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Capital and Labor Effects in a Recall Task: More Evidence in Support of Camerer and Hogarth (1999)[†]

Ondřej Rydval[*]

Abstract

This paper extends existing evidence on the interaction and relative productivity of cognitive effort and cognitive capital in an experimental environment. I focus on the impact of task-specific cognitive capital, which is central to the capital-labor argument of Camerer and Hogarth (1999) as well as related research in cognitive science and behavioral decision making. Using a memory recall task situated in an accounting setting, I show that the impact of task-specific accounting knowledge on recall performance varies with the timing of the introduction of performance-contingent financial incentives. I further illustrate that subjects better endowed with task-specific accounting knowledge greater improve recall performance in response to the introduction of performance-contingent financial incentives. I draw implications for further research of the capital-labor-production framework and for compensation practices in experiments as well as work settings.

Abstrakt

Článek rozšiřuje existující literaturu o relativní produktivitě a interakci kognitivního úsilí a kognitivního kapitálu na individuální úrovni v experimentálním prostředí. Soustřeďuji se na dopad úlohově specifického kognitivního kapitálu, ústředního pro kognitivní úsilí-kapitál argument Camerera a Hogartha (1999), i pro příbuzné výzkumy v kognitivní vědě a teorii rozhodování. Užítím testu paměti v prostředí účetnictví ukazuji, jak se mění dopad účetnicky specifického vzdělání na míru zapamatování s načasováním zavedení finančních incentiv závislých na výkonu. Dále ukazuji, že míra zapamatování subjektů lépe vybavených úlohově specifickým účetnickým vzděláním odpovídá na zavedení těchto finančních incentiv silněji. Rýsuji implikace pro další výzkum v oblasti balancování užití kognitivního úsilí a kapitálu, i implikace pro použití finančních incentiv ve firemních a experimentálních podmínkách.

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

JEL classification: C81; C91; C93; D83

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1. Introduction

Camerer and Hogarth (1999) propose an informal capital-labor-production framework that describes how financial incentives, through stimulating cognitive effort (labor), interact with various forms of cognitive ability (capital) in determining cognitive task performance. To date, however, there is sparse individual-level evidence on the interaction and relative productivity of labor and capital in cognitive production. Rydval and Ortmann (2004) illustrate that higher capital, measured by an IQ proxy, can be at least as important for performance in a psychometric test as scaling up piece-rate financial incentives. Palacios-Huerta (2003) and Awasthi and Pratt (1990), using schooling outcomes and a perceptual differentiation indicator as capital proxies, respectively, report that scaling up performance-contingent financial incentives is associated with greater improvement in judgmental decision making for individuals with higher capital.

This paper extends existing experimental evidence on capital-labor interaction by focusing on the impact of domain-specific cognitive capital, specifically task-specific accounting knowledge. Domain-specific cognitive capital is central to the capital-labor argument of Camerer and Hogarth (1999), and its role in cognitive production has long been debated in cognitive science (e.g., Anderson, 2000) as well as in accounting behavioral decision research (e.g., Libby and Luft, 1993, and Bonner and Sprinkle, 2002). Using a memory recall task situated in an accounting setting, I show that the impact of task-specific accounting knowledge (capital) on recall performance varies with the timing of the introduction of performance-contingent financial incentives. I further illustrate that subjects better endowed with task-specific accounting knowledge greater improve recall performance in response to the introduction of performance-contingent financial incentives. 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 recall task

The analysis in this paper is based on experimental data from Libby and Lipe (1992), who investigate the effect of introducing performance-contingent financial incentives on recall performance. Their 117 experimental subjects (auditing students) freely memorized a list of 28 internal accounting controls over the purchasing cycle and subsequently were asked to recall as many as possible. The authors split their subjects into three approximately equally numbered incentive treatments. In the FLAT treatment, subjects were paid a flat $2 participation fee. In the RETR and the ENC treatments, subjects were in addition paid $0.1 per each correctly recalled internal control, and there was also a $5 bonus for the top five performers. In the ENC(oding) treatment this performance-contingent incentive scheme was announced prior to the memorizing of the internal controls, while in the RETR(ieval) treatment the announcement was delayed until immediately prior to the recalling phase.[1]

The first column of Table 1 describes the variables of interest collected in Libby and Lipe's experiment.[2] *Recall* is the performance variable, i.e., the number of internal accounting controls recalled correctly, varying substantially across individuals. *Tmemo*

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[1] The $5 tournament-type bonus for top five performers was actually also present in the FLAT treatment, but was announced only after the experiment was over. Subjects could earn $2-11.80 in ENC and RETR, and $2-7 in FLAT. The recall task was followed by a recognition task (subjects learned this only after completing the recall task). See Libby and Lipe (1992) for further design and implementation details.

[2] Apart from one unidentifiable subject, the supplied data is identical to that used by Libby and Lipe.

denotes the time in seconds spent freely cycling through four computer screens while memorizing the list of internal controls. *Trecall* denotes the time in seconds spent recalling, which involved not only the mental process itself but also the physical process of typing the items into the computer. Libby and Lipe also collected two proxies for task-specific accounting knowledge (domain-specific cognitive capital): I denote by *Courses* the number of accounting credit hours taken by subjects, and by *Experience* the number of months of their auditing job experience. *Courses* and *Experience* vary considerably across subjects, presumably documenting their differential familiarity with the internal accounting controls in the recall task.

Table 1: Summary statistics for pooled sample and incentive treatments [a]

Treatment # subjects	POOLED 117	FLAT 41	RETR 38	ENC 38
Recall	11.21 (5.46) [1-23]	9.80[r*] (9.00)[m*]	11.61 (12.50)[m]	12.34[c*] (13.00)
Tmemo	345.75 (198.97) [63-1349]	307.44 (269.00)	345.74 (292.00)	387.11 (320.50)
Trecall	739.57 (366.53) [77-1675]	662.59 (597.00)	841.26[r] (770.50)	720.95 (642.00)
Courses	20.29 (4.44) [6-30]	20.49 (21.00)	20.05 (22.50)	20.32 (21.00)
Experience	0.85 (1.41) [0-6]	0.78 (0.00)[m]	0.87 (0.00)	0.89 (0.00)[m*]

[a] The POOLED column displays the mean, and beneath it the standard deviation (in parentheses) and the range (in brackets). The FLAT, RETR, and ENC columns display the mean and beneath it the median (in parentheses). Wherever appropriate, the r and the r* superscripts denote a significant difference at the 10% and the 5% level, respectively, between the relevant treatment and the treatment immediately to its left (except for FLAT which is compared to ENC), using the two-sided Wilcoxon ranksum test. As a robustness check, the m and the m* superscripts analogously denote a significant difference at the 10% and the 5% level, respectively, using the non-parametric two-tail continuity-corrected test for equality of medians. The c and the c* superscripts denote a significantly increasing trend at the 10% and the 5% level, respectively, from FLAT to RETR to ENC, as indicated by the non-parametric test for

trend across ordered groups developed by Cuzick (1985). The tests incorporate correction for ties.

Table 1 essentially replicates the main results of Libby and Lipe. In particular, the table displays the across-treatment variation attributable to the introduction of performance-contingent financial incentives in RETR and ENC. As noted by the authors, *Recall* performance exhibits a significantly increasing trend, improving on average from 9.8 items in the FLAT treatment to 11.61 and 12.34 items in the RETR and the ENC treatments, respectively. As pair-wise across-treatment comparisons confirm, *Recall* performance significantly improves under performance-contingent incentives, essentially regardless of the timing of their announcement in RETR and ENC. As for effort duration, the introduction of performance-contingent incentives in the ENC treatment is reflected in higher *Tmemo*, but only by a small and insignificant margin. Similarly, the delayed announcement of performance-contingent incentives in the RETR treatment is reflected in higher *Trecall*, significantly higher than in the FLAT treatment.

The bottom of Table 1 extends Libby and Lipe's results by displaying the across-treatment variation in the task-specific accounting knowledge proxies. Specifically, *Courses* does not vary across the incentive treatments, but median *Experience* is significantly higher in the ENC treatment than in the other treatments. Inspired by the last observation, I use Libby and Lipe's data to closer examine the impact of the task-specific accounting knowledge proxies on *Recall* performance.

3. The effect of task-specific accounting knowledge

My preliminary check of the data reveals that in the pooled sample, *Courses* is mildly correlated with *Recall* (r=0.17, significantly different from zero at the 10% level). *Experience* is not significantly correlated with *Recall*, but it is positively correlated with *Courses* (r=0.19, significantly different from zero at the 10% level). As noted by Libby and Lipe, these positive associations are considerably stronger in the RETR treatment, where the correlation between *Courses* and *Recall* amounts to r=0.37 (significantly different from zero at the 5% level).[3]

To quantify the variation in *Recall* performance attributable to between-subject differences in task-specific accounting knowledge, I split the experimental subject pool into two groups. The High-K group contains subjects who have above-median accounting education (*Courses*>21) <u>or</u> above-median auditing job experience (*Experience*>0); the Low-K group complements the High-K group.[4] Table 2 displays the resulting capital-based variation attributable to differences in task-specific accounting knowledge, both within the incentive treatments and in the pooled sample.

Following the analysis in Rydval and Ortmann (2004), I first compare the <u>capital</u>-based *Recall* differentials reported in Table 2 with the <u>incentive</u>-based *Recall* differentials reported in Table 1. The last column of Table 2 shows that the capital-based *Recall* differential in the pooled sample is on average about 3 correctly recalled internal accounting controls; this differential is highly significant and similar in size to the

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[3] The authors further report a correlation of r=0.44 between *Recall* and participants' auditing course grade; unfortunately the data on auditing course grades is not available for further analysis. Observing this high correlation, Libby and Lipe speculate that the impact of introducing performance-contingent 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 again not subject to closer empirical scrutiny.

[4] The idea is that accounting education is likely to be important for successful recall, but that having any positive amount of auditing job experience may fully substitute for it.

largest incentive-based *Recall* differential reported in Table 1 between FLAT and ENC.[5] Inspecting individual treatments in Table 2, by far the largest capital-based *Recall* differential arises in the RETR treatment, on average almost 7 internal accounting controls, which is more than twice the size of the largest incentive-based *Recall* differential reported in Table 1. The remaining capital-based *Recall* differentials in the FLAT and the ENC treatments are smaller than in the RETR treatment, but still comparable in size to the incentive-based *Recall* differentials reported in Table 1. These findings generally confirm those of Rydval and Ortmann (2004).

Table 2: Summary statistics for Low-K and High-K group [b]

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 (9.00)	10.31 (9.50)	7.53 (6.00)	14.26^{r*} $(15.00)^{m*}$	11.13 (11.00)	13.23 (13.50)	9.24 (9.00)	12.49^{r*} $(13.00)^{m*}$
Tmemo	342.67 (291.00)	287.12 (258.50)	344.20 (250.00)	346.74 (329.00)	417.38 (334.50)	365.09 (320.50)	369.15 (280.00)	330.59 (296.00)
Trecall	711.93 (644.00)	634.12 (587.00)	805.07 (590.00)	864.87 (836.00)	645.50 (548.50)	775.82 (807.50)	719.20 (575.50)	752.77 (690.00)

[b] The FLAT, RETR, ENC, and POOLED columns are sub-divided into the Low-K and the High-K groups defined in Section 3 (number of subjects in parentheses). All the columns display the mean and beneath it the median (in parentheses). Wherever appropriate, the r and the r* superscripts denote a significant difference at the 10% and the 5% level, respectively, between the sub-divided High-K and Low-K groups, using the two-sided Wilcoxon ranksum test. As a robustness check, the m and the m* superscripts analogously denote a significant difference at the 10% and the 5% level, respectively, using the non-parametric two-tail continuity-corrected test for equality of medians. The tests incorporate correction for ties.

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

The second noteworthy result observed in Table 2 is that, in contrast to the positive and relatively large capital-based *Recall* differentials discussed above, the capital-based effort differentials indicated by *Tmemo* and *Trecall* are insignificant and in several cases even negative. As Libby and Lipe caution, the two effort proxies 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.[6] Nevertheless, Awasthi and Pratt (1990) similarly find that their low- and high-capital subjects do not differ in terms of effort duration but do differ in terms of their judgmental performance.

Lastly, Table 2 illustrates the interaction of task-specific accounting knowledge and performance-contingent financial incentives. In particular, I compare across the three incentive treatments how Low-K and High-K groups respond to the introduction of performance-contingent incentives in RETR and ENC. Not indicated in Table 2 but tested in an analogous manner, the mean and median *Recall* performance of the High-K group is significantly higher (at the 5% level) in both RETR and ENC compared to FLAT. By contrast, *Recall* performance of the Low-K group is statistically indistinguishable among FLAT, RETR, and ENC. Hence individuals with higher task-specific accounting knowledge seem to be better able to improve their *Recall* performance in response to the introduction of performance-contingent financial incentives,[7] which bears close resemblance to the findings of Awasthi and Pratt (1990) and Palacios-Huerta (2003). As in the case of Palacios-Huerta (2003), however, it begs

[6] Camerer and Hogarth (1999) discuss alternative measures of effort duration and effort intensity.
[7] The presented evidence is only suggestive because the differences in the responsiveness of the Low-K and the High-K groups to the introduction of performance-contingent incentives are not significant (using a parametric t-test).

further experimental investigation to determine whether the stronger reaction of higher-capital individuals is predominantly due to the piece-rate or the tournament part of the incentive scheme.

4. Discussion

In line with Camerer and Hogarth's (1999) capital-labor-production framework, task-specific accounting knowledge (i.e., domain-specific cognitive capital) as well as performance-contingent financial incentives turn out to be important determinants of performance in the recall task. The results back up previously reported evidence that, first, the impact of cognitive capital can be as large or larger than the impact of introducing performance-contingent financial incentives; second, that effort duration does not seem to vary in a predictable fashion with cognitive capital; and third, that the performance of higher-capital individuals improves greater following the introduction of performance-contingent financial incentives.

A novel finding is that the impact of task-specific accounting knowledge (capital) on *Recall* performance varies with the timing of the introduction of performance-contingent incentives. Especially noteworthy is the large effect of task-specific accounting knowledge on the recall performance in the RETR treatment. As a plausible explanation, Libby and Lipe argue that following the delayed announcement of performance-contingent incentives, the RETR-treatment subjects probably attempted to recall weak memory traces of the presented internal accounting controls, and those with greater task-specific accounting knowledge – i.e., those better equipped with relevant synaptic networks – were more successful in doing so (see e.g., LeDoux, 2002).[8]

What else could account for the extraordinarily large effect of task-specific accounting knowledge on *Recall* performance in the RETR treatment? Although the presented results are qualitatively robust to alternative High-K / Low-K splits (e.g., those based on the *Courses* median only), it is nevertheless plausible – especially given the relatively small sample size – that the estimated impact of task-specific accounting knowledge is confounded with the impact of other determinants of *Recall* performance. In particular, one should ideally account for the impact of other forms of cognitive capital related to the recall task, such as short-term and working memory capacity (e.g., Kane et al., 2004). Furthermore, a potentially important factor influencing subjects' responsiveness to financial incentives is their ex ante degree of intrinsic motivation to engage in the recall task (e.g., Cacioppo et al., 1996).

The interaction of financial incentives and individual cognitive and motivational characteristics underlies Camerer and Hogarth's (1999) capital-labor-production framework. Empirically disciplining the framework will require not only identifying the relevant cognitive and motivational constructs, but also thinking thoroughly about the interrelations among them (e.g., Bonner and Sprinkle, 2002). Psychologists have argued that doing so may require analyzing not only measurable (objective) individual cognitive characteristics, but also the self-perceived (subjective) counterparts thereof (e.g., Bandura and Locke, 2003). Taking even one step further, economists have

[8] A related question in the background, pertaining not only to this example, is whether subjects better equipped with task-relevant capital were in some sense "smarter" before they acquired it. This endogeneity issue is implicitly discussed by LeDoux (2002) who argues that the process of cognitive capital development inevitably involves nurturing nature. See Plug and Vijverberg (2003) for an economic approach to the nature/nurture debate.

questioned whether decision makers can intentionally manipulate their cognitive self-perception, and whether such self-perception can be influenced by performance-contingent 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 (e.g., Bonner and Sprinkle, 2002). Consider, for example, the evidence discussed above suggesting that the use of performance-contingent financial incentives induces greater effort duration regardless of individuals' cognitive capital, yet it only seems to stimulate performance of individuals better endowed in cognitive capital. As a consequence, efficiently using performance-contingent financial incentives may involve directing their impact predominantly at the high-capital individuals in experimental subject pools or in firms' workforce, both in terms of maximizing performance outcomes and minimizing effort resource costs.

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