand when you are finished reading. The administrator will give you a short quiz to check your understanding of the instructions.

Introduction

You have been invited to participate in a decision-making study.

During today's session, you will perform a task which involves solving multiplication problems. For that, you will earn income in an experimental currency called *Lira*.

At the conclusion of today's study, the *Lira* you have earned will be converted to dollars at a rate of $1 for every 240 *Lira* earned. The resulting amount will be paid to you in cash.

Please read these instructions very carefully. You will need to understand these instructions to make money today. Also, you will be required to complete a quiz to demonstrate that you have a complete and accurate understanding of these instructions. After the quiz, the administrator will check your answers and discuss with you any questions that have been answered incorrectly.

Session Overview

The remainder of the session will take place on the computer. Please do not talk with other participants. If you have a question, you may raise your hand and the administrator will answer the question privately.

The study consists of 9 independent rounds. You are given a time limit of 5 minutes per round and a break of 1 minute after each round. Thus the main part of the session (i.e., excluding instructions, a post-session survey, and a compensation receipt) will last no more than 54 minutes [(9 rounds * 5 minutes per round) + (9 rounds * 1 minute per break)].

In addition, you should expect to spend approximately 40 additional minutes reading instructions, completing the quiz, and completing a short survey at the end of the session.

Compensation

In each of the 9 rounds, you will be given 6 multiplication problems.

You are precluded from using a calculator, paper or pencil during this session.

In order to solve accurately and quickly the type of multiplication problems given here, one is required to possess not only mechanical skills, but also general problem solving ability. In fact, these types of multiplication problems are often used in IQ tests designed to measure general intelligence level.

There will be 5 participants in your session. Each participant will be given the same multiplication problems in each round.

Your Pay (flat-wage condition)

In each round, you will earn 552 *Lira*, regardless of the number of problems you solved correctly.

Your Pay (performance-based compensation condition)

In each round, you will earn 180 *Lira* for each problem you solved correctly.

Task

In each round, you will be given 6 multiplication problems. For each problem, you will be provided with five possible answers, and you will choose the answer you believe to be correct.

You will choose both the number of problems and the order of problems you work on in each round.

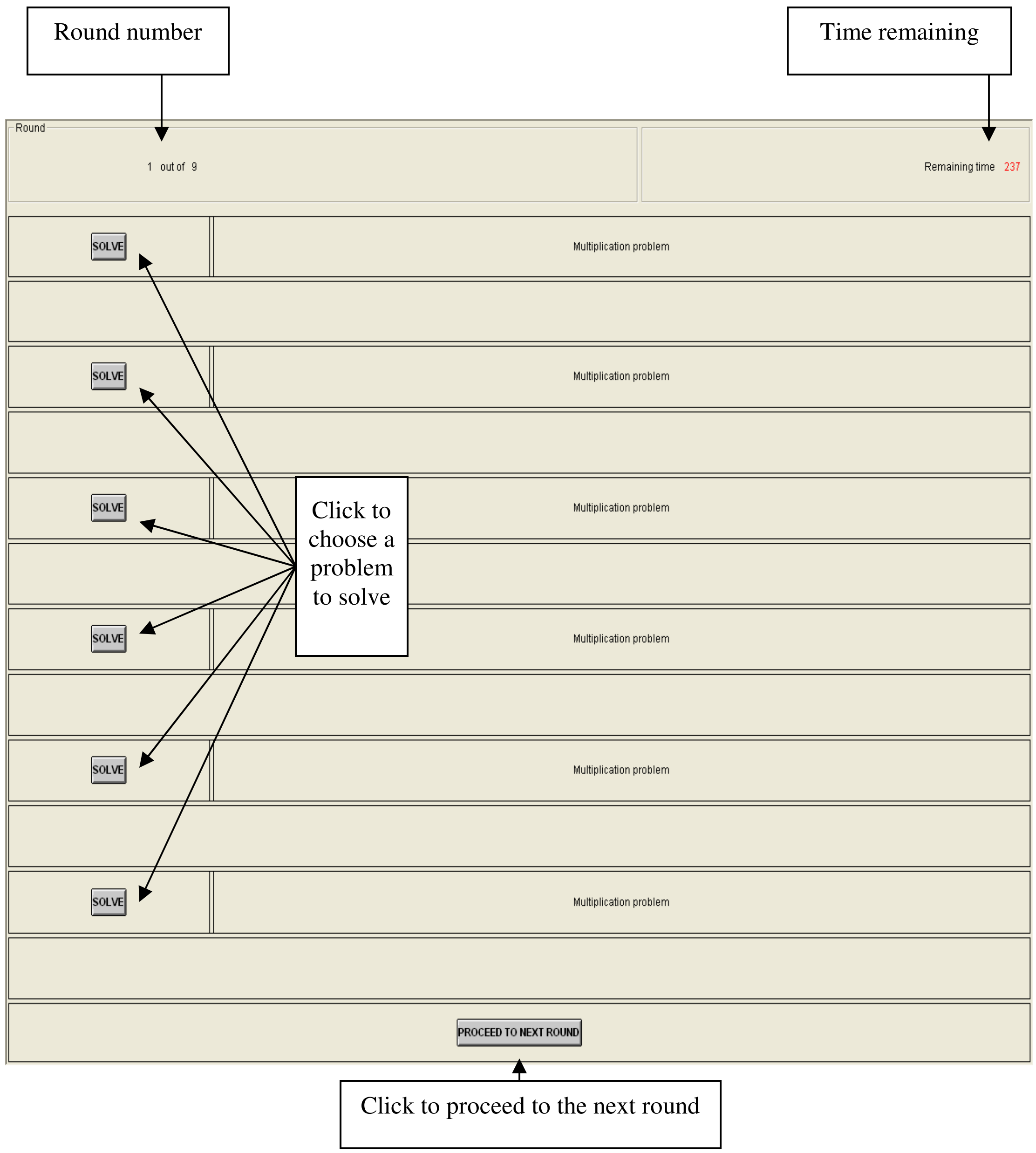
<u>Steps Within a Round</u>

Below is the first screen you will see once the task begins.

Note that the round number and time remaining in the current round is located at the top of the screen.

The first step will be to choose which problem, if any, you wish to solve. You will do so by clicking the "Solve" button for that problem.

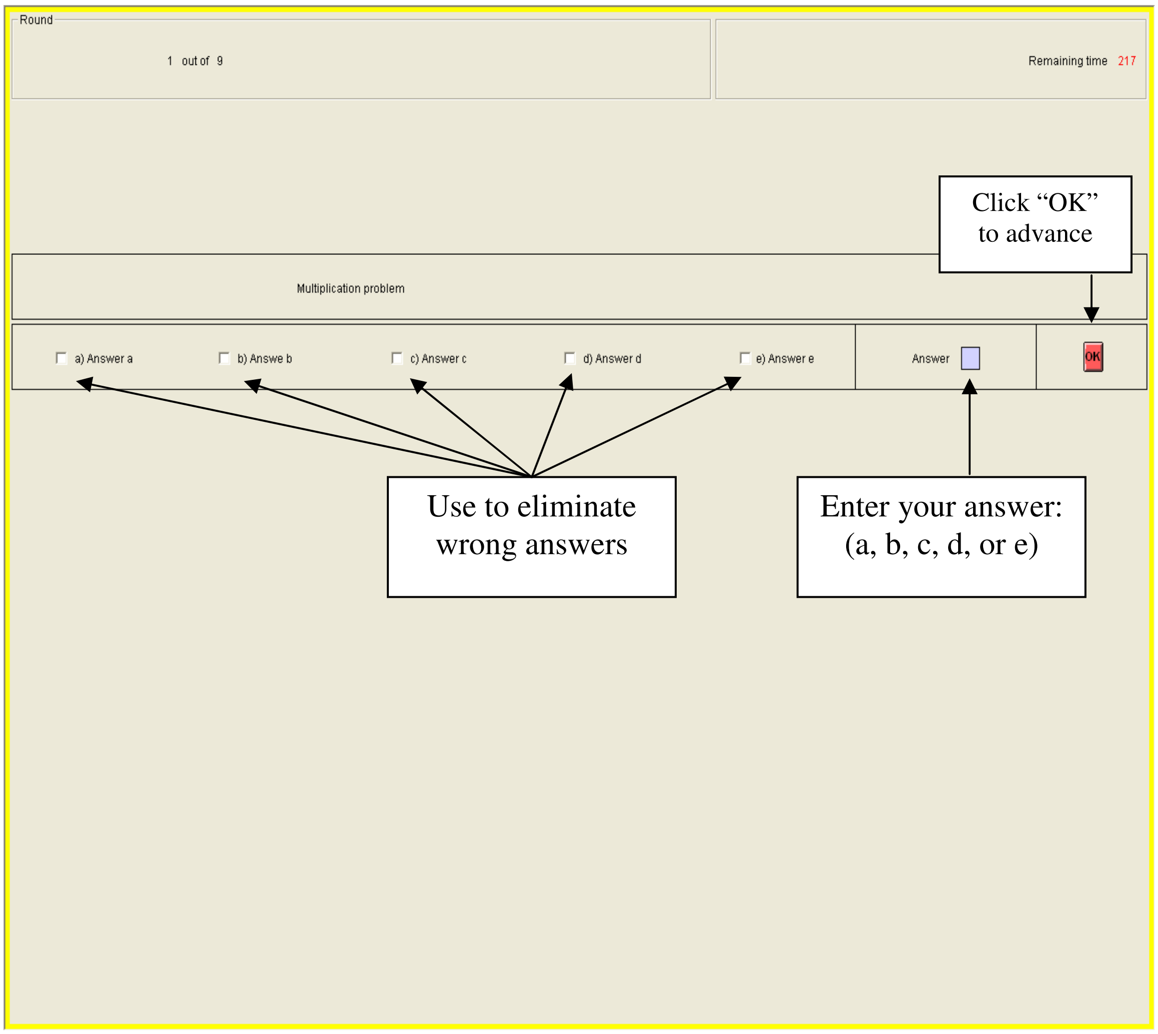
If you do not wish to solve any problem, you may click "*Proceed to the next round*" button.



Steps within a round (continued)

Once you have chosen a problem to work on, you will be offered the opportunity to provide your answer to the problem. At this point you need to provide your answer to the problem and then click "OK".

Note that once you have chosen a problem to work on, all other problems and the "*Proceed to next round*" button disappear from the screen.

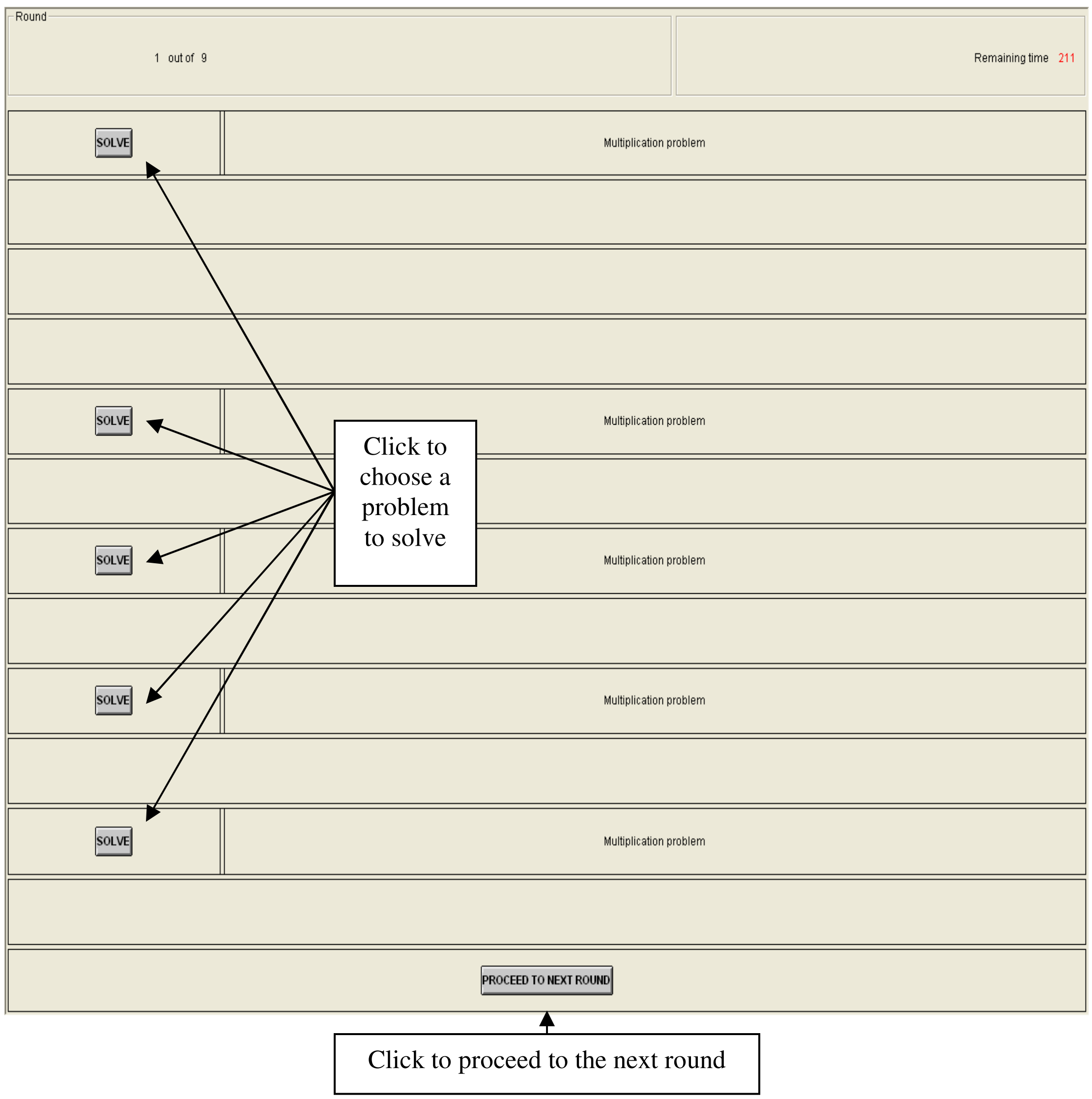


Steps within a round (continued)

Once you have provided an answer to the problem, all the other problems and the "*Proceed to next round*" button will reappear on the screen.

Your next step will be to choose another problem, if any, you wish to solve, or click "*Proceed to next round*" button,

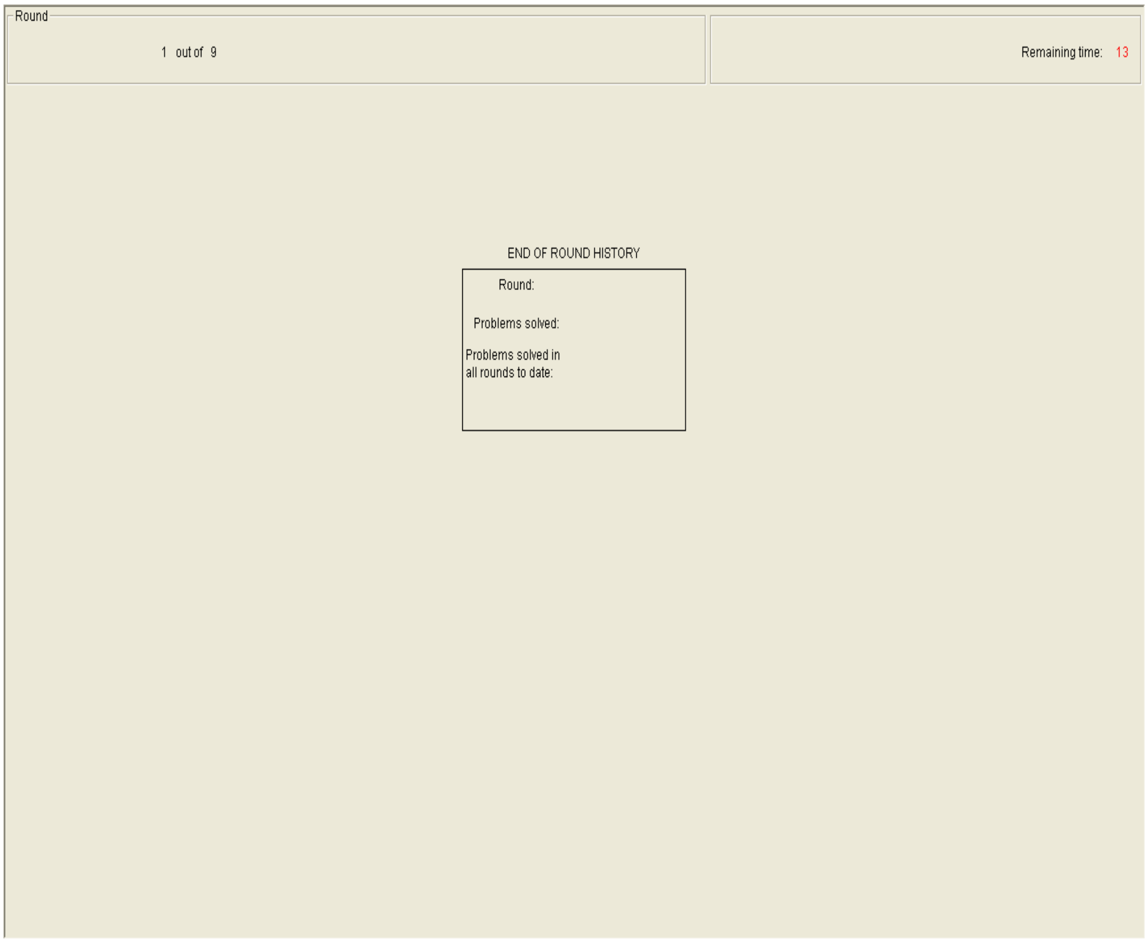
Note that problems that you have already answered disappear from the screen.



These steps repeat until you have clicked on "*Proceed to next round*" button or run out of time.

History Information – End of Round

At the end of each round, an "End of Round History" screen will appear. This screen shows how many problems you have solved correctly in the current round, and how many problems you have solved correctly in all rounds you have completed so far in the study. This information will remain on the screen for 15 seconds. This time is not counted towards your time used in that round.



After the "End of Round History" screen disappears, an additional 45-second break occurs. Again, this time is not counted toward your time used in that round.

After completing each round, the computer will automatically proceed to the next round. Procedures in all 9 rounds are identical.

<u>Relative Performance Information</u> (***Private RPI condition***)

At the end of rounds 3, 6, and 9, immediately after the “End of Round History” screen disappears, you will receive feedback comparing your performance to that of the other four participants in your session. Specifically, you will be told the rank of your performance.

Example: If the total number of problems you have solved correctly so far is the 3rd largest number in your session, you will receive the following feedback:

PARTICIPANT	RANK
Participant 1	
Participant 2	3
Participant 3	
Participant 4	
Participant 5	

This screen will show for 45 seconds. Immediately after this screen disappears the next round will begin.

<u>Relative Performance Information</u> (***Public RPI condition***)

At the end of rounds 3, 6, and 9, immediately after the "End of Round History" screen disappears, you will receive feedback comparing your performance to those of the other four participants in your session. Specifically, you will be able to see the individual performance ranking within your session.

PARTICIPANT	RANK
Participant 1	3
Participant 2	1
Participant 3	4
Participant 4	4
Participant 5	2

This screen will show for 45 seconds. Immediately after this screen disappears, the next round will begin.

<u>Available Time and Related Bonus</u>

You will have no more than 300 seconds (5 minutes) to complete each round.

Note that you may advance through the multiplication problems at your own pace, and may complete a round prior to available time running out. Once you have clicked on the "Proceed to next round" button, the clock stops, and your time for that round is computed.

If you complete all 9 rounds in less than 45 minutes (9 rounds x 5 minutes), you will receive an additional bonus of 1 *Lira* per second saved. For example, if you complete all 9 rounds in 36 minutes, you will get a time bonus of:

(45 – 36) * 60 = 540 *Lira*

If you fail to complete all 9 rounds in less than 45 minutes, the time bonus is 0.

<u>Completion</u> ***(flat-wage condition)***

Once all 9 rounds have been completed, you will answer a short survey and receive payment.

Your payment will be calculated in the following way:

	Cumulative payoff (552 *Lira* for each round)
+	
	Time Bonus (if any)
=	Total Payoff in *Lira*
÷	240 (conversion rate)
=	Total Payoff in Dollars

<u>Completion</u> ***(performance-based compensation condition)***

Once all 9 rounds have been completed, you will answer a short survey and receive payment.

Your payment will be calculated in the following way:

	Cumulative payoff (180 *Lira* x Total number of problems correctly solved)
+	Time Bonus (if any)
=	Total Payoff in *Lira*
÷	240 (conversion rate)
=	Total Payoff in Dollars

<u>Quiz</u> *(all conditions except as noted)*

Please raise your hand when you are finished, and the administrator will check your answers. You may look back at the instructions.

Please fill in the blank:

1. The experiment consists of ____ independent rounds. In each round you are given ____ multiplication problems.

2. You are given a time limit of ____seconds per round and a break of ____seconds after each round.

3. (*flat-wage condition only*) You will earn _____ *Lira* in each round, regardless of the number of problems you solved correctly.

3. (*performance-based compensation condition only*) You will earn _____ for each problem you solved correctly.

Please circle True or False:

True / False Your payoff depends on the number of problems correctly solved.

True / False Your payoff depends on how well you have performed compared to other participants.

True / False You are not allowed to use calculator during the session.

True / False You are allowed to use paper and pencil during the session.

True / False Each participant in your session will be given the same multiplication problems in the same order.

True / False You may choose the number of problems you work on in each round.

True / False You do not choose the order of problems you work on in each round.

True / False You may complete a round for less than 300 seconds.

True / False You are allowed to talk with the other participants during the session.

True / False You will have 300 seconds (5 minutes) to complete each round and you will earn time bonus for finishing the round before the time expires.

True / False You may provide your answer to a problem by checking the box in front of the answer.

True / False You may provide your answer to a problem by checking the boxes in front of all the wrong answers.

True / False (*private and public RPI conditions only*) At the end of rounds 3, 6, and 9, immediately after the "End of Round History" screen disappears, you will be given relative performance information comparing your performance to that of the other four participants in your session .

True / False (*private and public RPI conditions only*) You will be given relative performance information. This information is meaningless because other participants may have had easier multiplication problems to solve.

True / False (*private and public RPI conditions only*) The other participants in your session will be able to see your performance rank.

Questionnaire

The decision-making phase of the experiment has now ended. To help us better understand your decisions, please respond to the following questions. Recall that your identity will remain anonymous and your responses will be kept confidential.

1. Gender: M F

2. Age (in years): __________

3. Current grade status:

   Freshman Sophomore Junior Senior Graduate

4. What is your academic major? (answer "none" or "undecided" if applicable)

   ____

5. Have you ever participated in other experiments at this lab? Yes No

6. How many college-level math classes have you taken (answer with a number)?

Please respond to the following questions.

7. Below are three of the problems you saw earlier:

   Problem 1: 488 x 314
   Problem 2: 17 x 19
   Problem 3: 34 x 213

   Which one do you think is the easiest to solve?

   Problem 1 is the easiest to solve
   Problem 2 is the easiest to solve
   Problem 3 is the easiest to solve
   All three problems are equally easy to solve

8. Below are three of the problems you saw earlier:

Problem 1: 488 x 314
Problem 2: 17 x 19
Problem 3: 34 x 213

Which one do you think is the most difficult to solve?

Problem 1 is the most difficult to solve
Problem 2 is the most difficult to solve
Problem 3 is the most difficult to solve
All three problems are equally difficult to solve

9. In the earlier rounds of the session, to what extent did you feel time pressure?

1	2	3	4	5	6	7
Not at all			To a moderate extent			To a great extent

10. In the later rounds of the session, to what extent did you feel time pressure?

1	2	3	4	5	6	7
Not at all			To a moderate extent			To a great extent

11. How difficult did you find the multiplication problems?

1	2	3	4	5	6	7
Very easy			Moderately difficult			Very difficult

12. How complex did you find the compensation method?

1	2	3	4	5	6	7
Very simple			Moderately complex			Very complex

13. How interesting did you find your task?

1	2	3	4	5	6	7
Not at all interesting			Moderately interesting			Very interesting

14. To what extent did your strategy change during the study?

1	2	3	4	5	6	7
Not at all			To a moderate extent			To a great extent

15. How often did you think about how your performance (total number of problems correctly solved) ranked relative to other participants in the experiment?

1	2	3	4	5	6	7
Never			Sometimes			Very often

16. Were you nervous or concerned about how well you were performing (total number of problems correctly solved) relative to other participants in the experiment?

1	2	3	4	5	6	7
Not at all nervous or concerned			Somewhat nervous or concerned			Very nervous or concerned

17. Did thinking about how your performance ranked compared to other participants interfere with your ability to concentrate on the problems?

1	2	3	4	5	6	7
Not at all			Somewhat			Very much

18. (*Private and Public RPI conditions only*) How much attention did you pay to the information you received about relative performance ranking?

1	2	3	4	5	6	7
None			Some			Very much

19. (*Private and Public RPI conditions only*) Did your relative performance ranking affect your strategy?

1	2	3	4	5	6	7
Not at all			Somewhat			Very much

20. How did you feel about your performance?

1	2	3	4	5	6	7
Very ashamed			Neither ashamed nor proud			Very proud

21. To what degree do you think that general problem solving ability is important for succeeding in business?

1	2	3	4	5	6	7
Not at all			To a moderate degree			To a great degree

22. To what degree do you think that general problem solving ability is important for succeeding in life?

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all			To a moderate degree			To a great degree

23. Compared to the other participants in the session, do you feel that your general problem solving ability is:

1	**2**	**3**	**4**	**5**	**6**	**7**
Inferior			About the same			Superior

24. Do you think that the differences in performance in your session were due more to differences in individual effort levels or more to differences in individual problem solving abilities?

1	**2**	**3**	**4**	**5**	**6**	**7**
Entirely due to differences in effort			Equally due to differences in effort and ability			Entirely due to differences in ability

25. To what extent you agree with this statement: In order to solve multiplication problems accurately and quickly, one is required to possess not only mechanical skills, but also general problem solving ability?

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all			To a moderate extent			To a great extent

26. Please describe your strategy (if any) during the session.

____

____

____

____

____

____

____

____

____

27. Did your strategy change during the session? How?

Thank you!