A Novel Computerized Real Effort Task Based on Sliders

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Abstract

In this note, we present a novel computerized real effort task based on moving sliders across a screen which overcomes many of the drawbacks of existing real effort tasks. The task was first developed and used by us in Gill and Prowse (American Economic Review, 2012). We outline the design of our "slider task", describe its advantages compared to existing real effort tasks and provide a statistical analysis of the behavior of subjects undertaking the task. We believe that the task will prove valuable to researchers in designing future real effort experiments, and to this end we provide z-Tree code and guidance to assist researchers wishing to implement the slider task.

Keywords: Real effort task, Slider task, Design of laboratory experiments, Learning and time effects, Individual heterogeneity.

JEL Classification: C90, C91.

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1 Introduction

Many experimental designs feature a costly activity. For example, subjects choose how much effort to exert when competing in a tournament (Bull et al., 1987), when producing output as part of a team (van Dijk et al., 2001), when responding to the wages set by an employer (Fehr et al., 1997) and when earning endowments which then form the starting point for a bargaining game (Burrows and Loomes, 1994).

There are two ways of implementing costly activities in a laboratory experiment: via a monetary cost function which mimics effort by specifying output as a function of how much money the subject contributes (Bull et al., 1987); and using a real effort task. The monetary cost function allows the experimenter full control over the cost of effort. In particular, the experimenter can control the extent of any convexity in the cost of the activity and can also determine how the cost varies over individuals and over any repetitions of the game. Increasingly, laboratory experiments have featured real effort tasks, such as (i) solving mazes (Gneezy et al., 2003), mathematical problems (Sutter and Weck-Hannemann, 2003) or word games (Burrows and Loomes, 1994); (ii) answering general knowledge questions (Hoffman et al., 1994); (iii) counting (Abeler et al., 2009), decoding (Chow, 1983) or entering (Dickinson, 1999) strings of characters; (iv) performing numerical optimization (van Dijk et al., 2001); and (v) filling envelopes (Konow, 2000), cracking walnuts (Fahr and Irlenbusch, 2000) or other physical tasks. The main advantage of using a real effort task over a monetary cost function is the greater external validity of the experiment, which increases with how closely exerting effort in the task replicates the exertion of effort outside of the laboratory.

In this note we present a novel and simple computerized real effort task which overcomes many of the drawbacks of existing real effort tasks. Our task, first developed and used by us in Gill and Prowse (2012), consists of a single screen containing a number "sliders" which subjects move to a specified position within an allotted time. We call this the "slider task". The slider task has since been used by us in Gill and Prowse (2010) and Gill et al. (2012), and by others in Hetzel (2010), Bonein and Denant-Boemont (2011), Cettolin and Riedl (2011), Eacret et al. (2011), Hammermann et al. (2011), Abeler and Jäger (2012), Djawadi and Fahr (2012), Doerrenberg and Duncan (2012a), Doerrenberg and Duncan (2012b), Dolan et al. (2012), Evdokimov and Rahman (2012), Fahr and Djawadi (2012), Fonseca and Myles (2012), Kimbrough and Reiss (2012), Monahan (2012), Riener and Wiederhold (2012), Brown et al. (2013), Das et al. (2013) and Riener and Wiederhold (2013).

Section 2 outlines the design of the task. Section 3 details the advantages of our slider task compared to existing real effort tasks. Section 4 provides a statistical analysis of the behavior of subjects undertaking our task. Section 5 contains a practical guide for researchers wishing to implement the slider task. Section 6 concludes. z-Tree code accompanying this paper can be used to create real effort laboratory experiments featuring the slider task.

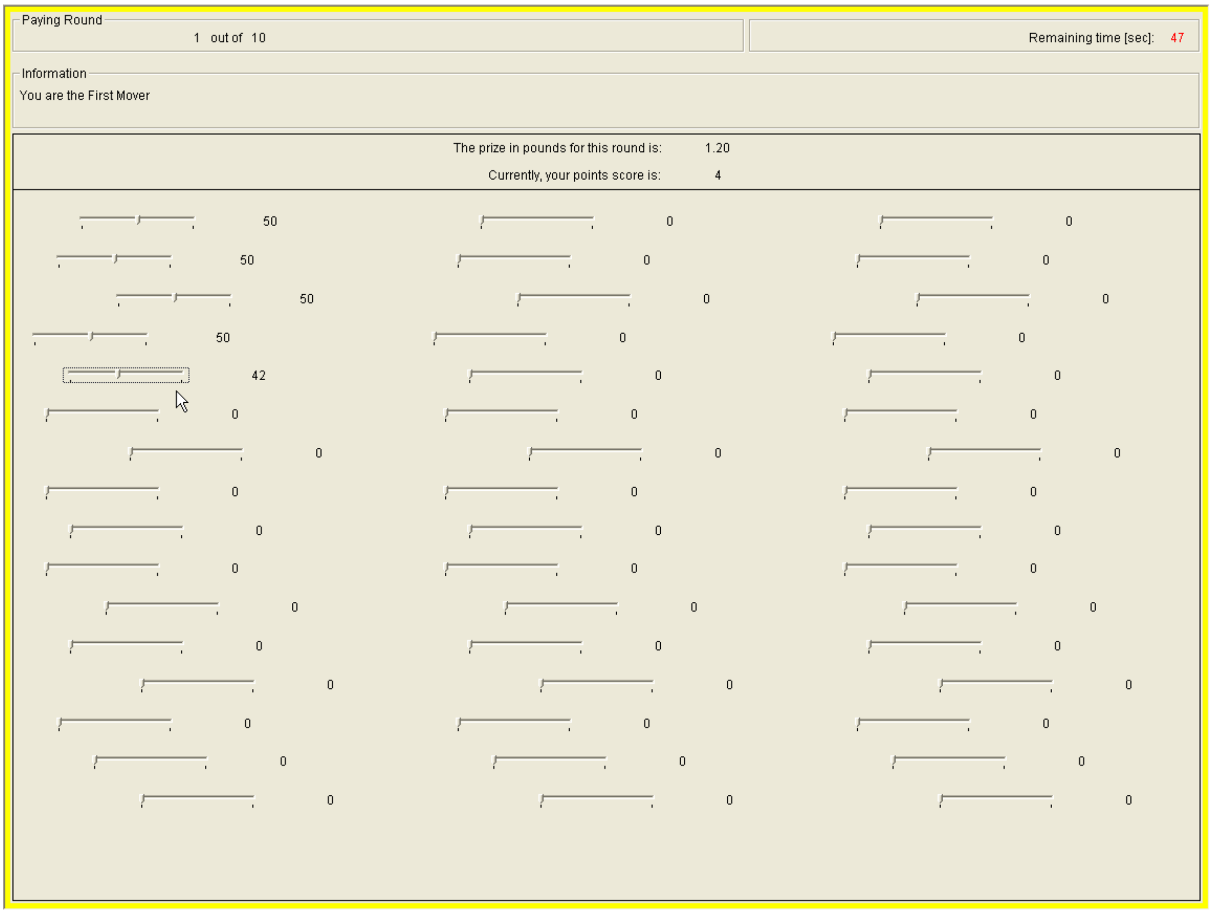
2 Design of the Slider Task

Our novel and simple real effort task consists of a single screen displaying a number of "sliders" programmed in z-Tree (Fischbacher, 2007). This screen does not vary across experimental subjects or across repetitions of the task. A schematic representation of a single slider is shown in Figure 1. When the screen containing the effort task is first displayed to the subject all of the sliders are positioned at 0, as shown for a single slider in Figure 1(a). By using the mouse, the subject can position each slider at any integer location between 0 and 100 inclusive. Each slider can be adjusted and readjusted an unlimited number of times and the current position of each slider is displayed to the right of the slider. The subject's "points score" in the task, interpreted as effort exerted, is the number of sliders positioned at 50 at the end of the allotted time. Figure 1(b) shows a correctly positioned slider. As the task proceeds, the screen displays the subject's current points score and the amount of time remaining.

(a) Initial position. (b) Positioned at 50.

Figure 1: Schematic representation of a slider.

Figure 2 shows a screen containing 48 sliders, as shown to the subject in the laboratory in Gill and Prowse (2012).



Note: The screen presented here is slightly squarer than the one seen by our subjects.

Figure 2: Screen showing 48 sliders.

In this example, the subject has positioned four of the sliders at 50 and a points score of 4 is shown at the top of the screen. A fifth slider is currently positioned at 42 and this slider does not contribute to the subject's points score as it is not correctly positioned. To ensure that all the sliders are equally difficult to position correctly, the 48 sliders are arranged on the screen such that no two sliders are aligned exactly one under the other. This prevents the subject being able to position the higher slider at 50 and then easily position the lower slider by copying the position of the higher slider. The number of sliders and task length can be chosen by the experimenter.

3 Advantages of the Slider Task

The slider task has a number of desirable attributes. First, the slider task is simple to communicate and to understand, and does not require or test pre-existing knowledge. Second, unlike solving mathematical problems, counting characters, solving anagrams, negotiating mazes or performing numerical optimization, the slider task is identical across repetitions. Third, the task involves little randomness, so the number of correctly positioned sliders corresponds closely to the effort exerted by the subject. Fourth, there is no scope for guessing, which complicates the design and interpretation of some existing tasks such as those based on counting characters or numerical optimization.

These attributes are also shared by the envelope filling task, in which subjects stuff real envelopes with letters. Crucially, however, the slider task provides a finely gradated measure of effort within a short time scale. In Section 4 we see that with 48 sliders and an allotted time of 120 seconds, measured effort varies from 0 to over 40. Thus substantial variation in behavior can be observed, and by getting subjects to repeat the identical task many times the experimenter can control for persistent unobserved heterogeneity using panel data methods. This allows robust statistical inference. For example, the experimenter can use repeated observations of the same subjects to estimate a distribution of effort costs, enabling structural estimation. The analysis in Gill and Prowse (2012) illustrates the use of such methods.

Thus the task's design overcomes the principal drawback of using real effort up to now, namely that "Since the experimenter does not know the workers' effort cost, it is not possible to derive precise quantitative predictions" (Falk and Fehr, 2003, p. 404). Furthermore, because the task is computerized, it is easy to implement and allows flexible real-time subject interactions.

4 Statistical Analysis of Behavior in the Slider Task

We used the slider task in 6 laboratory sessions conducted at the Nuffield Centre for Experimental Social Sciences in Oxford. Throughout, the slider task included 48 sliders (as shown in Figure 2) and the task length was 120 seconds. 20 subjects participated in each session.[1] At the beginning of every session half the subjects were told that they would be a "First Mover" and the other half told they would be a "Second Mover" for the duration of the session. At the beginning of each round, every First Mover was anonymously paired with a new Second Mover using the no contagion algorithm of Cooper et al. (1996). A prize for each pair was randomly chosen between £0.10 and £3.90 and revealed to the pair members. The First and Second Movers then completed the slider task sequentially, with the Second Mover discovering the points score of the First Mover she was paired with before starting the task. The prize was then awarded to one pair member based on the relative points scores of the two pair members and some element of chance.[2] In total we have data on 60 First Movers and 60 Second Movers, each observed during 10 rounds. For the purposes of analyzing behavior in the slider task, we look only at the behavior of the First Movers.[3]

[1]All the sessions were conducted on weekdays at the same time of day. The subjects were students who did not report Psychology or Economics as their main subject of study. The sliders were displayed on 22 inch widescreen monitors with a 1680 by 1050 pixel resolution. To move the sliders, the subjects used 800 dpi USB mice with the scroll wheel disabled. The experimental instructions can be found in Appendix C of Gill and Prowse (2009).

[2]The probability of winning the prize for each pair member was 50 plus her own points score minus the other pair member's score, all divided by 100. In addition to any prizes accumulated during the experiment, all subjects were paid a show-up fee of £4. The subjects also initially played 2 practice rounds against an automaton for which they were not paid. We do not include the practice rounds in the data analysis.

[3]Gill and Prowse (2012) analyzes interactions between the efforts of the First and Second Movers.

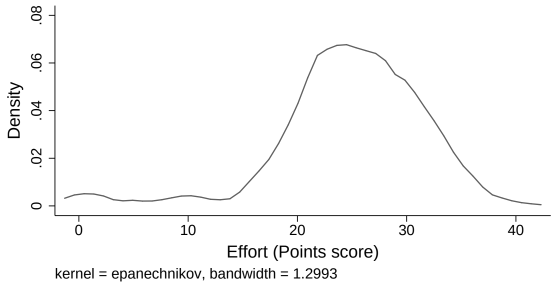
Table 1 summarizes the observed efforts of the First Movers in each of the 10 rounds.

Round	Obs.	Mean Effort	Median Effort	Minimum Effort	Maximum Effort
1	60	22.20 (6.07)	23	1	33
2	60	22.68 (6.66)	23.5	0	33
3	60	24.80 (6.03)	25.5	0	37
4	60	24.61 (5.90)	25	0	35
5	60	25.18 (6.94)	26	0	38
6	60	24.66 (7.45)	26	1	37
7	60	25.91 (5.81)	26	9	37
8	60	26.88 (5.82)	27	9	41
9	60	25.65 (8.48)	28	0	38
10	60	26.31 (6.72)	27	1	40

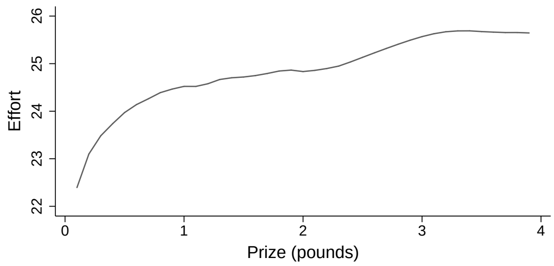
Table 1: Summary of First Movers' efforts by round.

We see that the mean points score tended to increase over the 10 rounds, from an average of 22.2 sliders in the first round to 26.3 sliders in the final round. Given the average prize was constant over rounds, this increase in effort is interpreted as a learning-by-doing effect. The maximum observed effort was 41 and therefore it appears that no subject was able to position correctly all 48 sliders in 120 seconds. We conclude that efforts were not constrained by the upper limit imposed by the design of the task. There are 7 observations of 0s. Of these, 5 correspond to two subjects who appear to have had difficulty positioning sliders at exactly 50 until a few rounds into the session. The remaining two observations of 0 correspond to a further two subjects who chose to exert no effort towards the end of their session in response to low prizes of £0.10 and £0.30.

Figure 3(a) shows the distribution of points scores. We see a substantial amount of variation in behavior. Specifically, a small cluster of subjects have zero or very low efforts, two-thirds of efforts lie between 20 and 30 inclusive, while around 20% of efforts exceed 30. Thus, despite subjects having only 120 seconds to complete the slider task, we see large differences in observed efforts. Figure 3(b) shows the results of a Lowess regression of the First Movers' efforts on the prize. We see that effort is increasing in the prize, particularly at low prizes. This provides evidence that subjects respond to financial incentives when completing the slider task.



(a) Distribution of efforts.



(b) Response of effort to the prize.

Figure 3: Graphic analysis of First Movers' efforts.

Table 2 presents the results of a sequence of fixed effects regressions of First Movers' efforts on the prize and round number. In Model (1) the First Movers' efforts were regressed on a linear time trend. Time effects are significantly positive. In Model (2) a full set of time dummies is included. The F statistic for the null hypothesis that the time trend is linear is 3.17 which corresponds to a p value of 0.0048. Thus time effects are non-linear. However, we are unable to reject linearity of the time effects starting from round 4: the F statistic for the null hypothesis that the time trend is linear from round 4 onwards is 1.61 with a p value of 0.1595. In model (3) the prize is included as an additional control. We see that the First Movers' efforts increase significantly in the prize, with a £1 increase in the prize causing an increase in effort of 0.7 of a slider.[4] In all the models, persistent unobserved individual effects account for about 75% of the unobserved variation in performance.

To summarize the analysis, we observe a considerable degree of heterogeneity in behavior, subjects respond positively to the value of the prize and efforts tend to increase over time.

[4]An additional regression, not reported, shows that there is no evidence of the square of the prize being a significant determinant of effort. Thus effort appears to be linear in the prize.

	(1)	(2)	(3)
Prize	-	-	0.671*** (0.157)
Round number	0.434*** (0.084)	-	-
-	-		
Round 2	-	0.483 (0.557)	0.404 (0.540)
Round 3	-	2.600*** (0.545)	2.498*** (0.565)
Round 4	-	2.417*** (0.562)	2.286*** (0.567)
Round 5	-	2.983*** (0.694)	2.823*** (0.682)
Round 6	-	2.467*** (0.797)	2.481*** (0.766)
Round 7	-	3.717*** (0.540)	3.694*** (0.516)
Round 8	-	4.683*** (0.686)	4.676*** (0.682)
Round 9	-	3.450*** (1.079)	3.482*** (1.044)
Round 10	-	4.117*** (0.754)	4.355*** (0.767)
Intercept	21.630*** (0.627)	22.200*** (0.466)	20.894*** (0.508)
σ_α	5.494	5.494	5.491
σ_ϵ	3.971	3.938	3.873
Observations	600	600	600
Subjects	60	60	60

Notes: σ_α denotes the standard deviation of the time invariant individual specific fixed effects and σ_ϵ is the standard deviation of the time varying component of the individual level error terms. Significance at the 10%, 5% and 1% levels is denoted by *, ** and ***.

Table 2: Fixed effects regressions for First Movers' efforts.

5 A Practical Guide to Using the Slider Task

This Section provides a guide to researchers wishing to implement the slider task in the context of their own laboratory experiments. Following some short comments pertaining to the preferred citation and important disclaimers, we describe the accompanying code, which allows researchers to implement easily the slider task in z-Tree. Finally, we list some practical considerations associated with the use of the slider task.

Citation

The slider task was developed and first used in an earlier paper of ours, Gill and Prowse (2012).[5] Should you use this real effort task, or otherwise want to refer to the slider task, we kindly request that you include the following citation:

Gill, D. and Prowse, V. (2012). 'A Structural Analysis of Disappointment Aversion in a Real Effort Competition.' *American Economic Review*, 102, 469–503.

Furthermore, if you implement the slider task by using or modifying our z-Tree code, we kindly request that you include the following statement in your paper:

"The code implementing the slider task is based on the code developed by Gill and Prowse (2012)."

Disclaimer

The accompanying file, named GillProwseSliderExample.ztt, provides an implementation of the real effort slider task used in Gill and Prowse (2012). The code we provide comes with no warranty or guarantee. In providing this code we take no responsibility with regard to the use or modifications of the code.

Programs and Code

The code is available from the authors upon request, and can also be downloaded direct from the website of Victoria Prowse.

The code provided takes the form of a .ztt file and should be run in z-Tree. The code consists of a single file, named GillProwseSliderExample.ztt. This is a z-Tree treatment file. The program implements the slider task for a single subject, with the number of rounds set to one. This code can easily be embedded into an experimental design in which a real effort task is required. Indeed, this is the exact real effort task used in the repeated sequential-move

[5] We also use the slider task in Gill and Prowse (2010) and Gill et al. (2012). The Introduction lists a number of other studies that have used the slider task.

tournament of Gill and Prowse (2012).[6] The treatment GillProwseSliderExample.ztt consists of three stages:

Stage 1 The subject is shown a screen informing her that the task is about to start. This screen is displayed for 5 seconds and then the program automatically moves to stage 2.

Stage 2 The subject is shown a screen displaying 48 sliders. The round number and the remaining time are shown at the very top of the screen, and between this information and the sliders there is a banner displaying the subject's current points score, i.e., the number of sliders currently positioned at exactly 50. This screen is displayed for 120 seconds and then the program automatically moves to stage 3.

Stage 3 The subject is shown a screen displaying her points score in the task. This screen is displayed for 20 seconds and then the program automatically ends.

We now give some more detail about this treatment. Prior to the treatment commencing a number of variables are created in the Background. First, the variable `Effort` is created. At any point during the treatment this variable equals the number of sliders currently positioned at exactly 50. Second, we create a set of 48 variables, denoted `qx` for `x` $= 1, ..., 48$. The variable `qx` is the current position of the x^{th} slider. Third, we create the variables `sx` for `x` $= 1, ..., 48$. The variable `sx` takes the value one if the current position of the x^{th} slider is equal to 50 and zero otherwise. All variables are initialized to zero.

Each time the position of a slider is adjusted the values of `qx` and `sx` associated with the particular slider in question are updated. The value of `Effort` is then updated, and the banner at the top of the screen is then refreshed to display the Subject's new points score. The values of all the variables at the end of the 120 second task are stored in the Subjects table, and can be accessed at later stages.

Practical Advice and Guidance

Screen Size

The average time taken to position a slider at exactly 50 depends on the size of the screen on which the task is displayed. We used relatively large screens, specifically 22 inch widescreen monitors with a 1680 by 1050 pixel resolution. 48 sliders and a 120 second task length was an appropriate configuration given the hardware employed, but may need adjusting if run on a different set-up. We believe that with our configuration it is impossible for any subject to position correctly all of the sliders (see Section 4). This ensures that the subject's effort choice is not constrained by the design of the task, so there is no incentive to work hard for the purpose of being able to rest at the end of the task.

[6]The code is the same as used by Gill and Prowse (2012) for the First Movers, except that the number of rounds has been set to one, the banner informing the subject that she is a First Mover has been removed and the line informing the subject of the prize for the round has also been removed.

Mice and Keyboards

To treat all subjects equally, they should use the same specification of mouse. Our subjects used 800 dpi USB mice with the scroll wheel disabled (by removing them from the mice) to prevent subjects from using the scroll wheel to position the sliders.[7] (Using the scroll wheel makes positioning the sliders much easier and requires less effort than a dragging and dropping technique using the left mouse button). Similarly, the keyboards were also disabled (by unplugging them) to prevent the subjects using the arrow keys to position the sliders. As well as dragging and dropping, it is possible to move the sliders in large fixed discrete steps by clicking the left mouse button with the cursor to the right or left of the current slider position. We did not point this out explicitly to our subjects, but told them that they could use the mouse in any way they liked to move the sliders.

Physical Space and Other Environmental Factors

Given subjects are being asked to complete a real effort task it is important that they all have the same amount of physical space, i.e., all the booths are the same size, and that all subjects have the same equipment, e.g., mouse mats, chairs etc.

Practice rounds

Practice rounds, with the opportunity for questions at the end of each round, are recommended to allow subjects to become familiar with the task. We used two practice rounds. Data from the practice rounds and the paying rounds indicate that this was sufficient practice. Specifically, after two practice rounds the round-on-round increase in effort was similar across rounds.

6 Conclusion

In this note we have described a computerized real effort task designed to overcome some of the drawbacks of existing real effort tasks. In particular, our slider task provides a finely gradated measure of performance and can be repeated many times in an experimental session. This allows the experimenter to control for persistent unobserved heterogeneity, allowing robust statistical inference. We believe that the slider task is a valuable addition to the stock of existing real effort tasks which will prove useful to researchers designing future real effort experiments. We have provided z-Tree code and guidance notes designed to assist researchers wishing to implement the slider task in the laboratory.

[7] Christopher Zeppenfeld (Cologne Graduate School) has kindly informed us that it is also possible to use an AutoHotKeys script in conjunction with z-Tree to disable the scroll wheel.

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