

Solving the "Candle Problem:" exploring the link
between financial incentives and performance
in individuals and groups.

by

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Abstract

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Supervisors: Sigve Tjøtta and Gaute Torsvik

Sam Glucksberg demonstrated in an experiment that the use of financial incentives could reduce performance in solving an insight problem. I wish to conduct a modified version of this experiment to investigate if his results can be duplicated. In addition, I wish to examine if the results are the same when a group of participants attempt to solve the same problem as individual participants.

The experiment was divided into two sessions. One session where pairs attempted to solve the problem, and one session where individual participants were asked to solve the same problem. Within each session the participants were either assigned to an incentivized or a non-incentivized condition.

The results from the experiment indicate that the use of financial incentives created no difference in the mean solution time within each session of the experiment; the incentivized and the non-incentivized participants performed equally well in both sessions. The difference between the sessions was, however, significant with the participants in the group session performing significantly better than the individual participants. The results also indicate that males might have a lower mean solution times than females.

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1. Introduction

This section will contain a brief introduction of the research on the use of financial incentives. An overview of the “Candle Problem” and Sam Glucksberg’s variation will follow. Then, the research questions of this thesis and the results from the experiment are presented. At the end of the chapter, there will be an overview of the disposition for the rest of the thesis.

In the context of this thesis, the term “financial incentives” refers to the possibility of attaining a financial reward by performing at a certain level.

1.1. An introduction of the research on the use of financial incentives

Performance-based compensation has long been used to increase effort and productivity among employees. The reason for using performance-based compensation is due to an apparent, well established and well documented relationship; the performance-based compensation is thought to increase motivation and effort, which in turn increase performance.

Over the last couple of decades, however, research found indications that, under certain circumstances, financial incentives may actually lead to a reduction in performance. One of the earliest and most well-known papers on this topic is Sam Glucksberg’s “The Influence of strength of drive on functional fixedness and perceptual recognition” (1962). Glucksberg conducted an experiment where the participants were asked to solve an insight problem. He found that the participants who were incentivized by a performance-based compensation actually performed worse than the non-incentivized participants.

In the beginning of the 1970's, research pioneered by Edward Deci found indications that the use of tangible rewards, especially financial incentives, could have detrimental effects on intrinsic motivation¹ (Deci, 1971). This intrinsic motivation was by Deci deemed crucial to the performance in the type of problem (i.e. insight problem) used by Glucksberg in his paper.

This and later research ((Amabile, 1985), (Ariely, Gneezy, Loewenstein, & Mazar, 2009) and (Deci, Koestner, & Ryan, 1999)) indicates that the relationship between financial incentive and performance is perhaps more complex than originally assumed. The types of tasks where the use of financial incentives is believed to be more likely to cause detrimental effects are in the so-called "insight problems." These effects include an over-optimal level of arousal (Yerkes-Dodson law²), increased propensity of functional fixedness, choking, known from the world of sport where misses are more common during competition than in practice (Dandy, Brewer, & Tottman, 2001), a narrowing of focus making the less obvious solutions harder to reach (Ordóñez, Schweitzer, Galinsky, & Bazerman, 2009) and increased risk taking (Larrick, Heath, & Wu, 2009).

The view that financial incentives can be detrimental to performance is not shared by everyone. Some researchers claim that the use of financial incentives does, in fact, increase performance. Kruse, Blasi and Freeman (2012) investigated whether linking an employee's pay to firm performance helped a number of firms vying to become one of the "100 Best

¹Intrinsic motivation refers to an interest or enjoyment for engaging in a task for no other reason than the task itself.

²Yerkes-Dodson law predicts that there is an optimal level of effort, and that beyond this point, the increasing effort starts to have a detrimental effect on performance (Yerkes & Dodson, 1908).

Companies to Work For in America” increase their employees’ performance. They found that the combination of group incentive pay and policies increasing employee influence led to reduced turnover and increased return on equity. Another paper used data from Dutch firms to investigate the relationship between performance-related pay and productivity. The study found that the use of performance-related pay increased productivity at the firm level with 9% and employment growth with 5% (Gielen, Kerkhof, & van Ours, 2010).

It is important to uncover the true effects of financial incentives. The tasks the typical employee in the western world performs are increasingly complex and rely on skills such as finding creative, non-conventional solutions and interpersonal relationships. This growing complexity combined with the fact that performance-based compensation is a very popular and common way of reimbursing employees,³ causes a huge potential “loss” in productivity, if the use of financial incentives does in fact reduce performance. The goal is that this thesis will make a contribution to the scholarship necessary to increase knowledge in this field.

1.2. The “Candle Problem”

The problem used by Glucksberg in his 1962 discourse is called the “Candle Problem.” This is also the problem the participants in the experiment conducted in relation to this thesis attempted to solve. The “Candle Problem” is usually conducted by first dividing the participants into two groups which differ in some pre-existing characteristic, such as time lived abroad (Maddux & Galinsky, 2009), age (German & Defeyter, 2000), or the level of financial incentive (Glucksberg, 1962).

³ <http://cep.lse.ac.uk/pubs/download/dp1112.pdf>

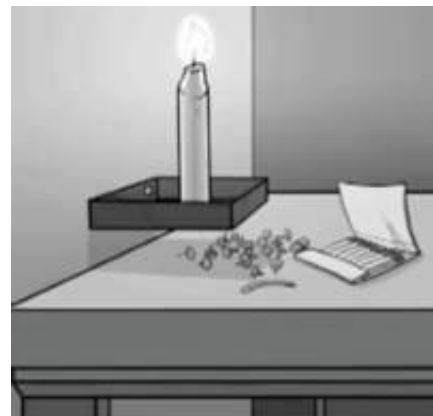
The participant is then presented with a candle, a box containing tacks and a box/book of matches, and asked to attach the candle to the wall by only using the objects presented so that the candle can burn properly, and that no wax will drip on the table or on the floor. The correct way to solve this problem is to be able to perceive that either the box containing the tacks or the box of matches can also act as a container or platform for the candle. See figure 1 for the standard setup and solution to the “Candle Problem⁴.” The participants usually have a time limit to solve the problem.

Figure 1 - The “Candle Problem⁵”

Standard setup



Solution



⁴ Note that in this depiction of the setup a book of matches is used, in the version conducted in regards to this thesis a box of matches were used. Using a box of matches gives an additional way to reach the solution; the box containing the matches can also be used a platform or container for the candle.

⁵ <http://lessonstream.org/2011/03/31/the-candle-problem/>

1.3. Glucksberg's version of the "Candle Problem"

Sam Glucksberg's version of the "Candle Problem" is the most well-known. In Glucksberg's experiment, 128 participants (males, randomly selected from the introductory psychology course at New York University) were divided into two groups. The two groups of 64 participants conducted each a different variation of the "Candle Problem," one in which the box was empty and the tacks were placed on the table ("tacks outside box" version), and one in which the tacks were situated inside the box ("tacks inside box" version). The participants in both groups were assigned either to a non-reward condition named "low-drive" (non-incentivized group), or a reward condition where they could receive \$5 for being among the top 25% fastest solvers, or \$20 for being the fastest, named the "high-drive" condition (incentivized group). Glucksberg's hypothesis for the "tacks outside box" version was, "when the correct habit is dominant, a high drive should facilitate problem solving," and for the "tacks inside box" version, the hypothesis was "when the correct habit is low in the habit hierarchy, a high drive should retard problem solving." A failure was defined as being unable to find the correct solution within the provided time limit of 15 minutes. In the "tacks outside box" version, the results were as expected; the group with the financial incentive performed better, both in a lower number of failures and a lower solution time.

The surprise came in the "tacks inside box" version, this time the incentivized group performed worse. See table 1 for results.

Table 1 - Glucksberg (1962), mean solution times, standard deviation in brackets

	Tacks outside box		Tacks inside box	
	Incentivized	Non-incentivized	Incentivized	Non-incentivized
Mean	3.67 (4.52)	4.99 (5.42)	11.08 (4.84)	7.41 (5.63)
Number of failures	2	6	16	10
N	32	32	32	32

Time is measured in minutes

Glucksberg reported a statistically significant difference between the incentivized and the non-incentivized group in the “tacks inside box” version when their results were evaluated by a t -test ($t = 2.73, P < 0.01$). The same discovery was not made in the “tacks outside box” version. He contributes the reason for not finding a significant difference in the “tacks outside box” version to the fact that the solution might have been too obvious, thus creating a ceiling effect⁶.

The hypothesis formulated by Glucksberg states: “When the correct habit is low in the habit hierarchy, a high drive should retard problem solving.” This statement can be interpreted as the existence of extrinsic financial incentives can inhibit the performance in problems classified as “insight problems.”

⁶ Since the solution where the tacks are outside the box is so obvious and easy to reach there is not much time to “gain” by exerting extra effort. So the increase in effort caused by the financial incentives doesn’t help to significantly lower the solution times.

1.4. Research Question

The results from Glucksberg's "tacks inside box" version of the "Candle Problem" are very insightful when viewed in the light of traditional economic theories, which predict that the use of financial incentives lead to an increase in the expected performance. It would, however, be interesting to conduct variations of Glucksberg's experiment to determine if the mechanism detected by Glucksberg is also valid under other circumstances, such as when both genders attempt to solve the "Candle Problem" and when participants cooperate in groups. In addition, little research has been done to directly compare the effect of financial incentives between individuals and groups.

The experiment conducted in association with this thesis is a variation of Glucksberg's experiment. The experiment was conducted in two sessions, one in which individual participants attempted to solve the "Candle Problem," and one in which pairs attempted to solve the problem. Allowing participants to attempt to solve the "Candle Problem" in groups has not, to my knowledge, been done before and will hopefully provide insights into the effects of financial incentives on performance in a group setting. Comparing the two variations can also highlight any differences in the response to financial incentives between groups and individuals.

Due to the results attained by Glucksberg and the relative similarity between his experiment and the experiment conducted in this thesis, it is expected that the results in the individual session will be the same. In the group session, the lack of precedence from earlier experiments makes any predictions regarding the results more difficult. Due to the relative similarities to Glucksberg's experiment, it is also expected that the financial incentive will have a performance retarding effect in the group setting. Earlier research has shown that groups have

better insight-problem solving abilities than individuals (Smith, Bushouse, & Lord, 2010), it is therefore expected that the groups will perform better than the individuals.

This thesis will investigate the following three hypotheses:

1. *The use of financial incentives will cause the incentivized participants to perform inferior to the non-incentivized participants in solving the “Candle Problem” on an individual level.*
2. *The use of financial incentives will cause the incentivized participants to perform inferior to the non-incentivized participants in solving the “Candle Problem” in a group setting.*
3. *The participants in the group session of the “Candle Problem” will perform at a higher level than the participants in the individual session.*

1.5. Results

The results from the experiment did not show any significant statistical difference in the mean solution times between the incentivized and the non-incentivized participants in either the individual or the group session. Therefore, hypotheses 1 and 2 are rejected. Between the two sessions, there was a difference in the mean solution time, with the participants in the group session having a significantly lower mean solution time than the participants in the individual session. Therefore, hypothesis 3 is not rejected. There are also some indications in the data that males might have a lower mean solution time than females.

1.6. Disposition

This thesis is organized in the following way. Following Section One, Section Two presents the conceptual framework, including the general theoretical framework, thesis specific considerations and an overview of some earlier versions of the “Candle Problem.” Section Three contains a description of the recruitment process, the experimental design and the procedure of the experiment. Section Four contains the descriptive and statistical analysis of the data. Section Five holds a discussion on the findings and some suggestions for further research. Lastly, Section Six contains the appendix.

2. Conceptual Framework

This chapter will first focus on outlining the general theoretical framework regarding the use of financial incentives, followed by a description of some aspects of the use of (financial) incentives more specific to this thesis and the “Candle Problem.” A short overview of earlier publications of the “Candle Problem” will follow before a brief summary will end the chapter.

2.1. General theoretical framework

The aspects of economic theory that are most relevant to the use of financial incentives and performance are rational choice theory, agency theory and incentive theory, the latter two of which are founded on the rational choice theory.

Rational choice theory is a theory that tries to understand and predict human behaviour. The modern approach (after Paul Samuelson (1938)) is based on revealed preferences; individuals act consistently and if they do, we can model their choices *as if* they maximize a utility function. This theory has been dominant within the field of economics for several decades and has, due to its apparent success, also gained popularity in other social sciences.

In economics, financial incentives are often studied in a principal agent framework. The basic idea in this model is that the principal does not have the time or expertise to perform a certain task; he therefore hires an agent to perform this task. In the context of this thesis, the agent can be thought of as an employee while the principal can be thought of as an employer. There exists an information asymmetry between the agent and the principal (the agent has better information regarding his preferences and effort than the principal), which creates two

problems: (i) the objectives of the agent may not be aligned with those of the principal, and (ii) the agent may have an incentive to shirk⁷.

Solutions to the agent-principal problems that have been suggested include: increased monitoring of the agent (Prendergast, 1999), more sophisticated screening processes and complete contracts. Increased monitoring can be interpreted as a signal of distrust from the principal⁸, and can in complex situations, be prohibitively expensive. Screening processes are designed to achieve a correct representation of the agent's preferences, so that the agent with the most similar objectives to the principal can be hired for the job. Complete contracts means that every possible outcome of the future is included in the contract with the respective rights and responsibilities of the parties involved. To create these complete contracts is a theoretical exercise and not possible in real life.

Agency theory further assumes that the level of compensation is linked to some observable, contractible outcome that is positively correlated with effort; a higher performance-based compensation will lead to a higher level of effort from the agent (Awasthi & Pratt, 1990), which in turn leads to a higher expected performance. This expected increase in performance originates in the rational choice theory. When financial incentives are used, two effects influence the behavior of the agent: (i) the additional wealth can be used by the individual to consume more goods, (ii) the relative "cost" of not working goes up (the opportunity cost of

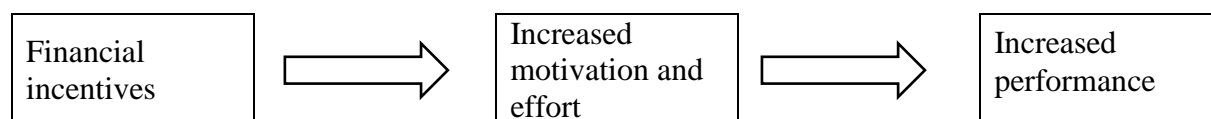
⁷ This depends on the preference of the agent. If the agent wants to maximize the same thing as the principal, then a problem does not exist; the more aligned the preferences are, the less of a problem shirking becomes.

⁸ This increased monitoring has, however, also been hypothesized to have positive effects: the increased monitoring can be perceived as supporting by the employee (Frey & Jegen, 2001).

leisure time increases), and work thus becomes relatively more profitable. Both of these effects are expected to cause a rational agent to increase his amount of effort.

While the scope of the agent-principal model is limited to explaining the relationship between financial incentives and effort, the incentive theory goes one step further and attempts to explain the relationship between financial incentives and increased performance by depending on two underlying assumptions: (i) financial incentives lead to an increase in motivation and effort, (ii) this increase in motivation and effort results in an increase in performance (see Figure 2).

Figure 2 - Standard incentive theory



Criticism has been raised against the first of these assumptions. Some scholars claim that the use of financial incentives can create a “conflict of motivation,” where the extrinsic motivation created by the use of financial incentives reduce, or crowd out, intrinsic motivation ((Deci, 1971) and (Frey & Jegen, 2001)). In addition, the “multi-task problem” has been put forth (Prendergast, 1999); when a part of the task is rewarded, the motivation and effort that goes into the non-rewarded part of the task can be reduced. An example of such can be a teacher whose pay is dependent on the students’ exam results; this can cause the teacher to focus on teaching the students exam-relevant questions, while overlooking other equally important parts of the curriculum.

Additionally, researchers hypothesize that the frequent use of financial incentives can cause a reduction of the individuals' perception of the "value" of the incentive (Suvorov, 2003). In other words, the incentive needs to consist of an increasingly larger amount to have the same effect on the motivation of the potential recipients. Furthermore, an unconsidered and exaggerated use of financial incentives can cause an "addiction" to rewards in the sense that a reward becomes expected when similar tasks are faced in the future. The use of incentives can also have a signaling effect on the attractiveness of the task, which can cause some individuals to view the tasks as more unpleasant when an incentive is used (Suvorov, 2003).

In the experiment conducted in this thesis, it is assumed that the first assumption in the standard incentive theory holds, and the focus will therefore be on the second assumption⁹.

Several research papers have claimed that the increase in effort and motivation does not necessarily lead to an increase in performance, especially in the so-called "insight tasks" (Ariely, Gneezy, Loewenstein, & Mazar, 2009), (Camerer & Hogarth, 1999) and (Gino & Ariely, 2012)).

Ariely (2009) and his colleagues subjected participants to six different tasks (2 tasks labeled as "memory tasks," 1 task labeled as a "creative task" and 3 tasks labeled as "motor skills tasks). They used three different levels of incentive during their experiment; low, medium and high. The participants could receive a reward dependent upon their assigned level of incentive (low, medium or high) and whether they reached either of two specified

⁹ This seems to be warranted in this situation; for students, the prospect of earning some extra money should be enough to increase motivation and effort. The experiment is an isolated occurrence and should not reduce, or crowd out, any intrinsic motivation among the participants. The problem of multi-tasking also seems irrelevant in this setting.

performance levels, labeled “good” or “very good.” The researchers found no significant difference in performance between the low and medium incentive levels, the participants in the low-incentive group, however, performed significantly better than the participants in the high-incentive group.

The fact that increased motivation and effort can lead to no improvement or even a reduction in performance seems out of place when considering economic theory, where it is commonplace to view effort as a choice which has a cost to the individual (Ariely, Gneezy, Loewenstein, & Mazar, 2009). When effort has a cost to the individual, and if too much effort decreases performance, the rational individual will reduce the amount of effort in order to achieve optimal performance and maximize his surplus. The fact that, under certain circumstances, the use of financial incentives can reduce performance, might suggest that the increase in motivation and effort is not controllable or voluntarily. This increase might cause other psychological phenomena, which can be detrimental to the performance in the task, to become prevalent.

Despite the possible detrimental effects that the use of financial incentives can have on performance¹⁰, the problems outlined in the principal agent framework have led to the rise of several types of compensation-schemes. These compensations-schemes are designed to incentivize a correct representation of the agent’s objective and efforts, and align the interest of the agent and the principal. The most common of these compensations schemes are individual performance-based compensation schemes and organization-wide gain sharing

¹⁰ Research (Deci, 1971) has shown that the use of rewards such as verbal praise, increased responsibility or other type of social recognition are a lot less likely to cause these detrimental effects .

plans. A performance-based compensation scheme is where an individual or several individuals are, partly or fully, compensated contingent on to what extent certain pre-defined goals are met. These goals are usually, but not necessarily, the result of negotiations between the individual(s) and some sort of employer/manager. The extent to which the performance-based compensation is part of the whole compensation package varies greatly across industries and professions. Performance-based compensation does not necessarily mean a cash bonus; it can also include stock options, stocks, contributions towards retirement savings or other types of financial compensation.

This type of variable compensation scheme has several varieties; performance-contingent compensation, completion-contingent compensation and engagement-contingent compensation.

2.2. Thesis specific considerations

While the previous part of the chapter was dedicated to more general considerations regarding the use of performance-based compensation, the following section contains topics more specific to this thesis and the “Candle Problem.”

Glucksberg hypothesized that the results he obtained could be contributed to the fact that when the solution is not straightforward, a financial incentive will intensify the effects of a psychological phenomenon named “functional fixedness,” and thus hamper the solution of the problem.

The German psychologist Karl Duncker first described functional fixedness in the 1930’s. He theorized that once an object or process has been associated with performing a certain task, it

can be challenging to perceive that it can be used in another way (Duncker, 1945). Duncker went on to design an experiment, involving a so-called insight problem, to conceptualize the idea of functional fixedness; this experiment was called the “Candle Problem.”

The existence of functional fixedness and other detrimental effects seems to be almost exclusively found in the so-called “insight problems.” Problems are, in this setting, usually divided into two main categories: mechanical problems and insight problems. The “Candle Problem” has been classified as an insight problem, which implies that it has certain characteristics; one, prior experience is not considered to be a critical factor in solving the problem. Two, restructuring of the problem is considered to be crucial in finding the solution (Ohlsson, 1984). Restructuring means that the individual attempting to solve the problem has to come to perceive the problem in a way that was not obvious upon initial consideration (Sheerer, 1963), or put another way, the solution is not straightforward.

Mechanical problems are the other main category of problems, and are typically memory or recall problems, probability matching tasks and clerical tasks (Camerer & Hogarth, 1999). A low or no initial level of intrinsic motivation characterizes these problems and cognitive ability is not considered crucial for solving them. The solution is often straightforward and the process of reaching it usually demands skills like attention, keeping track of past trials and persistence. Mechanical problems are also referred to as algorithmic or non-cognitive. In these types of problems, the financial incentive appears to have the expected effect of increasing performance through an increase in motivation and effort¹¹. Individuals are usually

¹¹ But also here, as earlier mentioned, does there exist exceptions (Ariely, Gneezy, Loewenstein, & Mazar, 2009).

assumed to have a higher level of intrinsic motivation for solving insight problems than for mechanical problems (Pink, 2009).

An important topic in regards to conducting an experiment is randomization. Randomization can be defined as “the assignment of experimental units to treatment by a random process such that neither investigator nor patient knows the treatment to be assigned at the time the patient is registered¹².”

This randomization process is critical to minimize confounding and selection bias. Confounding occurs when the correlation between two events are due to the fact that both events have a common cause. By randomizing the probability that some unknown variable could influence the dependent and independent variable, the likelihood of confounding is reduced. Selection bias can occur when the assignment of the participants follows a specific pattern. For example, if the first half of the participants to show up were assigned to a certain treatment while the second half of the participants were assigned to a different treatment, the results could be influenced by the fact that the participants showing up first shared some characteristic. If the participants had been randomly assigned to the treatment, the probability of selection bias would have been reduced.

During this thesis’ run of the “Candle Problem,” the participants were randomly assigned to the incentivized or non-incentivized group. The selection of which participants were to be in either the incentivized or non-incentivized group was not done until the time of the experiment, a procedure practice known as “allocation concealment.” Allocation concealment and random selection was achieved through having the participants blindly pick a piece of paper from a bowl just before they went into the room where the experiment was to be held.

¹² <http://www.biostat.umn.edu/~ph7420/2012/LECTURE%2003%202012.pptx>

In the bowl, from which the papers were drawn, there were an identical amount of papers with the numbers 1 or 2. A 1 indicated that the pair would be in the incentivized group, while a 2 indicated that they would be in the non-incentivized group.

A possible bias in an experimental setting consists of both observable and unobservable variables. Through randomization, the bias becomes equally distributed across the different treatments of the participants. The bias is therefore equally distributed between the different treatment groups. The use of randomization makes it possible to use probability theory to explain the results, and thus allows conclusions to be drawn on the effect of the treatment.

Another important aspect of the experiment is the different characteristics of a group vs. an individual in a problem-solving situation. Extensive research has been done on the topic, and the results seem to be quite clear; groups perform better than individuals in both insight and mechanical problems (Smith, Bushouse, & Lord, 2010). Some of the benefits that have been emphasized are the group members' ability to help each other to break the individual's locked pattern of thought, the group's superior memory capacity and the group members' variety of ideas and suggestions (Sage, 2010). There are researchers who argue that certain group features can, at least in a brainstorming setting, inhibit creative efforts. These inhibiting features include attention loss and social inhibitors (Mumford, Feldman, Hein, & Nagao, 2001).

Additional group characteristics have also been found to possibly influence the group's performance. Examples of such characteristics are the level of trust (Klimoski & Karol, 1976), the similarity of the personalities and the cultural diversity of the group members (Hoffman, 1959) and (Watson, Kumar, & Michaelsen, 1993)). The issues of trust, personalities and cultural diversity are beyond the scope of this thesis and are therefore not addressed further.

The problems discussed in this thesis are not physically demanding so that a group would not benefit from its physical superiority.

2.3. Different versions of the “Candle Problem”

Central in this thesis is an experiment where the participants are asked to solve the “Candle Problem,” this problem is classified as an insight problem. The “Candle Problem” has earlier been used by several researchers ((Fleck & Weisberg, 2004), (German & Defeyter, 2000), (Gino & Ariely, 2012) and (Maddux & Galinsky, 2009)). It is worth noting that all experiments referred to in this sub-chapter used both genders, as opposed to Glucksberg, who only used male participants.

Maddux and Galinsky (2009) investigated if living abroad increases creativity. They found that people who have spent time living abroad are more creative and argue, based on their findings, that living abroad helps to broaden the mind and thus makes the individual more able to find the correct albeit hidden solution to a problem. They base their conclusions there among the results of the “Candle Problem,” that the time spent abroad played a significant role in solving the problem more quickly.

German and Defeyter (2000) used the “Candle Problem” to show that children aged 6 and 7 are significantly slower to use the box as a support for the candle to solve the problem when it has been shown to have containment properties, than children at the age of 5. They thereby suggest, that the children aged 5 are somewhat immune to the effects of functional fixedness, showing no difference in solution times when the standard properties of the box containing the tacks are shown. The results are interpreted to reveal that children develop intuitions on the properties of objects based on past experience.

Fleck and Weisberg (2004) examined whether the use of verbal protocol, i.e. thinking “out loud,” would help the participants in solving a range of insight problems. One group of the participants was asked to say out loud everything they thought of as they attempted to solve a number of insight problems, while the other group was not. The “Candle Problem” was one of these insight problems. The participants were presented with the standard articles for solving the problem (candle, a book of matches and a box of thumbtacks). They found no significant difference in the solution times between the two groups of participants.

Gino and Ariely (2012) used the “Candle Problem” as part of their research to investigate whether creative people are more dishonest than non-creative people. They conducted five experiments in which the “Candle Problem” was part of the second experiment. The design of the “Candle Problem” in this version gave participants a picture of the articles available laying on a table next to a wall. The participants were then instructed to figure out, using only the objects in the picture, how to attach the candle to the wall so that the candle burns properly and does not drip wax on the table or floor. The time available to the participants was 3 minutes. The results from the “Candle Problem” showed that the participants already deemed as creative were more successful in solving the “Candle Problem.” The end result from the study showed that, individuals who were deemed as creative were also found to behave more dishonestly.

More uses of the “Candle Problem” can be found in the following papers: (Chrysikou, 2006), (Galinsky & Moskowitz, 2000) and (Greene & Noice, 1999).

Other types of insight problems that have been used to study the effects of incentives on insight problems includes: “The Nine-Dot problem¹³” (Kershaw & Ohlsson, 2004), “Luchins’ Water-Jar Experiment¹⁴” (McGraw & McCullers, 1979) and ”Packing Quarters¹⁵” (Ariely, Gneezy, Loewenstein, & Mazar, 2009).

¹³ The Nine-Dot problem consists of connecting nine dots on a piece of paper by drawing four straight continuous lines that pass through each of the nine dots without lifting the pencil of the paper. Kershaw and Ohlsson (2004) argue that the difficulty of many insight problems is due to a number of factors and they conduct an experiment with the nine dot problem to investigate why this problem is difficult.

¹⁴ McGraw and McCullers’ experiment included 10 problems regarding measuring a certain amount water using three different sized jugs. These 10 problems were modeled after an experiment conducted by Luchins (1942), hence the name. The first 9 problems required relatively complicated three-jug solutions, while the 10th problem had a simpler two-jug solution. Rewards were given to one group of participants while not to the other group. They found that the non-rewarded participants performed better at problem 10. This superiority was also prevalent in problems 1-9, but the difference was not significant.

¹⁵ Part of the study by Ariely et al. (2009) referred to earlier. The game of “Packing Quarters” involves fitting nine metal pieces of quarter circles into a black wooden frame within a given time. To fit eight pieces is not too difficult, but to fit the last piece, all the pieces have to be packed in a certain way.

2.4. Summary

As mentioned, the true effects of the use of financial incentives are still not completely understood, and the debate is ongoing. Some researchers (Ariely, Gneezy, Loewenstein, & Mazar, 2009) & (Glucksberg, 1962)) have found that, at least under certain circumstances, financial incentives can have detrimental effects on the performance in insight tasks. It seems like the use of financial incentives can hinder individuals' ability to think outside the box. Several explanations for this reduction in performance have been suggested including choking, over-optimal level of arousal, functional fixedness, narrowing of focus and increased risk-taking. The effect of financial incentives in mechanical tasks is, in general, performance enhancing, as suggested by the rational choice, agency and incentive theories.

As the standard of living in the western world continues to rise, it is a timely question to ask if individuals, when their materialistic needs are fulfilled, still are motivated by the prospect of receiving tangible rewards. As mentioned, some research does indicate that the use of rewards such as increased responsibility, social recognition and verbal praise, have fewer of the detrimental effects that have been observed by the use of financial rewards. Fewer negative effects on these types of non-tangible rewards might suggest that the employees are concerned by issues such as distribution of wealth, sustainability, personal development and realisation, and non-material rewards.

On the topic of group performance vs. individual performance, there appears to be a strong tendency that groups perform better in a wide range of tasks. This superior performance has been attributed to the groups' greater memory capacity, the wide range of ideas that group members can provide and the triggering-of-memory that can occur when the plethora of ideas are discussed.

As shown above, the “Candle Problem” has been used to investigate a number of hypotheses, from the effect of having lived abroad on creativity, if creative individuals behave more dishonest, the effects of thinking out loud while solving an insight problem, to the difference in propensity of experiencing functional fixedness among different aged children. However, it does not seem that the “Candle Problem” has been used to investigate the effect of financial incentives in a group setting, or the difference in the effects of financial incentives in a group vs. in an individual.

The results attained by Glucksberg are quite contradictory to a lot of traditional economic theories, however, the lack of published replications and variations of Glucksberg’s results make the strength, applicability and commonness of his results unknown.

3. The Experiment

This section contains the recruitment process, the design and the procedure of the experiment. The experiment was divided into two sessions. The term “group session” refers to the session where pairs attempted to solve the ”Candle Problem,” while the term “individual session” refers to the session where individual participants were asked to solve the same problem. The group session was conducted on Thursday, April 26th, 2012, and the individual session was conducted on Thursday, June 7th, 2012. Both sessions were conducted on the University of Bergen campus.

For the group session, the aim was to have 60 participants—a total of 30 pairs—15 in the incentivized group and 15 in the non-incentivized group. Due to a mistake, 16 pairs were assigned to the incentivized group and 14 to the non-incentivized group. For the individual session, the aim was to have 30 participants, 15 in the incentivized group and 15 in the non-incentivized group. In the end, 27 individuals participated, 13 in the incentivized group and 14 in the non-incentivized group.

3.1. Recruitment process

The group session

The participants for the group session were recruited either through an invitational e-mail or through posters put up on the campus of the University of Bergen. At first, approximately 220 individuals received an e-mail (see appendix A1). The e-mail invited the recipient to participate in an experiment, and informed him/her that the experiment would last approximately 20 minutes and that he/she would receive NOK 100 for participating. To sign

up, the participants had to follow a link in the invitation email to the Expmotor¹⁶ web page, where they could sign up by filling in their name, e-mail address, phone number and desired time of participation.

The individuals who were invited first had, at an earlier point in time, indicated their interest in participation in economic experiments. The first round of invitations garnered a total of 14 participants (a feedback rate of 6.3%). The invitation was then sent out to all students in the Department of Economics and to students taking the following three courses: General Psychology 1 (PSYK101), Methods in the Social Sciences (MET102) and Organizational Theory (AORG101). In addition, posters were put up around the university area. In total, approximately 700 people received the second round of invitations, which resulted in 44 additional participants (6.3% of the total individuals invited). On the day of the group session a total of 58 participants had registered. Additional participants (2) were recruited on campus during the session. An explanation for the relatively low number of respondents could be that the time of the group session was fairly close to the exam period.

On the day of the group session, the participants in the morning period (9 a.m. – 11:40 a.m.) received an SMS at approximately 8 a.m. reminding them of their participation. The participants in the afternoon period (12:20 p.m. – 14:40 p.m.) received the reminder SMS at approximately 12 p.m.

¹⁶ Developed by Thomas Halvorsen and Erik Sørensen at The Norwegian School of Economics (NHH) in Bergen.

The individual session

The recruitment process for the individual session was, in general, the same as for the group session. One difference was that the invitations were sent out earlier (9 days in advance) than for the group session (the first invitations were sent out 4 days in advance). The invitations were sent earlier because experience showed that more time could cause additional individuals to sign up. The invitations were identical, except for the logical changes in time, date and location. Due to the fact the most students had already finished their exams and were thus deemed to be unlikely to participate, the invitations were only sent out to students still attending classes. This included 401 first year law (JUSS 111) and 123 first year biology students (BIO 101).

At the time of the individual session, 29 participants were registered (5.15 % of the total individuals invited). Due to maintenance, the rooms booked for the individual session were unavailable (this discovery was made in the afternoon the day before, and the session had to be moved to another floor). The participants were made aware of this change in the reminder of participation SMS they received on the morning (approx. 8 a.m.) on the day of the individual session. 6 of the registered participants failed to show up; 4 were replaced with random students during the session.

3.2. Design

Two rooms were booked to for the group session, making it possible to have two pairs conducting the experiment simultaneously. For the individual session, four rooms were booked, making it possible to have four participants conducting the experiment simultaneously. It was a goal to conduct the experiment in as short amount of time as

possible, to minimize the chance that the participants would know the setup or the solution of the problem. The group session was conducted over the course of 5,5 hours and the individual session over the course of 3 hours.

Figure 3a below shows the setup of the experiment. A corkboard was attached to the wall. Attached to the corkboard was a white A4 sheet of paper. The sheet of paper represented the “wall” during the experiment and was attached approximately 15 cm up from the surface of the table. The corkboard was attached to the wall with tack-it, and the sheet of paper was attached to the corkboard with tack-it as well. Two chairs for the participants were placed on either side of the table.

The participants were also provided with a candle (height approx. 9 cm, diameter 2 cm), a box of matches (length 5.8 cm, width 3.5 cm and height 1.8 cm), and a box (length 5.8 cm, width 3.3 cm and height 1.6 cm) containing approximately 40 tacks (see figure 3b below). The candle, box of matches and box containing the tacks were covered with a cloth until the experiment started. Outside the rooms where the experiment was taking place, a waiting area was set up. The set up for the individual session was as identical as possible, with the exception that the second chair by the table was removed. The experiment leader was seated approx. 3 meters diagonally away from the table, as out of sight as possible.

Figure 3 - Setup of the experiment



Figure 3a. Setup of the experiment.
(During the individual session one chair was removed).



Figure 3b. Articles available to the participants.

3.3. Procedure

In the group session, the participants were assigned to random pairs, if possible, with someone they did not know. In the waiting area, one participant from each pair was instructed to pick a number from a bowl; this number could either have the value of 1 or 2. A 1 indicated that the pair would be in the incentivized group, while a 2 indicated that they would be in the non-incentivized group. In the morning period of the group session, 16 pieces of paper were put in the bowl (8 numbered “1” and 8 numbered “2”). For the afternoon period, 16 new pieces of paper were put into the bowl (8 numbered “1” and 8 numbered “2”). For the individual session, 30 pieces of paper (15 numbered ‘1” and 15 numbered “2”) were put in the bowl at the start of the session.

The pair was, after drawing a number, sent randomly to one of the two rooms. After entering the room, the participants were instructed to sit down at each side of the table. The participants then handed the experiment leader the piece of paper with the number on, and in return received the first set of instructions outlining the experiment. The specific instruction was dependent on the number they had drawn earlier.

In the individual session, the participants picked a piece of paper with a number as they arrived and immediately entered an available room and followed the same procedure. The numbers on the piece of paper were the same and had the same significance as in the group session. The first set of instructions for the incentivized group in the group session is presented in figure 4 (for the original Norwegian version see appendix A1):

Figure 4 - First set of instructions

Welcome to the experiment.

Depending on how quickly you solve the coming problem you each have the opportunity to win NOK 1000 or NOK 200. The participants in the pair solving the problem the quickest will each receive NOK 1000, while the participants in the pairs solving the problem second and third quickest will each receive NOK 200.

You will cooperate in solving the problem, only the articles under the cloth may be used. The time will be measured.

You have 15 minutes available to solve the problem.

Any questions you have must be raised before the experiments starts.

Please indicate to the experiment leader when the aforementioned instructions are understood.

The instructions for the non-incentivized group were identical, except that the first paragraph (“Depending on how...”) was omitted, thereby just asking the participants in the non-incentivized group to cooperate to solve the problem in as little time possible (for the original Norwegian version, see appendix A1).

For a student, the possibility of winning NOK 1000 was deemed as a tempting prize. The prize amount is also roughly equivalent to the amount offered by Glucksberg (\$5/\$20 in 1960 equals NOK224/NOK896 in 2012¹⁷).

After the participants indicated that the instructions were understood, they handed them back to the experiment leader. Then, all participants in both sessions received an identical task description, and at the same time, the articles were uncovered and the time started.

The task description is presented in figure 5 (for the original Norwegian version see appendix A1).

Figure 5 - Task description

Tasks: Attach the candle to the wall, defined by the A4 sheet of paper, so that the candle can burn properly and that no wax will drip on the table or on the floor when the candle is lit. The candle cannot be in contact with the table.

The instructions to the participants in the individual session were as identical as possible, with the logical changes made to adjust the instructions from plural to singular (for the original Norwegian version see appendix A1).

The time would stop either when the problem was solved in accordance with the instructions given, or when the time limit was reached (15 minutes).

¹⁷ [Adjusted for inflation](#); \$5 (1962) = \$38.41 (2012), \$20 (1962) = \$153.65 (2012)

[Average of monthly exchange rate April \(5.7481\) and May 2012 \(5.9104\)](#) = 5.8293

\$38.41 = NOK 223.9 and \$153.65 = NOK 895.67.

After the participants had solved the problem, they would leave the room and go to the waiting area where they would receive NOK 100 for participating. The participants were also asked not to discuss the experiment before 3 p.m. in the group session and 12:30 p.m. in the individual session.

The articles (sheet of paper, matches, candle, tacks or boxes) that had any markings on them from previous use were replaced and the articles covered, and the experiment was then ready to be repeated. In both experiments, four participants were scheduled to arrive every 20 minutes.

In the group session, one extra participant was booked for the first two periods in the morning (9 a.m. and 9:20 a.m.) and the first two periods in the afternoon (12:20 p.m. and 12:40 p.m.). In case all five participants showed up, the last participant to arrive would receive NOK 100 for showing up and then asked to participate later (if so, the participant would again receive NOK 100). All four participants that were overbooked showed up to the experiment, two agreed to come back later and two received the money for showing up without any later participation. In the individual session, no over-booking was done.

After the entire experiment was completed, the participants who were to receive money were contacted by e-mail and given the option of either providing their bank details for wireless transfer of the prize, or receiving the prize in person. All participants in both sessions who were to receive a prize opted to have the money transferred online.

4. Results

This chapter will present the results from the experiment and the analysis done with the data. All of the analysis was done with the STATA software version 11.2. The results are presented in the following way; first there will be a subchapter containing the descriptive analysis, including a Box-and-Whisker plot. Then, there will be a subchapter with the statistical analysis consisting of a Mann-Whitney test and two regression analyses. The data from the experiment can be found in appendix A2.

To determine if any of the participants in either session had any prior experience with the “Candle Problem” they were, after completing the task, asked if they were familiar with the problem or the solution. This caused 1 pair from the incentivized group and 4 pairs from the non-incentivized group in the group session to be eliminated from further analysis. In the individual session, none of the participants answered that they had any prior knowledge of the experiment. This left a total of 15 pairs in the incentivized group and 10 in the non-incentivized group from the group session, and 13 participants in the incentivized group and 14 in the non-incentivized group from the individual session.

It is interesting to note that while none of the pairs in the group session failed to find a solution to the “Candle Problem” within the provided time limit (15 min), 4 in the incentivized and 4 in the non-incentivized group (7 female and 1 male) failed to find the solution in the individual session. This result has been noted as ‘15.00’ (see appendix A2). The analysis with only the participants who managed to solve the problem has been labeled “only successful participants.”

When the data was analyzed, it was found that *within* each session, there was no significant difference between the incentivized and non-incentivized participants. However, *between* the two sessions, there was a significant difference in the mean solution times. The participants who attempted to solve the problem in pairs had a lower mean solution time than the participants who attempted to solve the problem individually.

4.1. Descriptive Analysis

This sub-chapter will contain a descriptive table with some key statistics from the two sessions and a Box-and-Whisker plot.

Table 2 - Descriptive table, robust standard error in brackets

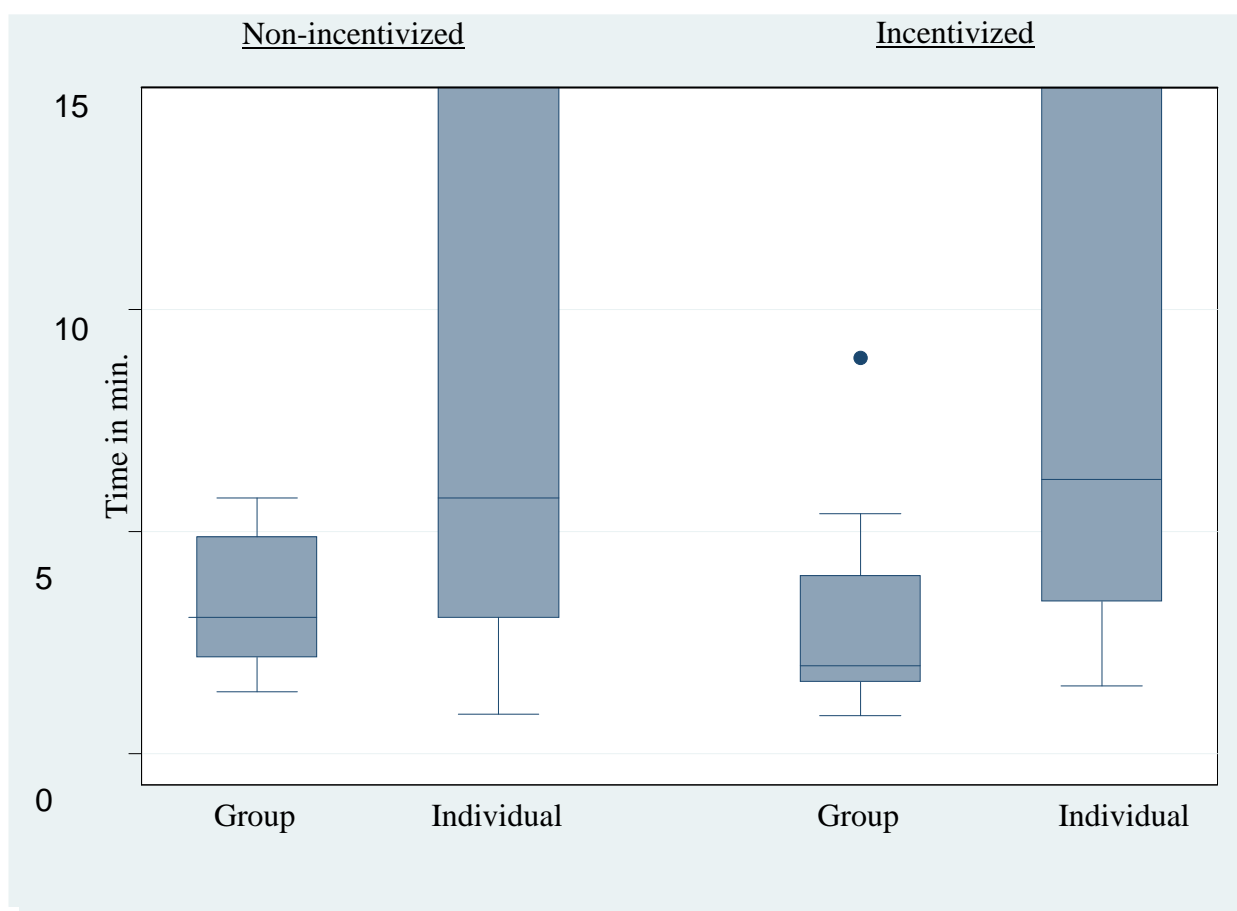
	Individual session		Group session	
	<u>Incentivized</u>	<u>Non-incentivized</u>	<u>Incentivized</u>	<u>Non-incentivized</u>
Mean	7.72 (5.43)	7.42 (5.27)	2.97 (2.07)	3.41 (1.55)
Median	6.17	5.7	1.98	3.23
Kurtosis/Skewness	0.078/0.404	0.196/0.248	0.016/0.004	0.16/0.891
Min	1.53	0.88	0.85	1.38
Max	15	15	8.9	5.75
Male (ratio)	0.23	0.36		
Male/Male (ratio)			0.27	0.2
Male/Female (ratio)			0.53	0.6
Number of failures	4	4	0	0
N	13	14	15	10

Time is measured in minutes.

In the group session, the three quickest solution times were 0.85 min, 1.38 min and 1.38 min. In the individual session, the three quickest solution times were 0.88 min, 1.53 min and 1.9 min.

Below is a graphical representation of the results from the experiment. The Box-and-Whisker plot graphically visualize the difference in the solution times in the two sessions under both the incentivized and the non-incentivized condition.

Figure 6 - Box-and-Whisker plot for the two sessions



The lower limit of the box is the 25th percentile (Q1), the line within the box is the 50th percentile (median) and the upper limit of the box is the 75th percentile (Q3). The bottom

whisker is the lower quartile minus 1.5 times the interquartile range, while the top whisker is the upper quartile plus 1.5 times the interquartile range¹⁸.

The mark above the top whisker in the incentivized group box is an outlier. The reason that the boxes from the individual session appear not to have a top whisker is due to the fact that a large enough proportion of the participants failed to find the solution to the problem within the provided time limit, thus creating a cluster of data at the top specter of the figure.

4.2. Statistical Analysis

The statistical analysis includes a Mann-Whitney test and a regression analysis. The results from the Mann-Whitney test will be presented first. The statistical analysis confirms what was possible to deduct from the Box-and-Whisker plot displayed earlier; the difference within each session was not significant while the difference between the sessions was significant. Additionally, a t-test was conducted and the results can be viewed in appendix A3.

4.2.1 Mann-Whitney test

A Mann-Whitney is a non-parametric rank-sum test that does not require that the sample belong to a normally distributed population. The kurtosis/skewness statistics presented in the descriptive table indicate that the population from where the samples for the experiment were drawn might not be normally distributed.

¹⁸ Interquartile range (IQR); a measure of dispersion, it is the difference between the upper (Q3) and lower quartile (Q1) (Upton & Cook, 1996).

The Mann-Whitney test indicates that there are no significant differences between the incentivized and the non-incentivized participants in either session. The z-value between the incentivized and the non-incentivized participants within the group session is 0.916 and within the individual session -0.098, neither which are a significant difference. Between the two sessions, however, the z-value is -3.44, which is a significant difference at a significance level of 1%.

4.2.2 Regression analysis

Two OLS-regressions were conducted for each session and between the two sessions. One in which the dependent variable was *Time* and one in which the dependent variable was the logarithm of *Time* labeled *lnTime*. The results can be viewed in the tables below.

The regressions were done to further explore any difference within each session, and to investigate if a difference between the sessions could be determined. There is also one column for only the successful participants in the individual session. The use of OLS implicitly assumes that the independent variables are exogenous, have no multicollinearity and that the error term has equal variance across the sample. The process of randomization and the nature of the data should ensure that these assumptions are fulfilled.

The first regression is a straightforward OLS-regression with *Time* as the dependent variable and dummy variables for gender, incentivized and the combination of male and incentivized (for the group session is this combination male/male and incentivized). This computes the size and sign of the change in the dependent variable of a change from 0 to 1 in the independent dummy variable. For the second regression, a new dependent variable was defined: *lnTime*, which is the logarithm of the variable *Time*. This regression had the same independent dummy

variables as the first regression. This *lnTime* regression was conducted to investigate if the relationship between the independent variables and the dependent variable could be non-linear. The interpretation of the coefficients from the *lnTime* regression is normally: when multiplied by 100, the percentage change in the dependent variable resulting from a one-percentage change in the independent variable. As this case involves dummy variables, the interpretation is somewhat different: the base of the natural logarithm, e , to the power of the coefficient of the independent variable, minus 1, multiplied by 100, gives the percentage change in the independent variable when the independent dummy variable changes from 0 to 1.

Table 3 - Regression analysis, dependent variable: *Time*, (standard errors in brackets)

Variable	Group	Individual	Individual (only successful participants)	All participants
Incentive	-0.536 (0.89)	-1.1 (2.401)	0.585(1.29)	-0.852 (1.27)
Male		-5.006 (-2.91)**	-0.372(1.39)	
Male ¹⁹				-3.918 (1.764)**
Male/Male	-1.284 (1.70)			
Female/Male	0.568 (1.00)			
Male x Incentivized		3.301 (4.51)	-2.677 (2.24)	
Male ²⁰ x Incentivized				2.681 (2.457)
Male/Male x Incentivized	0.83 (1.9)			
Group				-4.666 (1.09)***
Constant	3.33 (1.01)	9.21 (1.74)	4.574 (0.98)	8.38 (1.078)
R ²	0.111	0.123	0.17	0.312
N	25	27	19	52

***, **, * indicates a level of significance of respectively 1%, 5% and 10%.

¹⁹ In this instance, the male dummy is for both sessions, meaning there was either a male participant in the individual session, or a male/male group configuration in the group session.

²⁰ In this instance, the male dummy is for both sessions, meaning there was either a male participant in the individual session, or a male/male group configuration in the group session.

Table 4 - Regression analysis, dependent variable: *lnTime*, (standard errors in brackets)

Variable	Group	Individual	Individual (only successful participants)	All participants
Incentive	-0.285 (0.276)	-0.034 (0.381)	0.247 (0.36)	-0.161 (0.228)
Male		-0.52(0.462)	0.116 (0.389)	
Male ²¹				-0.549 (0.317)*
Male/Male	-0.496 (0.523)			
Female/Male	0.08 (0.31)			
Male x Incentivized		0.041 (0.715)	-0.896 (0.628)	
Male ²² x Incentivized				0.255 (0.441)
Male/Male x Incentivized	0.414 (0.583)			
Group				-0.779 (0.197)***
Constant	1.169 (0.31)	1.911 (0.28)	1.274 (0.28)	1.957 (0.193)
R ²	0.108	0.082	0.147	0.285
N	25	27	19	52

***, **, * indicates a level of significance of respectively 1%, 5% and 10%.

The regression analysis showed that the financial incentive caused no difference in the mean solution time between the incentivized and the non-incentivized participants in either session. However, the dummy variable *Male* in the individual session was significant at a 5%

²¹ In this instance, the male dummy is for both sessions, meaning there was either a male participant in the individual session, or a male/male group configuration in the group session.

²² In this instance, the male dummy is for both sessions, meaning there was either a male participant in the individual session, or a male/male group configuration in the group session.

confidence level in the *Time* regression. Furthermore, the *Male* dummy when all the participants were considered was significant at a 5% confidence level in the *Time* regression and at a 10% confidence level in the *lnTime* regression. In addition, the *Group* dummy was significant at a 1% confidence level in both regressions.

5. Discussion

This chapter contains a brief summary of the experiment, a more detailed discussion regarding the results, as well as some possible explanations for the results and suggestions for further research.

Two identical sessions of the “Candle Problem” have been conducted, the only difference being that in one session individual participants attempted to solve the problem, while in the other session, groups of participants attempted to solve the problem. The effects of the financial incentives have been investigated and the results from the two sessions have been compared.

From the data obtained from the experiment, there is no indication that the financial incentive had any effect on the level of performance. There exists no significant difference between the incentivized and the non-incentivized participants in either of the two sessions. The data suggest that the mean solution times in the group session are lower than the mean solution times in the individual session.

On the basis of the data collected during the experiment, hypotheses one and two are rejected and hypothesis three is not rejected, leading to the following three main conclusions to be drawn; firstly, the use of financial incentives did not affect the mean solution times of individuals in this version of the “Candle Problem.” Secondly, the use of financial incentives did not affect the mean solution times of groups in this version of the “Candle Problem.” Thirdly, participants working together in a group have a lower mean solution time than individuals in this version of the “Candle Problem.” Rather than using financial incentives, the results suggest that encouraging individuals to collaborate is a more effective way of improving performance in this version of the “Candle Problem.”

In addition, the data indicates that on an individual level, the mean solution time for males is lower than the solution time for females when all the participants in the individual session are considered. When only the successful participants are considered, no significant difference can be detected. The reason for this difference could be that 7 out of the 8 participants who did *not* manage to solve the “Candle Problem” before the time ran out were females. Furthermore, when all participants in both sessions are considered, the dummy variable *Male* is significant in both regressions. This possible gender difference is a thought-provoking indication and should both be considered as a possible factor in future designs of this experiment, as well as a conceivable starting point for research regarding gender differences in solving insight problems. The dummy variables *Male*Incentivized* and *Male/Male*Incentivized* was not found to be significant. Neither when all participants in the experiment were considered could any effect of “male and incentivized” be detected.

The results from the individual session do not match the results attained by Glucksberg. There are, however, a number of differences between this version and Glucksberg’s which could explain this difference. In this version of the experiment, both females and males participated, whereas Glucksberg only had male participants. This gender difference is a potentially significant factor, especially when considering that the significance of the *Male* dummy in parts of the regression. The reason for having both genders participating was mostly of a practical nature; by allowing both genders to participate, the recruitment process was expected to be easier. Additionally, in the other versions of the “Candle Problem” referred to in this thesis, participants of both genders were used. It was also not within the scope of this thesis to investigate possible gender differences.

Two regressions analyses with only the male participants from both sessions were conducted, with respectively *Time* and *lnTime* as the dependent variables, and “*Incentive*” and “*Group*” as the independent dummy variables. None of the dummy variables were found to be significant.

There were also some differences in the articles available to the participants; in this version the participants were given a box of matches, compared to the participants in Glucksberg’s experiment, who were given a book of matches. The reason for this difference is that the books of matches are no longer available in Bergen. A sheet of A4 paper defined the “wall” in this experiment, whereas in Glucksberg’s experiment, the wall was a 36*24 inch corrugated paper board. The sheet of paper might have been perceived as flammable and this might have caused some participants not to opt for attempting to attach the candle to the “wall” by melting wax. Some participants did ask if they could use the sheet of paper in their solution; they were told that this was not an option. The reason for this “wall” modification was to ensure that the “wall” could be replaced easily so that no marking of prior participants would be visible. In addition, the use of plain paper was the more cost-effective option.

The instructions to the participants in this recent experiment also differed from the ones used by Glucksberg. Glucksberg’s instructions to the non-incentivized participants included a paragraph stating; “We are doing pilot work on various problems in order to decide which will be the best one to use in an experiment we plan to do later. We would like to obtain norms on the time needed to solve.” For the incentivized participants, Glucksberg included a paragraph saying: “Depending on how quickly you solve the problem you can win \$5.00 or \$20.00. The 25% of the Ss (i.e. participants) in your group will win \$5.00 each; the best will receive \$20.00. Time to solve will be the criterion used” (Glucksberg, 1962). Brackets added. There are two main differences between Glucksberg’s instructions and the ones used in the

experiment for this thesis. First, Glucksberg's instructions informed the non-incentivized participants that they were part of a pilot study, and did not mention anything about a time limit. Glucksberg's reason for omitting information about the time limit was to make the participants think it was the problem that was being tested and not the participants themselves. Secondly, the instructions to the incentivized participants said that the top 25% will be rewarded; the instructions did not specify how many people this would include.

The fact that the instructions to the non-incentivized participants do not mention anything about the time available to solve the problem has an important implication; there is the possibility that the competition aspect, as well as the financial incentive, influenced the performance of the participants in the incentivized group in Glucksberg's experiment. Some of the explanation for the difference in the results between the two experiments could be due to the competition aspect and not the financial incentive per se. It was a goal for the experiment conducted in relation to this thesis to be able to isolate the effect of the financial incentive from any possible effects of the competition aspect. Therefore, both the incentivized and the non-incentivized participants in this recent version were informed that they had 15 minutes available to solve to problem.

There are also some general aspects of conducting an experiment that could have implications on the results. The fact that the individuals knew that they were participants in an experiment might have caused them to expect a non-conventional solution. The participants in this recent experiment might have been more accustomed to partaking in experiments and thus, to a larger degree than in Glucksberg's case, could have anticipated this type of unconventional solution.

Another possible explanation for the results is the selection process of the participants. As outlined, the participants were mainly first year students. In addition, the invitations for the

group session were sent out to people who had earlier indicated interest in participating in experiments. These particular individuals were from different fields of study and in different years. At least 14 participants were from the latter group, so it is safe to assume that a certain amount of the participants in the group session were not first year students. In addition, due to some participants failing to show up to the experiment, random people were asked to partake, this totaled 4 participants in the group session and 6 participants in the individual session (these were not necessarily first year students either). Perhaps individuals who had been studying for several years react differently to financial incentives, or the “Candle Problem” itself, than first year students.

The real life applications of the results are rather limited. A real life work place is a lot more complex and unpredictable than this experiment can account for. The types of tasks employees face also differ both in their complexity, scale and scope. These differences make it difficult to draw any relevant conclusions from the results in the experiment. It is, however, important to note that through experiments and future research, it might be possible to identify factors that have a determining effect on performance.

Suggestions for future research

On the basis of the results from the experiment, a natural continuation would be to replicate the setup with a larger sample to see if the findings can be confirmed, and if any additional conclusions can be made. Given the indications of a gender difference in the individual session, it would be interesting to further examine if this difference could also be detected in a group setting with all female and all male groups. It would also be interesting to have the participants attempt a range of different insight problems to rule out any problem specific

properties. It could also be possible to compare individuals who have studied for several years against first year students to see if there exist any differences.

A replication of Glucksberg's experiment would also be useful to investigate if his findings can be reproduced. This would include only male participants, altering the instructions and replacing some of the articles.

6. Appendix

Appendix A1. Invitation and instructions

*Invitation*²³ (Norwegian).

(Emnefeltet på e-posten: Invitasjon til å være med på økonomisk eksperiment.)

Du er invitert til å være med på gjennomføringen av et eksperiment som handler om problemløsning.

Eksperimentet vil ta ca. 20 minutter og vil bli gjennomført torsdag 26. april i rom 105 og 106 i Lauritz Meltzers hus (SV-bygget) i Fosswinckelsgate 6.

Eksperimentet går ut på å løse et praktisk problem og ingen forkunnskaper er nødvendig. Alle deltagerne vil motta kr 100 for oppmøte.

Vennligst gå inn på en av websidene under ved å klikke på linken og meld deg på et av tidspunktene med ledig plass.

- For å melde deg på formiddagssesjonen (kl. 09.00 – 11.20), vennligst bruk følgende link: [www...](#)
- For å melde deg på ettermiddagssesjonen (kl. 12.20 – 14.20), vennligst bruk følgende link: [www...](#)

Eventuelle spørsmål kan rettes til Joachim.ramm@student.uib.no eller på tlf. 452 925 99

På forhånd tusen takk.

Vennlig hilsen

Joachim Ramm

²³ These are the instructions sent out to the potential participants for the group session. The invitation for the individual session was identical with the exception of the time and date.

Invitation (English translation).

(Subject: Invitation to participate in economic experiment)

You have been invited to participate in an experiment involving problem solving.

The experiment will last approximately 20 minutes and will be conducted Thursday 26. April, in room 105 and 106 in Lurtiz Meltzers house (SV-building) in Fosswinkelsgate 6.

The experiment involves solving a practical problem and no prior knowledge is required. All participants will receive NOK 100 for attendance.

Sign up on one of the available times by following the links to the website under:

- To participate in the morning session (09.00 – 11.20), please use the following link:
www...
- To participant in the afternoon session (12.20 – 14.20), please use the following link:
www...

Any questions can be directed to Joachim.ramm@student.uib.no or phone number: 452 925 99.

Thank you in advance.

Kind regards

Joachim Ramm

Instructions, the incentivized group, group session (for English version see chapter 3).

Velkommen til eksperimentet.

Avhengig av hvor hurtig dere løser det kommende problemet vil dere hver ha muligheten til å vinne kr 1000 eller kr 200. Deltagerne i paret som løser problemet hurtigst vil motta kr 1000 hver, men deltagerne i de parene som løser problemet nest og tredje hurtigst vil motta kr 200 hver.

Dere skal nå i samarbeid forsøke å løse problemet, kun artiklene under duken kan benyttes. Tiden vil bli målt.

Der har 15 minutter tilgjengelig for å løse problemet.

Eventuelle spørsmål må tas opp før eksperimentet starter.

Vennligst indiker til eksperimentleder når de overnevnte instruksjonene er forstått.

Instructions, the non-incentivized group, group session (for English version see chapter 3).

Velkommen til eksperimentet.

Dere skal nå i samarbeid forsøke å løse et problem, kun artiklene under duken kan benyttes. Tiden vil bli målt.

Der har 15 minutter tilgjengelig for å løse problemet.

Eventuelle spørsmål må tas opp før eksperimentet starter.

Vennligst indiker til eksperimentleder når de overnevnte instruksjonene er forstått.

Task description (for English version see chapter 3).

Oppgave: Fest lyset til veggen, definer av A4-arket, slik at lyset kan brenne skikkelig, og ikke noe stearin vil dryppe på bordet eller gulvet når lyset er tent. Lyset skal ikke være i kontakt med bordet.

Instructions, the incentivized group, individual session (for English version see chapter 3).

Velkommen til eksperimentet.

Avhengig av hvor hurtig du løser det kommende problemet vil du ha muligheten til å vinne kr 1000 eller kr 200. Deltageren som løser problemet hurtigst vil motta kr 1000, mens deltagerne som løser problemet nest og tredje hurtigst vil motta kr 200 hver.

Kun artiklene under duken kan benyttes. Tiden vil bli målt.

Du har 15 minutter tilgjengelig for å løse problemet.

Eventuelle spørsmål må tas opp før eksperimentet starter.

Vennligst indiker til eksperimentleder når de overnevnte instruksjonene er forstått.

Instructions, the non-incentivized, individual session (for English version see chapter 3).

Velkommen til eksperimentet.

Du skal nå forsøke å løse et problem, kun artiklene under duken kan benyttes. Tiden vil bli målt.

Du har 15 minutter tilgjengelig for å løse problemet.

Eventuelle spørsmål må tas opp før eksperimentet starter.

Vennligst indiker til eksperimentleder når de overnevnte instruksjonene er forstått.

Appendix A2. Data from the experiment

Observation	Time	Group	Incentive	Male	Male/Male	Female/Male
1	1.5	1	1	-	1	0
2	1.47	1	0	-	1	0
3	1.8	1	1	-	1	0
4	2.62	1	0	-	1	0
5	3	1	1	-	1	0
6	3.05	1	1	-	1	0
7	0.85	1	1	-	0	1
8	1.38	1	0	-	0	1
9	1.38	1	1	-	0	1
10	1.6	1	1	-	0	1
11	1.98	1	1	-	0	1
12	2.68	1	0	-	0	1
13	3.27	1	1	-	0	1
14	3.78	1	0	-	0	1
15	4.01	1	1	-	0	1
16	4.37	1	0	-	0	1
17	4.88	1	0	-	0	1
18	5.4	1	1	-	0	1
19	5.75	1	0	-	0	1
20	8.9	1	1	-	0	1
21	1.6	1	1	-	0	0
22	1.98	1	1	-	0	0
23	2.17	1	0	-	0	0
24	4.27	1	1	-	0	0
25	5.01	1	0	-	0	0

26	1.53	0	1	0	-	-
27	1.9	0	1	1	-	-
28	2.32	0	1	1	-	-
29	3.42	0	1	0	-	-
30	3.97	0	1	0	-	-
31	5.37	0	1	0	-	-
32	6.17	0	1	0	-	-
33	7.48	0	1	0	-	-
34	8.17	0	1	0	-	-
35	15	0	1	0	-	-
36	15	0	1	1	-	-
37	15	0	1	0	-	-
38	15	0	1	0	-	-
39	0.88	0	0	0	-	-
40	2.45	0	0	0	-	-
41	2.82	0	0	1	-	-
42	3.07	0	0	1	-	-
43	3.72	0	0	1	-	-
44	5.52	0	0	1	-	-
45	5.52	0	0	0	-	-
46	5.88	0	0	1	-	-
47	6.75	0	0	0	-	-
48	7.27	0	0	0	-	-
49	15	0	0	0	-	-
50	15	0	0	0	-	-
51	15	0	0	0	-	-
52	15	0	0	0	-	-

Appendix A3. Results from the unpaired two-sample t-test with equal variances

Session	Treatment	Number of observations	Mean time (min)	Std. Error (min)	Comparison of the two levels of treatment, t-value (p-value in brackets)	Comparison of the two sessions, t-value (p-value in brackets)
Group session	Incentivized	15	2.97	0.53	-0.569 (0.575)	
		10	3.41	0.49	0.145 (0.886)	
Individual session	Non-incentivized	13	7.72	1.41		
		14	7.42	1.51		
Comparison of the two sessions (all participants)	From session one	25	3.15	0.37		-3.98 *** (0.000)
	From session two	27	7.56	1.001		
Comparison of the two sessions (only "successful" participants)	From session one	25	3.15	0.37		-2.1 ** (0.042)
	From session two	19	4.43	0.505		

***, **, * indicates a significance level of respectively 1%, 5% and 10%

Appendix A4. Budget

Session 1 (26. April)

Over booking 4*100	400
Attendance fee 60*100	6000
2 nd & 3 rd place 4*200	800
1 st place 2*1000	2000
Materials	485

Session 2 (7. June)

Attendance fee 27*100	2700
2 nd & 3 rd place 2*200	400
1 st place 1*1000	1000
Materials	406

Total	14191
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All denominations are in NOK.

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