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The Impact of Beliefs on Effort in Telecommuting Teams*

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Abstract

The use of telecommuting policies remains controversial for many employers because of the perceived opportunity for shirking outside of the traditional workplace; a problem that is potentially exacerbated if employees work in teams. Using a controlled experiment, where individuals work in teams with varying numbers of telecommuters, we test how telecommuting affects the effort choice of workers. We find that differences in productivity within the team do not result from shirking by telecommuters; rather, changes in effort result from an individual's belief about the productivity of their teammates. In line with stereotypes, a high proportion of both telecommuting and non-telecommuting participants believed their telecommuting partners were less productive. Consequently, lower expectations of partner productivity resulted in lower effort when individuals were partnered with telecommuters. Our results suggest that managers should actively engage in disseminating productivity information to their telecommuting team in order to avoid negative effects on productivity.

JEL Classification: M51 M54 J21 J24 J28 C90

Keywords: Telecommuting, Team Production, Productivity, Economic Experiments

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1. Introduction

Many workers perform at least some work in a location other than the traditional office. According to the 2010 American Time Use Survey, approximately 23% of the full-time employed performed some work at home on an average day.[1] Restricting the sample to wage and salary workers (excluding self-employed) only reduces this percentage to 19%.

Though the number of workers who perform at least some work at home is substantial, it is not necessarily the result of employers choosing to adopt telecommuting policies - the 2012 National Study of Employers found that only 6% of employers offered paid work at home for the majority of employees. Moreover, existing telecommuting policies are being reversed and telecommuters are being recalled to the office, suggesting a switch in the previous trend observed from the mid-1990's to the mid-2000's, where telecommuting rates almost doubled (Noonan and Glass, 2012).[2]

At first glance, this trend is puzzling given the many known benefits which include decreased transportation costs, worker control over their work environments, and increased flexibility (Nilles, 1975; Mokhtarian, 1991). Accordingly, telecommuting policies have been shown to increase employee satisfaction, which attracts a higher quality, more diverse workforce, and reduces turnover (Baruch, 2000, Pinsonneault and Boisvert, 2001; Bailey and Kurland, 2002). For employers, telecommuting policies indirectly lower costs through increased employee retention and directly lower costs through reduced overhead expenditures associated with housing employees in a traditional office (Piskurich, 1996).[3]

Even though the adoption rate has been relatively high, Matthews and Williams (2005) estimated that approximately 40% of the work force in the United States could still potentially telecommute; yet, taking into account the known benefits, why so few managers have chosen to implement regular telecommuting policies remains unclear. One obvious conjecture for the lack of adoption is that managers hold strong beliefs that telecommuting will lead to shirking outside of the office - a problem that is potentially exacerbated by the widespread use of teams in the workplace. The goal of the research reported in this paper is to provide direct evidence of the consequences of telecommuting on work performed in teams.

Our current understanding of how the telecommuting environment affects worker productivity is not well understood (Bailey and Kurland, 2002; Menezes and Kelliher, 2011). A number of survey studies, which ask telecommuters directly if they are more productive in their telecom-

[1] The average day is a measure defined by the American Time Use Survey (ATUS) that is the average distribution of hours measured across all persons in the reference population for all days of the week.

[2] Yahoo CEO Marissa Mayer's decision to recall telecommuters in 2013 was a prominent example of a recent reversal (Tkaczyk, 2013). The large electronics retailer, Best Buy, followed suit a week after Yahoo's decision was publicized (Pepitone, 2013). In 2012, Bank of America implemented more restrictions into its flexible time work program, "My Work" (O'Daniel, 2012).

[3] Piskurich (1996) estimated that telecommuting may save as much as $8,000 per worker annually.

muting environment or in the office environment, have found that employees who telecommute self-report that they are more productive (see for example Bailyn, 1988; Belanger, 1999; Hill et al., 1998). The self-reported surveys are extremely useful as a first approximation, but the potential for misreporting cannot be ruled out. An earlier example of a non-survey study is DuBrin (1991), which compares the productivity of workers a manager allowed to telecommute with those the manager did not allow to telecommute. DuBrin found that telecommuters were more productive, but this study is not able to isolate the effect of work environment because of potential selection effects - the workers who are allowed to telecommute may have built up the trust of the manager through their work ethic. The above difficulties in gathering productivity measures are exaggerated when considering work performed in teams.

To overcome the difficulties involved in isolating the response to the work environment, we utilize an incentivized real-effort experiment which randomly assigned the participants (workers) to either telecommute or work in an office-like environment. Random assignment to work location was also used in two recent studies, Dutcher (2012) and Bloom et al. (2012), to examine individual productivity differences across work environments. Dutcher designed an experiment around creative and dull tasks which randomly assigned individuals to an office-like environment or a location of their choice and found that the productivity of the telecommuters decreased for the dull task, but increased for the creative task. Bloom et al. (2012) performed a randomized field experiment in China with a company seeking to implement a telecommuting environment for its call center employees. Bloom et al. found that the performance of those working from home exceeded that of those working in the office.

While these studies contribute to an understanding of individual productivity when workers telecommute, to our knowledge, no empirical evidence exists for the impact of telecommuting policies on individual productivity within a team. Arguably, the examination of telecommuting policies on work performed in teams should be of utmost importance given the prevalence of team usage in the workplace (Milliken and Martins, 1996) and the well-known incentives for shirking under team production (Alchian and Demsetz, 1972; Holmström, 1982; Jones, 1984; Albanese and van Fleet, 1985).

Work performed in teams is more likely to lead to individual shirking behavior when an individual's effort is masked in the team output (Jones, 1984). A common managerial solution to this free-rider problem involves either direct monitoring by managers or member monitoring in the case of self-managed teams (Albanese and van Fleet, 1985; Erez et al., 2002). However, monitoring is substantially more difficult (if not impossible) in the telecommuting environment, and so telecommuting teams may result in lower productivity than their traditional office counterparts if individuals choose to free-ride.

In this research, we examine the behavior of both telecommuting and non-telecommuting individuals working in teams. To accomplish this, we designed a novel experiment where the experiment participants were randomly assigned to work on team production tasks based in either a traditional structured office-type location or an unstructured location of their choice.

Our participants were drawn from a subject pool of undergraduate and graduate students and the work involved a paid typing task which asked the subjects to correctly decode a string of 6 letters into a set of 6 numbers. With the simplicity of our design and choice of task, we are able to identify the basic behavioral reasons driving effort choices in this environment.

Regardless of their location, all subjects participated initially on their own where they were paid a piece-rate wage based on how many typing tasks were correctly completed in a set period of time. This individual stage familiarized the participants with the exact task to be performed in a team. Following the individual stage, the subjects were matched with two teammates to participate in a team stage that mimicked the individual stage in all aspects except that payment was now based on average team output. After the initial team stage, the participants were twice rematched with new teammates for two additional team rounds. Each team round varied the locational composition of the members in the team where every subject was teamed with 0 (2), 1 (1), and 2 (0) teammates who were telecommuters (non-telecommuters).

A priori we hypothesized that observed differences in a worker's productivity when moving from a group with more telecommuters to a group with fewer telecommuters would result from a worker's beliefs over other team members' productivity. Specifically, if an individual's productivity within a group is conditioned on their beliefs, then beliefs that other members are free-riding (even if it is false) may adversely impact team productivity in a way that would not otherwise occur in a traditional office where it is easier to observe how much effort is being exerted by other team members. For example, if traditional office workers are conditional cooperators, and if they believe their telecommuting teammates are choosing to shirk, they will reciprocate by exerting less effort.[4] Similarly, when placed in a group with no telecommuters, traditional office workers may have more optimistic beliefs of high teammate productivity and will respond by increasing effort levels. To examine how an individual's productivity within a team is influenced by beliefs over the productivity of other team members, we adopted an incentivized beliefs measurement technique, which asked the individual to estimate the output of their partner(s). Accuracy of the estimate was rewarded by monetary payment, which incentivized participants to truthfully report their beliefs of partner productivity (Palfrey and Wang, 2009). We elicited these beliefs for both telecommuters and non-telecommuters, which provides an overall picture of worker beliefs and allows us to control for differences in team production arising not because of location, but because of beliefs over the relative productivity of partners.

We find that the majority of individuals believed that telecommuters were less productive than their non-telecommuting counterparts, but we do not find evidence of shirking by telecommuters to support this belief. Rather, we find that output differences in teams with telecommuters result from an individual's beliefs about the output of their teammates. Specifically, when individuals believed that their telecommuting partners were less productive than their

[4] A conditional cooperator is one who is willing to contribute more effort to the team as long as others in team are also contributing more effort, and will reduce effort if others in the team are reducing effort. The terminology comes from public goods theory where work teams have been modeled as a public goods game (Dickinson, and Isaac, 1998; Keser and Van Winden, 2000; Fischbacher et al. 2001)

non-telecommuting partners, they worked less in the group with telecommuters. Interestingly, both telecommuters and non-telecommuters held the belief that telecommuting partners were productively inferior to non-telecommuting partners, and both responded reciprocally to these beliefs, but the effect of the telecommuter partner beliefs was stronger.

These findings have direct consequences for managers who currently manage or plan to implement telecommuting teams. Our results indicate that if workers are allowed to telecommute, partnering the telecommuters in teams with non-telecommuters could result in lower effort by both office-based and telecommuting workers due to beliefs that telecommuting partners will shirk. To offset the productivity declines in the team environment, managers should engage in activities that update and maintain the workers' perceptions (beliefs) that all members of the team are contributing high effort.

2. Experimental Design

The experiment was designed around two types of subjects: non-telecommuters and telecommuters. Non-telecommuters were individuals recruited to participate in the laboratory at a pre-specified time. Telecommuters were individuals recruited to participate online at a place of their choosing anytime within a 24 hour block of time.[5] To avoid self-selection issues, the assignment of location was random and subjects in both locations wcere recruited in exactly the same manner.[6]

Each subject, regardless of type, participated in a series of four 8-minute rounds that gave them the option to spend their time on a paid typing task, unpaid games of tic-tac-toe, or some combination of both tasks. The paid typing task required subjects to decode a series of 6 random letters into a series of 6 numbers using a code that changed with each combination of letters.[7] All subjects received the same random sequence of letters and code in each round and across all four rounds the typing task was always paid while tic-tac-toe was never paid.[8] Tic-tac-toe was included as an unpaid outside option so that productivity results for the paid task are not biased towards higher levels exclusively via boredom in the laboratory. To maintain parallelism in the experimental design, the unpaid option was given to all participants regardless of location. Prior to the set of paid rounds, all subjects participated in an unpaid and virtually unlimited practice period of the typing task and tic-tac-toe. Neither of the tasks required practice for mastery, but including this round familiarized subjects with the interface used during the paid rounds.[9]

[5] We did place one restriction on the location choice of telecommuting subjects. We asked that they participate in any location except the computer laboratory where the laboratory experiment was taking place to ensure true location differences.

[6] The participation (show-up) rate was similar for subjects recruited to both locations thus ensuring that the assignment to location was truly random.

[7] We used a revolving code to minimize learning effects.

[8] Experimental instructions and screenshots from the experiment are given in the Appendix.

[9] The program had 100 random codes for the subject to practice with before the codes would repeat and unlimited games of tic-tac-toe. On average, subjects correctly coded 14 words in the coding task and played 5 games of tic-tac-toe in the practice round.

The first paid 8-minute round was always played as an individual, regardless of location. The individual round gave subjects experience in the mechanism before they went on to the team round. The individual round paid 8 €-cents for each correctly coded set of 6 letters. Following the individual stage, all subjects then entered into a series of three team rounds that varied the locational composition of partners. In order to isolate the environmental effects, our teams were purposefully minimalistic with no interaction, feedback of partner performance, and were teams primarily in the sense that team output was the determinant of pay rather than individual output.[10] Subjects' anonymity was preserved through the use of a random number for identification and payment.

The team stage itself was identical to the individual stage in that each subject had the option of using the entire 8 minutes on the paid typing task or unpaid tic-tac-toe, or some combination of both. However, in the team rounds the payment for the typing task was now equal to 8 €-cents multiplied by the average correct output of the team so that effort exerted in the paid task was exerted for the team. In other words, we implemented a team pay scheme that involved equal revenue sharing between the partners. Note that this reduced the marginal payment for each correctly coded word by 2/3.

Prior to each team round, we primed the subjects with their location and their partners' locations, which changed in each round. To guarantee that subjects were fully aware of the location of their teammates, we also included prominent location information at the top of the screen where the subjects performed the tasks. Partner types define our experimental treatments:

1. **Mixed Partners (LT)** – each subject was matched with one telecommuter and one non-telecommuter.

2. **Telecommuting Partners (TT)** – each subject was matched with two telecommuting partners.

3. **Non-telecommuting Partners (LL)** – each subject was matched with two non-telecommuting partners.

Recognizing that this type of task may result in fatigue or learning over subsequent rounds, leading to the possibility of order effects, we ran four orders of the above treatments for each location type of subject. This resulted in 8 total sessions summarized in Table 2.1.[11] We use *Lab* (L) to denote non-telecommuters who participated in the laboratory and *Telecommuter* (T) to denote subjects participating in a location of their choice. We ensured that subjects were matched in a round with others primed with the same group composition.[12]

[10] Subjects were told that no one in their team would ever observe any of their decisions or outcomes.

[11] We used several test to confirm that no order effect exists. Thus, in our analysis we pool the data.

[12] For example, in the two telecommuter team treatment, the instructions for the lab participants specified that they would be placed into a team with two individuals participating in a location of their choice, while the

Order	Lab (# of Subjects)	Telecommuter (# of Subjects)
1	LL, TT, LT (17)	TT, LL, LT (18)
2	LL, LT, TT (19)	TT, LT, LL (16)
3	TT, LT, LL (18)	LL, LT, TT (17)
4	LT, TT, LL (16)	LT, LL, TT (14)

Table 2.1: Treatment order and number of subjects in each session

At the end of the four rounds, we elicited beliefs regarding the performance of their co-participants. Six questions were asked regarding co-participant outcomes for the individual round and the three team rounds. Each question was incentivized according to Palfrey and Wang (2009) using the payoff equation:

$$question\ earnings = 100 - (Actual\ Outcome - Guess)^2$$

All answers were paid in €-cents with a correct answer yielding payment of € 1. The use of the quadratic rule implied that incorrect answers were also paid, but as the distance between the respondent's answer and the correct answer increased, earnings decreased rapidly, providing strong incentives to answer with accurate beliefs. Incorrect answers that would lead to negative earnings were capped at zero.

For individual round beliefs, subjects were asked to guess the average performance of those who participated in the lab and the average performance of telecommuters. In teams, subjects were asked to guess the performance of their teammates. When their teammates were both from the same location, the subjects were asked to guess the average of both teammates, while in the mixed partner treatment, subjects were asked to guess the absolute performance of each teammate.

After beliefs, we also elicited risk preferences using a mechanism adapted from Eckel and Grossman (2008). Subjects were offered a choice between five binary 50/50 gambles where both expected value and risk are increasing in the order of gambles. Choosing a lower gamble corresponds to higher risk aversion. The experiment ended with subjects filling out a non-incentivized survey to gather basic data, such as demographic information.

The experimental design was programmed using Z-tree software (Fischbacher, 2007), and subjects were recruited through ORSEE (Greiner, 2004). We ensured that the recruitment procedure did not reveal that some of the subjects would be asked to participate online or the nature of the experiment. After the initial recruitment, subjects that would participate in

instructions for the telecommuting subjects stated that they would be paired with one partner in the laboratory and one partner also participating in a location of their choice. Priming for the other treatments was conducted in a similar fashion, taking into account differences in a subject's perception of the location of partners based on their own location.

the laboratory were instructed of the time and place to participate via e-mail. Telecommuting subjects were sent an e-mail that directed them to a website with a link that contained an installer for the client-side of Z-tree (zleaf) which would connect to the university server for these subjects to participate online. The telecommuting subjects were instructed to participate in a location of their choice and informed that they had 24 hours to complete the experiment.

The nature of the experiment required that payment was delayed for all subjects, which has the added benefit that the payment delay was identical for both telecommuters and non-telecommuters. Each subject received an e-mail within 3 days of their participation that their payment was ready and that they should bring their unique subject ID with them to collect payment. The average subject payment was € 13.87 – all of which was from incentivized tasks.

3. Hypotheses

Our first hypothesis is derived from the commonly held (mis)perception that telecommuters are less productive than their office-based counterparts.

Hypothesis 1: Subjects will hold beliefs that their telecommuting teammates are less productive than their office-based teammates.

The second hypothesis examines what happens as a result of Hypothesis 1. Several studies (Alchian and Demsetz, 1972; Dickinson and Isaac, 1998) demonstrate that work performed in teams has features of a public good where a majority of subjects are conditional cooperators (Keser and Van Winden, 2000; Fischbacher et al. 2001). Conditional cooperation implies that subjects in a team will work harder if they believe others are also working hard but the reverse occurs if they believe others are slacking off.

Hypothesis 2: Subjects' productivity while in a team will positively correlate with their beliefs about their team members' productivity.

Testing Hypothesis 1 and 2 requires two things. First, it requires us to know what subjects' beliefs are about their teammates, which were gathered via an incentivized mechanism. Second, it requires us to determine if these beliefs influence behavior. Specifically, we will examine how subjects' beliefs vary with the location of their teammates and how this influences their own behavior. In our setting, this hypothesis predicts that if subjects have varying beliefs on the productivity of their team members, based on location, their effort in the team will reflect these beliefs. The most obvious implication of this hypothesis is if subjects believe that telecommuters are less productive, regardless of location, then Hypothesis 2 predicts lower resulting effort when the individual is partnered with a telecommuter.

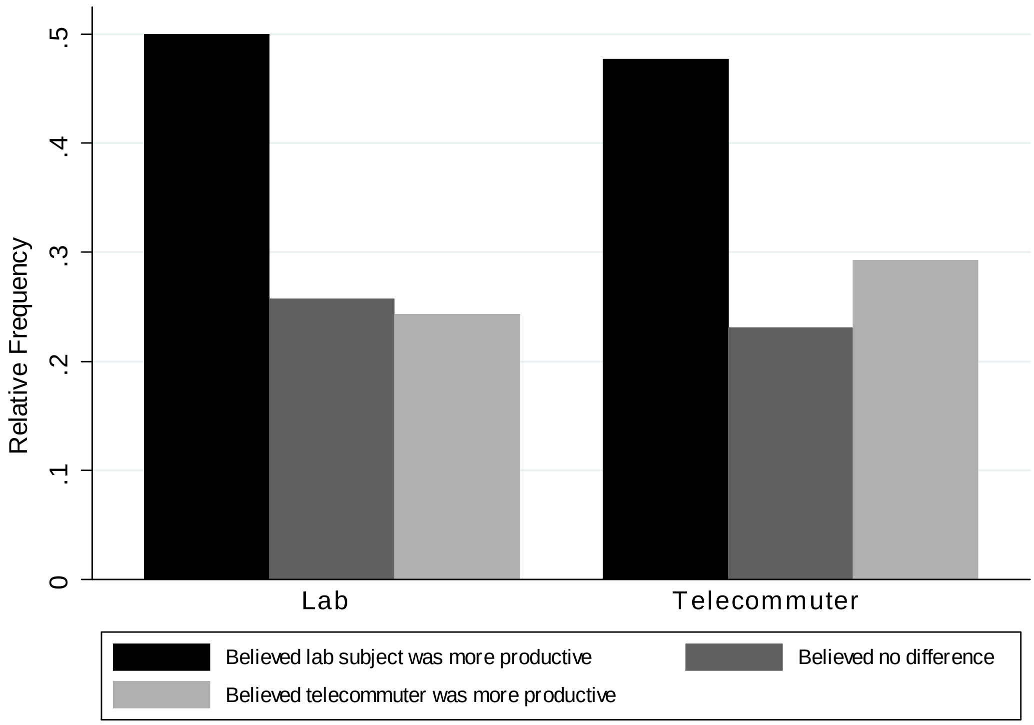

Figure 4.1: Relative frequency of beliefs regarding telecommuting productivity.

4. Results

To test Hypothesis 1, we will begin our analysis with an overview of the beliefs data. We first examine the differences in beliefs when subjects were asked to predict the output of telecommuters and non-telecommuters within the same treatment (mixed partner treatment). This is a clean starting point to examine differences in beliefs since this treatment provides us with the subject's true beliefs about the productivity of telecommuters and non-telecommuters in the same team setting. Recall, the beliefs were incentivized so the closer subjects were to correctly predicting the outcomes, the more money they received.

Figure 4.1 breaks down this data by examining the relative frequency of subjects who thought those based in the lab were more productive than, as productive as, or less productive than telecommuters. It is evident that many more subjects believed that lab subjects (non-telecommuters) were more productive than telecommuters than believed they were less productive or equally productive.

A McNemar's test confirms that the number of subjects who thought those in the lab were more productive is greater than those who thought there was no difference ($p<0.01$) or who thought telecommuters were more productive ($p<0.01$). The same result can also be found when looking at beliefs over productivity in the individual treatment where subjects were also asked to compare the productivity of subjects in each location. In the individual treatment, 47% believed those in the lab were more productive, while 26% thought there was no difference, and 27% believed telecommuters were more productive. We also find that subjects' perceptions about the relative productivity of non-telecommuter vs. telecommuter are fairly consistent across all treatments. Using a pair-wise correlation, we find that the differences in beliefs between the LL and TT treatments are strongly correlated with differences in beliefs in the LT treatment (p= 0.001) and with differences in beliefs in the individual treatment (p=0.006). A ttest also confirms that there is no statistical difference between these three measures ($p \geq 0.142$).

In contrast to the modal belief held by both telecommuters and non-telecommuters that telecommuters are less productive than non-telecommuters, we find no significant evidence that telecommuters were actually less productive than non-telecommuters. In the individual stage, which is the most appropriate treatment to determine differences in productivity arising solely from location, the average non-telecommuter output was 22.36 correctly coded strings of letters while telecommuters averaged 23.74 (t-test for differences; p = 0.211).[13]

Result 1: Both telecommuters and non-telecommuters believed that telecommuting would have a detrimental effect on productivity.

Having established Hypothesis 1, we now turn to Hypothesis 2, which predicts beliefs will influence effort choices.

To begin the examination of how beliefs correlate with effort decisions, Figure 4.2 provides a scatterplot of an individual's output in the team versus beliefs about teammates' output in all treatments for both telecommuters and non-telecommuters. Included in each of the graphs is a dashed line representing a simple regression and a 45-degree reference line. Observations above the 45-degree line indicate that the individual produced more output than what he believed his partners produced, while observations below the 45-degree line imply that the individual believed his partners were more productive. From this figure, it is easy to see the positive correlation between output and beliefs, though some heterogeneity is obviously present.

To go beyond simple correlations, we take advantage of the fact that our experimental design employed two extreme treatments where first, an individual was paired with two telecommuters (TT) and second, the same individual was paired with two lab-based, non-telecommuting subjects (LL). Contrasting the beliefs and effort decisions of both telecommuters and non-telecommuters between these treatments provides straightforward evidence for how subjects reacted to the locational composition of the team.

Figure 4.3 charts the difference in output between the two treatments when subjects believed

[13] Similar to the individual stage, the team treatments also do not result in significant differences in average output between telecommuters and non-telecommuters (t-tests): LL (p=0.677), TT (p=0.236), and LT (p=0.137). However, we do find a great deal of heterogeneity present in the team environment. As such, this simple analysis of averages fails to address features of teamwork that may change effort (i.e. beliefs of partner productivity), and more generally, subject heterogeneity. We account for these issues more formally in the next section through regression analysis.

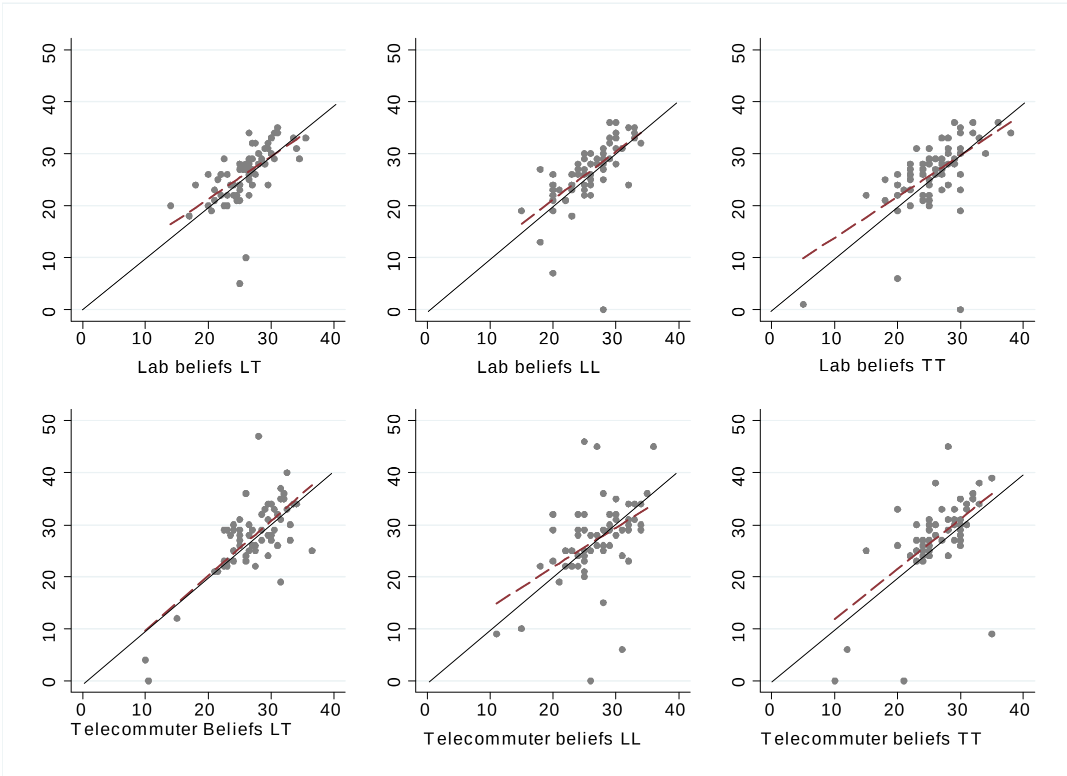

Figure 4.2: Scatterplot of average beliefs over partner productivity (x-axis) versus output (y-axis)

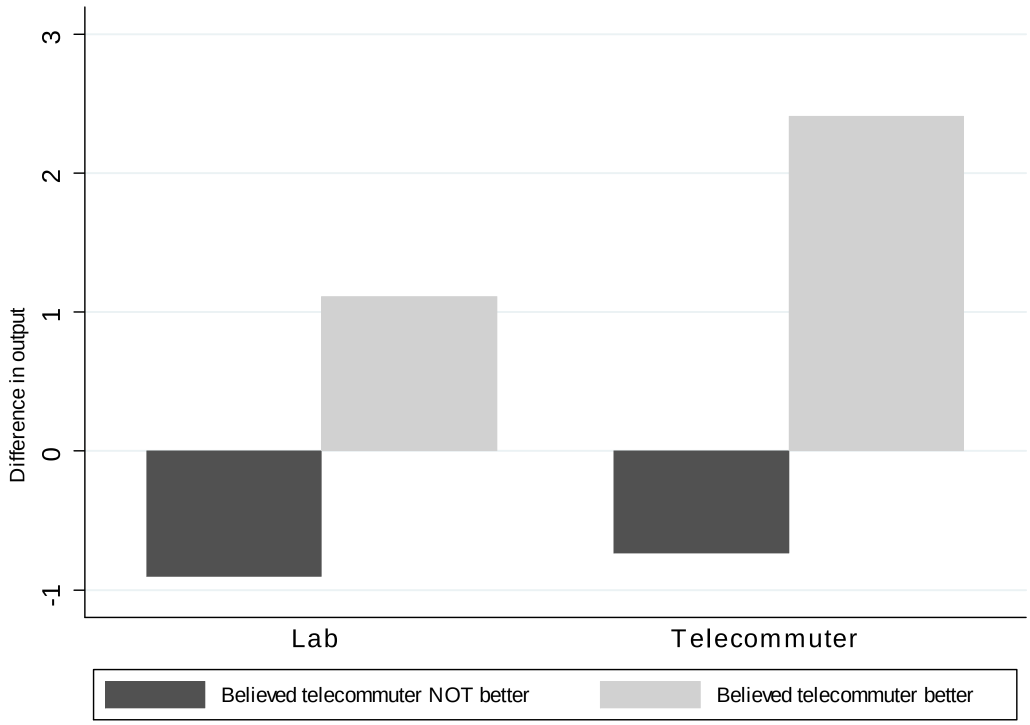

Figure 4.3: Correlation of beliefs with an increase in productivity when subjects are paired with telecommuting teammates (TT) versus when they are paired with non-telecommuters (LL).

the telecommuter was less productive (NOT better) and when subjects believed the telecommuter was more productive (better). The vertical axis represents the difference in a subject's output when paired with two telecommuting subjects versus when they were paired with two non-telecommuting subjects. Values above zero indicate that the subject produced more when paired with two telecommuters than when paired with two non-telecommuters while values below zero imply the opposite.

The graph shows that subjects who believed that telecommuters are better than their lab counterparts increased their output when paired with two telecommuters over what they produced when they were paired with two non-telecommuters. The reverse is true when subjects believed that telecommuters were not better. If a subject held beliefs that telecommuters were less productive than those in the lab, output in TT was below their productivity when they were paired with non-telecommuting teammates (LL). Notice that these results hold regardless of whether or not the subject was lab-based or a telecommuter.

For a more formal understanding of output decisions and how they relate to beliefs, we turn to regression analysis seen in Table 4.1. The dependent variable is the difference in output when a subject was paired with two telecommuters (TT) versus when they were paired with two lab subjects (LL), following what was previously shown in Figure 4.3. This variable ranges from -21 to 20, and is positive for 54% of the telecommuters. By contrast, it is only positive for 36% of non-telecommuters, which is significantly less than the telecommuters (ttest, p=0.034). This indicates that telecommuters were more likely to increase their productivity when paired with telecommuters than their non-telecommuting counterparts. In line with what is shown in Figure 4.3 then, the main explanatory variables in the regression are the beliefs of their teammates output.

In Model 1, we use the differences in beliefs when a subject was paired with two telecommuters versus when they were paired with two non-telecommuting teammates (Difference in Beliefs).[14] In Model 2, we replace the beliefs difference with the separate beliefs a subject held about the productivity of their non-telecommuting teammates (Beliefs of Lab Teammates) and the beliefs of their telecommuting teammates (Beliefs of Telecommuting Teammates). The purpose of this specification is to determine which of the two sets of beliefs, the beliefs a subject held about their telecommuting teammates or the beliefs they held about their non-telecommuting teammates, were more important in explaining the variance in output. Model 3 adds an interaction of these two beliefs with location to explore if telecommuter or lab-based subjects differed in their behavior. In addition to these primary variables, we also include control variables for Home (=1 if the subject was a telecommuter and 0 otherwise), gender (Female = 1 if female and 0 if male), the difference in the number of tic-tac-toe games played, and a risk tolerance measure. Our risk measure is the gamble chosen in the Eckel-Grossman mechanism where lower

[14] We use the beliefs from the LL and TT treatments because these are the beliefs that should most influence the effort decisions in those treatments - our dependent variable - but, as previously noted, beliefs across treatments are highly correlated.

Difference in Output	(1)	(2)	(3)
Constant	−0.175 (0.907)	−1.264 (5.317)	−4.843 (4.359)
Difference in Beliefs	0.454*** (0.089)		()
Beliefs of Lab Teammates		−0.346*** (0.098)	−0.352** (0.150)
Beliefs of Lab Teammates×Home			0.011 (0.198)
Beliefs of Telecommuting Teammates		0.514*** (0.091)	0.520*** (0.122)
Beliefs of Telecommuting Teammates×Home			−0.014 (0.182)
Female	0.418 (0.624)	0.152 (0.622)	0.153 (0.627)
Home	1.120* (0.594)	0.999* (0.586)	1.072 (3.790)
Difference in Tic-Tac-Toe	−0.374*** (0.121)	−0.417*** (0.120)	−0.417*** (0.126)
Risk Measure (1-5)	−0.124 (0.209)	−0.037 (0.209)	−0.036 (0.210)
Observations	135	135	135
$R-squared$	0.262	0.293	0.293

Table 4.1: Regressions on the difference in correctly coded output when a subject was paired with two other subjects who were at home (TT) versus when they were paired with two other subjects who were in the lab (LL). Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

numbers correspond to higher risk aversion.

Notice that because the dependent variable is the output of a subject when paired with two telecommuters minus output when paired with two non-telecommuters, Figure 4.3 implies that there exists a negative correlation between the beliefs about lab subjects and this difference in output, and a positive correlation on the beliefs of telecommuters. In other words, the difference in output should become more negative as beliefs regarding the productivity of non-telecommuters become more positive since there is a positive relationship between beliefs and effort. Similar logic applies for the beliefs of telecommuter productivity.

From all models, it is evident that beliefs are highly correlated with output differences. In Model 1, we see that belief differences are strongly correlated with differences in output where the coefficient for the differences in beliefs is positive and significant at the 1% level. Turning to Model 2, it is confirmed that this correlation exists for both beliefs seen in the significant negative effect for Beliefs of Lab Teammates and the significant positive effect for Beliefs of Telecommuting Teammates. This means that subjects are reciprocating effort in response to their perceptions of partner productivity. Turning to Model 3, the non-significant effects on the interaction terms of beliefs×Home shows that the effects of beliefs are not influenced by the location of the subject.

Result 2: Individual effort is positively related to beliefs about their teammates' output.

	OLS	Probit
Constant	-0.213	-0.546
	(1.002)	(0.369)
Believed Telecommuter Shirked More	-1.472^{**}	-0.533^{**}
	(0.649)	(0.237)
Female	1.064	0.184
	(0.672)	(0.244)
Home	1.034	0.542^{**}
	(0.639)	(0.232)
Difference in Tic-Tac-Toe	-0.431^{***}	-0.136^{***}
	(0.129)	(0.051)
Risk Measure (1-5)	-0.085	0.068
	(0.225)	(0.083)
Observations	135	135
$R-squared$	0.146	

Table 4.2: In the OLS model, the dependent variable is again the difference in correctly coded output when a subject was paired with two other subjects who were at home (TT) versus when they were paired with two other subjects who were in the lab (LL). In the Probit model, the dependent variable is equal to 1 if the subject's output was higher when paired with two other subjects who were at home (TT) than when they were paired with two other subjects who were in the lab (LL). Standard errors in parentheses. *** p<0.01, ** p<0.05

For robustness, we re-ran Model 2 on various sub-samples and using different specifications. Specifically, we re-ran Model 2 for males, females, high productivity subjects, and low productivity subjects. We also used a probit regression in our robustness checks where the dependent variable is a binary indicator equal to 1 if the difference in output is negative. Though the measures differ some, the basic effect of a positive relationship between effort and beliefs still holds. For succinctness, we relegate this analysis to the Appendix.

We now turn our attention to which set of beliefs, telecommuter or non-telecommuter partner productivity, has a larger impact on an individual's effort. From Model 2 in Table 4.1, we can see that the size of the effect on beliefs about telecommuting teammates is larger than for lab teammates and a Wald test confirms that the difference is significant (p = 0.019). So, even though beliefs of both types of partners are important, we find that the beliefs of telecommuting partners impact output choices more than beliefs of lab partners.

Result 3: Beliefs of telecommuting partners are more influential in determining own output choices than beliefs of non-telecommuting partners.

From Result 2, we have established that the average subject in our setting is a conditional cooperator. Table 4.2 provides additional regressions to examine the conditional cooperation behavior in more depth. Conditional cooperation in our framework relies not only on the expected output of a teammate, but also on how that output was achieved; i.e., was the output when paired with telecommuters different due to the perceived difference in the amount of effort telecommuters were exerting (perceptions of shirking), or some other outcome measure such as ability or differences in access to better technologies?[15] We examine this question by including a new explanatory binary variable, Believed Telecommuter Shirked More, which is equal to 1 if a subject believed telecommuters would be more likely to shirk than non-telecommuters in the team treatments compared to the individual treatments.[16]

This contrasts with the Difference in Beliefs variable used in the previous regressions provided in Table 4.1 as the old variable only differenced beliefs between team treatments while this variable measures the perceived relative drop off in effort between the individual and team treatments. The benefit of this new variable is that it is able to isolate perceptions of shirking since ability and other exogenous factors like technology differences would be constant across the individual and team rounds. The first model is a standard regression that mirrors Model 2 from Table 4.1 in all ways except that our new beliefs variable replaces the previous beliefs measures. The second model uses a probit regression where the dependent variable is binary indicator equal to 1 if the difference in output between the team treatments is negative (a subject contributed more in LL than in TT).

From both regressions, we can see that having beliefs that telecommuters shirked more from the individual to the team phase significantly affected the differences in output. The marginal effect from the probit model (not reported here) indicates that if a subject believed a telecommuter shirked more, they were 20% less likely to contribute more in TT than in LL.

5. Conclusion

In this research, we address a fundamental question for managers: How does telecommuting influence the individual effort exerted in teams? Answering this question is vital since managers still have reservations about allowing their employees to work outside the office. We focus on teams because the additional free-riding incentives present in work performed in a group compounds fear that the telecommuting environment fosters shirking behavior.

In order to provide more relevant policy recommendations, we also set out to answer, not just if, but why productivity may vary when someone moves from working in a traditional office-based team to a telecommuting team. To answer this, we designed an experiment which randomly assigned subjects to participate in either the laboratory at a specified time, or online in a location and time of their choice. They were asked to perform a paid real-effort task in teams of three where treatments varied the number of telecommuters. The participants were also asked to estimate the output of their non-telecommuting and telecommuting partners of the previous rounds as a measurement of beliefs. We incentivized this portion of the experiment so that correct and near-correct answers received a relatively high payoff, ensuring the accuracy

[15] Note that because we randomized our experiment, there should be no differences due to perceived ability, nonetheless, there could be differences due to other factors.

[16] More precisely, this variable is calculated by looking at the differences in beliefs a subject had of a telecommuter and non-telecommuter when they moved from the individual stage to the team stages. If a subject believed a non-telecommuter would increase their output more than a telecommuter, this variable is equal to 1.

of these beliefs.

The central result of our study is that we observe significant variation in the effort of individuals when they are partnered with telecommuters versus when they are partnered with non-telecommuters, and this is driven primarily by an individual's beliefs over their partners' productivity. The majority of participants - telecommuters and non-telecommuters alike - believed that telecommuters were less productive. The effort observed across treatments was found to be positively related to these beliefs, which provides an explanation for why individuals may be less productive when they are in a telecommuting team.

This paper has two main implications for managers currently managing telecommuters or considering implementation of a telecommuting policy. First, we do not find evidence of exaggerated shirking by telecommuters in teams. Second, we do find that the majority of individuals (including telecommuters) believe telecommuters are more likely to shirk and many reduce their relative work effort in response. Consequently, teams that include at least one telecommuter would benefit from manager reinforcement that all team members are contributing high effort to maintain high effort levels across all workers.

In addition to the telecommuting environment, these results tie into the literature on team production modeled in a public goods framework (Dickinson and Isaac, 1998; Croson, 2001; van Dijk, Sonnemans, and van Winden, 2001) and parallel earlier work on conditional cooperation in a chosen effort setting (Keser and Van Winden, 2000; Fischbacher et al., 2001). We confirm the robustness of conditional cooperation in a real-effort environment where we find that individuals who contributed less (more) effort to the paid task believed their teammates also contributed less (more) effort to the paid task.

Our study is an initial investigation into how individuals respond to the presence of telecommuters when working in teams. By design, the work environment we examine is stark with limited feedback and interaction between partners. This deliberate choice was made to avoid confounding factors in our results, but at a cost of realism. We also purposefully chose a mundane task, instead of a task where more creativity would be involved, to increase the attractiveness of shirking so that this study would be able to serve as a baseline for behavior in telecommuting teams. Future research should extend the environment with (possibly repeated) interaction between partners, feedback to teammates about performance, and task variety.

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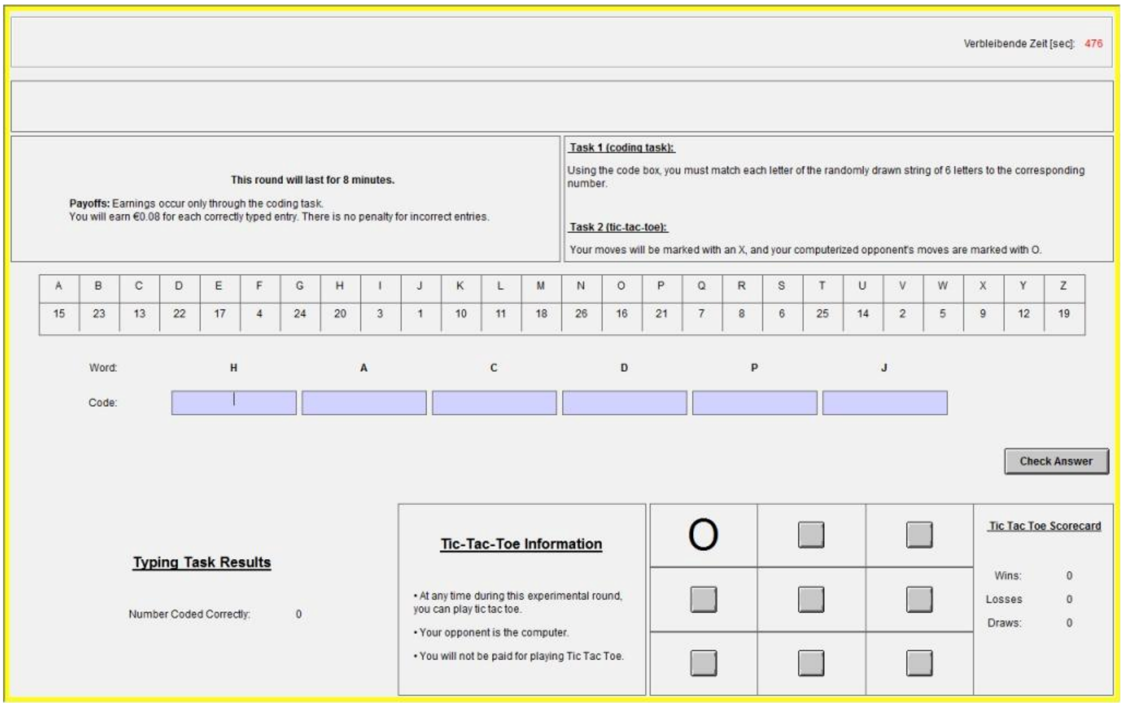
Appendix

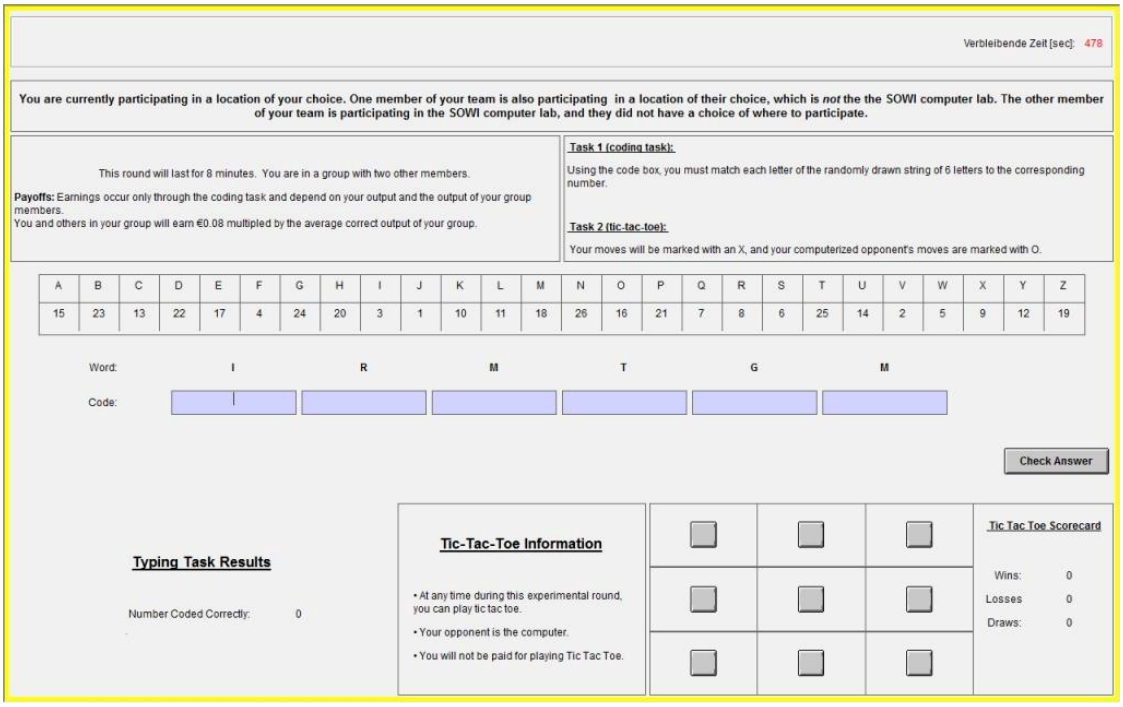
Robustness Checks

Difference in Output	Female	Male	Lower Productivity	Higher Productivity	Probit
Constant	−4.636 (3.206)	−2.884 (3.042)	−6.461** (2.676)	−5.300 (4.409)	−0.863 (0.864)
Beliefs of Lab Teammates	−0.177 (0.122)	−0.614*** (0.161)	−0.281** (0.129)	−0.315* (0.176)	−0.144*** (0.042)
Beliefs of Telecommuting Teammates	0.340** (0.131)	0.727*** (0.136)	0.558*** (0.107)	0.485*** (0.167)	0.152*** (0.041)
Home	1.191 (0.759)	0.722 (0.922)	1.794** (0.788)	0.313 (0.883)	0.631*** (0.243)
Female			−0.760 (0.845)	0.923 (0.926)	−0.017 (0.252)
Difference in Tic-Tac-Toe	−0.347** (0.158)	−0.460** (0.184)	−0.355*** (0.125)	−0.732** (0.334)	−0.141** (0.054)
Risk Measure (1-5)	0.010 (0.263)	−0.069 (0.343)	−0.136 (0.274)	0.030 (0.320)	0.071 (0.087)
Observations	74	61	68	67	135
$R-squared$	0.166	0.421	0.453	0.182	

Table 5.1: Regressions re-running Model 2 . Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Screenshots





Experimental Instructions

Introduction:

Thank you for participating in today's experiment. These instructions explain the nature of today's experiment as well as how to work the computer interface you will be using.

These instructions are complex, please make sure you read through them carefully. The instructions and stages of the experiment are self-paced, so when you have finished and a "Continue" button is available, please press it.

General Description:

This is an experiment on the economics of decision making where you will have the chance to earn money based on the decisions made by you and others. You should be able to complete the entire experiment on your own without any external assistance of any kind.

You will have the opportunity to make money during today's experiment, which consists of four, 8-minute rounds. Because of the nature of the experiment, your payment cannot be immediately calculated. More detailed instructions for how you can pick up your cash payment for participation today will be given at the end of the experiment.

All payments are confidential; no other participant will be told the amount you make.

Tasks:

In each round, you will be able to choose between two tasks. You can split your time among the tasks however you choose. Meaning you can spend all of your time on task I and none on task II, all of your time on task II and none on task I, or some combination of task I and task II, or neither.

Please press "Continue" to see an example of the tasks you will be presented with in each round.

Task 1:

For task I, a string of 6 random letters is displayed below a code bar. The code bar will link a series of letters with a corresponding number. Your task is to find the corresponding number associated with the letters and type it in the space provided. Once you are satisfied with your answer, you will hit the "check answer" button to submit your answer. For each correctly coded string, you will receive €0.08.

The example below shows you the layout of the game. After you submit a code correctly, the code bar will change and a new set of random letters will appear

In this example, the correct code would be 10 17 12 11 22 17. You would get credit for this answer by typing each number in the box below each letter which corresponds to this number in the code bar. However, because this is an example, the "Check Answer" button is non-functioning. During the actual experiment, you would submit your answer with the "Check Answer" button.

Please press Continue to see an example of the second task you will be presented with in each round.

Task 2:

In task II, you will be playing a game against the computer. The game is commonly known as tic-tac-toe. There are nine spaces in which to either put an X or an O. The X represents your choice, while the O represents the computer's choice. You will win the game when you have three X's in a row.

You will be able to track your wins and losses against the computer. You will not be paid for playing tic-tac-toe.

Practice:

To familiarize yourself with the tasks and computer interface, you will be taken to a practice round. You will not be paid for this round, it is only for practice purposes. Please press continue to enter into the practice round.

When you have finished practicing the two tasks, you may continue whenever you are ready by clicking Continue.

Below, you will see an example screen of the screen you would see during a round. You will always have the ability to play both tasks in a round.

In the actual experiment, the left box will contain detailed information about how you will be paid while the right box will contain the summary instructions for both tasks.

Payoffs:

As explained previously, you will be presented with two tasks: the coding task and tic-tac-toe. For each correctly coded string in the coding task, you will receive €0.08. Incorrectly coded strings carry no penalty of payment. Tic-tac-toe is unpaid. Let's go through an example of how payoffs work.

Payment Example:

Assume in this round you correctly coded 35 strings of random characters in the allotted time. Since you will get €0.08 for each correctly typed entry, you would receive €2.80 for this round.

If on the other hand you correctly coded 30 strings of random characters in the allotted time, you would receive €2.40 for this round.

Timing:

The time remaining in each round will be displayed in the upper right corner of your screen. When the time limit of 8 minutes has expired, you will automatically be taken to a new screen with instructions on how to proceed. When you are ready, please click continue to enter into round 1.

New Instructions:

The tasks and time limit (8 minutes) in this round are the same as the previous round. However, there is an important change. The difference between this round and the previous round you played is that instead of playing as an individual, you will now be playing in a group of two others and your pay will now depend on your choices and the choices of two others. The others in your group will either perform the task in the SOWI Computer lab or in a location of their choice. More on the locations in a moment.

You will be randomly and anonymously matched with the others in your group. The other members of the group will be given the same two tasks that you are, and as before, the coding task is the only task paid, however, the way that the coding task is paid has changed.

New Payoffs:

In this round, you and the other 2 members of your group will accumulate group earnings equal to €0.08 for each correctly coded string your group solves, together. These group earnings will then be equally divided between you and the other two members of your group. In equation form, your payoff = [€0.08 * (your output + member 1's output +member 2's output)]/3

To understand how the team payment scheme differs from the individual payment scheme, please click "Continue" to see examples.

Group Payment Examples:

Suppose for example you solve 30 coding problems correctly (recall that tic-tac-toe is still unpaid) and the other two group members each solved 20 . You and the other two members of your group would now receive [€0.08 * (30+20+20)]/3 = €1.87, which is less than the payoff example previously given for the individual payment scheme where you contributed 30.

If, on the other hand, you solve 30 problems and the other two group members each solved 40, you and the other two members of your group would now receive [€0.08 * (30+40+40)]/3 = €2.94, which is more than the example of the individual payment scheme where you contributed 30.

As another example, suppose that you correctly solved 28 and the other two group members each solved 30. You and the other two members of your group receive [€0.08 * (28+30+30)]/3 = €2.35, which is less than in the example for the individual payment scheme where you contributed 30.

As a final example, suppose that you and the other two group members each solved 30 coding task problems correctly. You and the other two members of your group receive [€0.08 * (30+30+30)]/3 = €2.40, which is the same as in the example for the individual payment scheme where you contributed 30.

Group Member Information:

All choices are anonymous. The other members in your group will **never** be told your specific output, nor will they be told the amount that you played tic-tac-toe. Likewise, you will never be told the specific output of your group members or how much they played tic-tac-toe.

The only information you will be given about the other members of your group is where they will be participating. Similarly, the other members of your group will only know that you are participating in "the SOWI computer lab (“a location of your choice"). The members of your group are not necessarily participating today.

You are about to begin the next round, but before you begin, we will give you information about the location of the members of your group.

Location of the members of your Group:

You are currently participating in “the SOWI computer lab" ("a location of your choice"). The other members of your group are also participating in “the SOWI computer lab." (“a location of their choice, which is not the SOWI computer lab (for example, they may be participating from home on their personal computer).

When you are ready, please click continue to enter into the next round.

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E. Glenn Dutcher, Krista Jabs Saral

The impact of beliefs on effort in telecommuting teams

Abstract
The use of telecommuting policies remains controversial for many employers because of the perceived opportunity for shirking outside of the traditional workplace; a problem that is potentially exacerbated if employees work in teams. Using a controlled experiment, where individuals work in teams with varying numbers of telecommuters, we test how telecommuting affects the effort choice of workers. We .nd that differences in productivity within the team do not result from shirking by telecommuters; rather, changes in effort result from an individual.s belief about the productivity of their teammates. In line with stereotypes, a high proportion of both telecommuting and non-telecommuting participants believed their telecommuting partners were less productive. Consequently, lower expectations of partner productivity resulted in lower effort when individuals were partnered with telecommuters. Our results suggest that managers should actively engage in disseminating productivity in formation to their telecommuting team in order to avoid negative effects on productivity.

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