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The Interaction between Financial Incentives and Task-specific Cognitive Capital: More Evidence in Support of Camerer and Hogarth (1999)†

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Abstract

This paper extends existing evidence on the interaction between financial incentives and cognitive capital. I focus on the impact of task-specific cognitive capital, the role of which is central to the capital-labor-production framework of Camerer and Hogarth (1999) and has long been studied in cognitive science and behavioral decision research. Using a task situated in an accounting setting, I show that both financial incentives and task-specific cognitive capital, and especially their interaction, matter for performance. In particular, the effect of task-specific cognitive capital on performance is stronger under performance-based financial incentives as compared to flat-rate incentives. The interaction effect arises because performance-based financial incentives lead to better performance only for individuals with more task-specific cognitive capital. I draw implications for compensation practices in experiments as well as work settings.

Keywords: Financial incentives, Cognitive abilities, Experiments, Field experiments

JEL classification: C81; C91; C93; D83

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1. Introduction

In an attempt to portray how financial incentives induce performance in cognitively demanding tasks, Camerer and Hogarth (1999) propose a capital-labor-production framework. The authors informally describe how financial incentives may interact in non-trivial ways with intrinsic motivation in stimulating cognitive effort (labor), and how the productivity of cognitive effort may in turn vary across individuals due to their different cognitive abilities (capital).

To date, however, there is sparse empirical evidence on the relative importance of cognitive capital and effort as inputs of cognitive production. In fact, due to the complexity of measuring cognitive effort (see, e.g., Camerer and Hogarth, 1999), the existing empirical accounts of the capital-labor-production framework focus on the reduced-form interaction between financial incentives and cognitive capital. Awasthi and Pratt (1990) and Palacios-Huerta (2003) show that introducing and/or raising performance-based financial incentives yields a larger increase in judgmental performance for individuals with higher cognitive capital, as proxied by a perceptual differentiation test and schooling outcomes, respectively.[1] Rydval and Ortmann (2004) illustrate that cognitive capital appears at least as important for performance in an IQ test as does a sizeable variation in piece-rate financial incentives.

In this paper, I extend the above evidence by focusing on the interaction between financial incentives and more *task-specific*, as opposed to domain-general, forms of cognitive capital. The role of task-specific cognitive capital in cognitive production is central to the capital-labor-production framework of Camerer and Hogarth (1999) and has been extensively studied in cognitive science and behavioral decision research (see, e.g., Anderson, 2000, Libby and Luft, 1993, and Bonner and Sprinkle, 2002, for reviews).

Using a task situated in an accounting setting, I show that both financial incentives and task-specific cognitive capital, and especially their interaction, matter for performance. In particular, the effect of task-specific cognitive capital – proxied by accounting knowledge – on performance

[1] Awasthi and Pratt (1990) also illustrate that effort duration increases uniformly with the introduction of piece-rate financial incentives, quite regardless of their subjects' cognitive capital (i.e., perceptual differentiation test score).

is stronger under performance-based financial incentives as compared to flat-rate incentives. The interaction effect arises because performance-based financial incentives lead to better performance only for individuals with more accounting knowledge. I draw implications for further research of the capital-labor-production framework and for compensation practices in experiments as well as work settings.

2. The task and experimental design

To illustrate the effect of task-specific cognitive capital and its interaction with financial incentives, I use data from an earlier experimental study by Libby and Lipe (1992). Their experiment is a computerized memory task in which subjects are asked to memorize and subsequently recall a list of accounting items – specifically, sentence-long expressions used by accountants in the internal control/audit system.[2]

Libby and Lipe study the effect of introducing performance-based financial incentives on recall performance. They randomly split the subjects – 117 accounting and auditing students – into three incentive treatments. In the flat-rate (FLAT) treatment, subjects know from the start that they earn \$2 regardless of their recall performance. In the encoding (ENC) and retrieval (RETR) treatments, subjects additionally earn \$0.1 per each correctly recalled accounting item and can also earn a \$5 prize for the best five performers. In ENC, this performance-based incentive scheme is announced prior to memorizing (i.e., prior to encoding) of the accounting items, whereas in RETR, the scheme is announced only *after* memorizing (i.e., prior to retrieval) of the accounting items.[3]

Table 1 replicates the main results of Libby and Lipe.[4] *Recall* performance (the number of accounting items recalled correctly) varies considerably across individuals as well as across the incentive treatments. As noted by the authors, *Recall* exhibits a significantly increasing trend

[2] See Table 1 in Libby and Lipe (1992) for details.
[3] The FLAT treatment featured the \$5 tournament-type prize as well but the prize was announced only after the experiment. Overall, subjects could earn \$2-11.80 in ENC and RETR and \$2-7 in FLAT. The recall task was followed by another task (which subjects did not know until after completing the recall task). See Libby and Lipe (1992) for further implementation details that appear innocuous with respect to the results presented here.
[4] Apart from one missing observation (subject), my dataset is identical to that analyzed in Libby and Lipe (1992).

from FLAT to RETR to ENC, with the averages being 9.80, 11.61 and 12.34 items, respectively. *Recall* is significantly higher on average in ENC compared to FLAT (at the 5% level using a *t*-test and a Wilcoxon rank-sum test) but there is no significant difference in *Recall* between RETR and ENC. Hence the differential timing of announcing the performance-based incentive scheme does not seem to affect *Recall* performance on average.

Table 1 also displays two proxies for effort duration: *Tmemo* denotes the time spent memorizing the accounting items, and *Trecall* denotes the time spent recalling the items. In ENC, announcing the performance-based incentive scheme prior to memorization leads to a significantly higher *Tmemo* compared to FLAT (at the 10% level using a *t*-test). In RETR, announcing the performance-based incentive scheme prior to recall leads to a significantly higher *Trecall* compared to FLAT (at the 5% and 10% level using a *t*-test and a Wilcoxon rank-sum test, respectively).

Table 1 further contains two proxies for task-specific cognitive capital, namely accounting knowledge: *Courses* denotes the number of accounting credit hours taken by subjects, and *Experience* denotes the number of months of their auditing job experience. Although neither *Courses* nor *Experience* vary significantly across treatments, they both vary across subjects, potentially reflecting subjects' differential familiarity with the accounting items encountered in the memory task. Hence I compare the impact of accounting knowledge and financial incentives on *Recall* performance, as detailed below.

3. The effect of accounting knowledge and financial incentives on performance

To first illustrate the size of the impact of accounting knowledge on *Recall* performance, I split subjects into two groups. The High-K group contains subjects with above-median accounting education (*Courses*>21) *or* above-median auditing job experience (*Experience*>0), and vice versa for the Low-K group. The rationale for the split is that more accounting education is likely to be important for *Recall* performance but having any positive amount of auditing job experience substitutes for it.[5]

[5] A practical reason for the split is that it yields relatively balanced sample sizes for the High-K and Low-K groups in each incentive treatment. The results presented in Table 2 are robust, in the statistical

Table 2 displays the capital-based differentials, i.e., the differentials attributable to differences in accounting knowledge between the High-K and Low-K groups. Focusing first on *Recall* performance, the largest capital-based *Recall* differential reported in Table 2 arises in RETR, on average almost 7 correctly recalled accounting items, which is highly significant and more than twice the size of the largest incentive-based *Recall* differential between FLAT and ENC reported in Table 1. The capital-based *Recall* differentials in FLAT and ENC are insignificant and smaller than in RETR but are still comparable in size to the incentive-based *Recall* differentials. The last column of Table 2 shows that the capital-based *Recall* differential in the pooled sample is on average slightly above 3 accounting items, which is highly significant and similar in size to the largest incentive-based *Recall* differential reported in Table 1.[6] These findings generally confirm those of Rydval and Ortmann (2004) who likewise find capital-based performance differentials to be at least as important as incentive-based performance differentials.

Table 2 further shows that, in contrast to the positive and significant capital-based *Recall* differentials, the corresponding effort differentials in *Tmemo* and *Trecall* are insignificant and go in either direction. As Libby and Lipe caution, *Tmemo* and *Trecall* are noisy measures of effort duration, let alone effort intensity: *Tmemo* can be confounded by individual differences in reading speed and *Trecall* by differences in computer literacy (typing speed).[7] Nevertheless, Awasthi and Pratt (1990) similarly find that people with low and high cognitive capital do not differ in effort duration but do differ in judgmental performance.

Table 3 presents multivariate analysis that disentangles the impact of task-specific cognitive capital and financial incentives on *Recall* performance. In column (1), *Recall* is regressed on the proxies for accounting knowledge, *Courses* and *Experience*, while the treatment dummies, *RETR* and *ENC*, capture any remaining *Recall* differences in the incentive treatments with respect to FLAT. The estimates suggest that while *Recall* is significantly higher in both RETR and ENC

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significance sense, to alternative High-K / Low-K splits, for example those based only on the median of *Courses* (e.g., *Courses*≥21 or *Courses*>21). Other splits based on the *Experience* variable are problematic in terms of balancing the sample sizes since only 30% of subjects have auditing job experience.

[6] Note that the pooled capital-based *Recall* differential is unlikely to be driven by incentive effects, simply because the High-K group in the pooled sample contains a decreasing percentage of FLAT to RETR to ENC subjects. Admittedly, the pooled capital-based *Recall* differential is driven by the exceptionally large differential in RETR.

[7] Camerer and Hogarth (1999) discuss alternative measures of effort duration and effort intensity.

compared to FLAT, confirming the incentive-based differentials reported in Table 1, *Recall* also improves with higher *Courses* (significantly) and *Experience* (insignificantly), confirming the capital-based differentials reported in Table 2.

Column (2) further includes interactions of *Courses* with the incentive treatments (*Courses x RETR* and *Courses x ENC*). As a consequence, the treatment dummies and accounting knowledge proxies become insignificant. In columns (3) and (4), however, omitting the insignificant treatment dummies from the estimation reveals a significant interaction between *Courses* and the incentive treatments. Namely, the impact of *Courses* on *Recall* is almost twice as high in RETR and ENC compared to FLAT.[8]

Combining the evidence from all three tables, the incentive-based differentials in *Recall* performance (reported in Table 1) seem primarily driven by the stronger impact of accounting knowledge on *Recall* under performance-based financial incentives (as reported in Tables 2 and 3). Table 2 further suggests that this result is primarily due to subjects with more accounting knowledge responding stronger to performance-based financial incentives. Specifically, *Recall* of the High-K groups is significantly higher at the 5% level in both RETR and ENC compared to FLAT (using a *t*-test and a Wilcoxon rank-sum test). By contrast, *Recall* of the Low-K groups is statistically indistinguishable among FLAT, RETR and ENC.[9]

4. Discussion

In line with Camerer and Hogarth's (1999) capital-labor-production framework, task-specific cognitive capital in the form of accounting knowledge, and especially its interaction with

[8] Interactions of *Experience* with *ENC* and *RETR* as well as higher-order moments of *Courses* and *Experience* turn out individually and jointly highly insignificant and hence are not included in any of the estimations in Table 3. Libby and Lipe's (1992) dataset unfortunately does not contain any other observable characteristics such as demographics (with the exception of age which is nevertheless strongly correlated with *Courses*) that would permit controlling for sample composition differences. Libby and Lipe report a Pearson correlation of 0.44 between *Recall* and subjects' auditing course grade but the latter data is not available for further analysis. Observing the strong correlation, Libby and Lipe speculate that the impact of introducing performance-based financial incentives on *Recall* performance may depend on the decision maker's accounting knowledge base. The conjecture that "incentive-induced effort may interact with knowledge" is revisited in Libby and Luft (1993, p.443) but is not subject to closer empirical scrutiny.

[9] I should note, however, that the *difference* in the responsiveness of the Low-K and the High-K groups to announcing performance-based incentives is not significant (using a parametric *t*-test).

financial incentives, seem important determinants of *Recall* performance in the memory task. Specifically, the effect of accounting knowledge on *Recall* performance is stronger under performance-based financial incentives as compared to flat-rate incentives. The interaction effect seems to arise because performance-based financial incentives lead to better performance only for individuals with more accounting knowledge.

The above evidence of the positive interaction between incentives and task-specific cognitive capital bears close resemblance to the findings of Awasthi and Pratt (1990) and Palacios-Huerta (2003) who use more domain-general cognitive capital proxies. As in the case of Palacios-Huerta, however, it warrants further investigation to determine whether the positive interaction is predominantly due to the piece-rate or the tournament part of the performance-based incentive scheme.

To the extent that Libby and Lipe's (1992) dataset is relatively small and does not contain potentially important individual characteristics that would permit accounting for sample composition differences, the evidence presented above should be viewed as suggestive only. One would ideally account for the impact of other forms of cognitive capital related to the memory task, such as short-term and working memory (e.g., Kane et al., 2004). Subjects' responsiveness to financial incentives might also be influenced by their ex ante intrinsic motivation to engage in the memory task (e.g., Cacioppo et al., 1996). Another general concern is whether subjects better equipped with task-specific cognitive capital are in some sense "smarter" before they acquire it. Such endogeneity issues are implicitly discussed by LeDoux (2002) who argues that the process of cognitive capital development inevitably involves "nurturing nature," i.e., further developing inherited forms of cognitive capital.[10]

The interactions between financial incentives and cognitive, motivational and other personality characteristics underlie Camerer and Hogarth's (1999) capital-labor-production framework. Empirically disciplining the framework clearly requires not only identifying the relevant cognitive and motivational constructs but also thinking thoroughly about the structural relationships among them. Psychologists have argued that doing so may require attending not only to measurable, objective cognitive characteristics but also to their self-perceived, subjective

[10] See Plug and Vijverberg (2003) for an economic approach to the nature/nurture debate.

counterparts (e.g., Bandura and Locke, 2003). Taking even one step further, economists have questioned whether decision makers can intentionally manipulate their cognitive self-perception and whether that self-perception can be influenced by performance-based incentives (e.g., Benabou and Tirole, 2002, 2003). These and other literatures should serve as a rich source of possible identifying restrictions.

Camerer and Hogarth's (1999) capital-labor-production framework deserves much further research, and its potential implications for compensation practices in experiments and work settings are wide-ranging (see, e.g., Bonner and Sprinkle, 2002). Consider, for example, the evidence discussed above suggesting that performance-based financial incentives tend to induce greater effort duration regardless of cognitive capital but lead to better performance only for individuals with more cognitive capital. As a consequence, efficiently using performance-based financial incentives may involve directing their impact predominantly at high-capital individuals in experimental subject pools or in company workforce, in order to maximize performance outcomes and minimize effort resource costs.

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Table 1: Summary statistics for the pooled sample and the incentive treatments

Treatment # subjects	POOLED 117	FLAT 41	RETR 38	ENC 38
Recall	11.21 (5.46) [1-23]	9.80$^{t^*r^*}$ (4.17)	11.61 (5.57)	12.34$^{c^*}$ (6.33)
Tencoding (in seconds)	345.75 (198.97) [63-1349]	307.44^{t} (127.38)	345.74 (210.03)	387.11 (243.08)
Trecall (in seconds)	739.57 (366.53) [77-1675]	662.59 (313.99)	841.26$^{t^*r}$ (432.89)	720.95 (331.18)
Courses	20.29 (4.44) [6-30]	20.49 (3.96)	20.05 (5.18)	20.32 (4.24)
Experience	0.85 (1.41) [0-6]	0.78 (1.29)	0.87 (1.60)	0.89 (1.37)

Notes: The POOLED column displays the mean and beneath it the standard deviation (in parentheses) and the range (in brackets) for the pooled sample. The FLAT, RETR and ENC columns display the mean and beneath it the standard deviation (in parentheses) for the three incentive treatments. The t and t* superscripts denote a significant difference at the 10% and 5% level, respectively, between the relevant treatment and the treatment immediately to the left (except for FLAT which is compared to ENC), using a two-sided *t*-test accounting for unequal variances whenever appropriate. Analogously, the r and r* superscripts denote a significant difference at the 10% and 5% level, respectively, using a two-sided Wilcoxon rank-sum test. The c and c* superscripts denote a significantly increasing trend at the 10% and 5% level, respectively, from FLAT to RETR to ENC, as indicated by a non-parametric test for trend across ordered groups developed by Cuzick (1985). The latter two tests incorporate correction for ties.

Table 2: Summary statistics for the Low-K and High-K groups

Treatment	FLAT		RETR		ENC		POOLED	
# subjects	Low-K(15)	High-K(26)	Low-K(15)	High-K(23)	Low-K(16)	High-K(22)	Low-K(46)	High-K(71)
Recall	8.93 (4.79)	10.31 (3.77)	7.53 (4.37)	14.26$^{t^*r^*}$ (4.61)	11.13 (6.22)	13.23 (6.41)	9.24 (5.31)	12.49$^{t^*r^*}$ (5.20)
Tmemo	342.67 (146.81)	287.12 (112.77)	344.20 (302.43)	346.74 (126.42)	417.38 306.79)	365.09 (188.86)	369.15 (260.39)	330.59 (146.38)
Trecall	711.93 (377.77)	634.12 (274.81)	805.07 501.54)	864.87 (391.93)	645.50 (329.87)	775.82 (328.68)	719.20 (404.15)	752.77 (342.32)

Notes: The FLAT, RETR and ENC incentive treatments and the POOLED sample are sub-divided into the Low-K and High-K groups as defined in Section 2 (number of subjects in parentheses). Each cell displays the mean and beneath it the standard deviations (in parentheses). The t and t* superscripts denote a significant difference at the 10% and 5% level, respectively, between the sub-divided High-K and Low-K groups, using a two-sided *t*-test accounting for unequal variances whenever appropriate. Analogously, the r and r* superscripts denote a significant difference at the 10% and 5% level, respectively, using a two-sided Wilcoxon rank-sum test adjusting for ties whenever appropriate.

Table 3: OLS regressions of *Recall* performance on incentive treatment dummies, accounting knowledge proxies and their interactions.

REGRESSOR	(1) Estimate (std. err.)	(2) Estimate (std. err.)	(3) Estimate (std. err.)	(4) Estimate (std. err.)
intercept	5.434** (2.295)	8.090** (3.816)	6.913*** (2.239)	7.000*** (2.247)
RETR	1.869* (1.089)	-4.329 (5.047)	—	—
ENC	2.546** (1.233)	2.710 (6.258)	—	—
Courses	0.205* (0.111)	0.076 (0.186)	0.139 (0.112)	0.126 (0.114)
Experience	0.232 (0.323)	0.193 (0.333)	—	0.226 (0.322)
Courses x RETR	—	0.306 (0.247)	0.105** (0.052)	0.103* (0.053)
Courses x ENC	—	-0.0089 (0.307)	0.120** (0.059)	0.119** (0.060)
R-squared	0.074	0.090	0.073	0.076
Joint significance	(**)	(**)	(**)	(**)

Notes: Subjects = 117 (41 in FLAT, 38 in RETR and 38 in ENC). Heteroskedasticity-robust standard errors in parentheses. *,**, and *** denote significance of estimates at the 10%, 5% and 1% level, respectively.