

# “Is the Missing 1 Dollar in the Cheater’s Hand ?” : The Cheater Detection Module as a Constraint within Insight Problem Solving

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## Abstract

Previous studies (Cosmides, 1989; Gigerzner & Hug, 1992; Hasegawa & Hiraishi, 2000) have shown the Cheater Detection Module (CDM) to be an adaptive heuristic within social environments and that it can improve human reasoning in many social exchange contexts. The purpose of this study is to examine the effects of the CDM on problem solving. To that aim, the ‘30-dollar room’ problem (Isaak & Just, 1992) is employed, which involves a social exchange context.

Generally speaking, we use heuristics to efficiently solve normal problems. While heuristics can function effectively in practical contexts, they can also be obstacles to solving insight problems (Knoblich, 1999; Hiraki & Suzuki, 1997). We hypothesize that the CDM will make it difficult to find the correct answer for this insight problem.

In order to investigate this hypothesis, we compare solution rates for the standard ‘30-dollar room’ problem with isomorphic problems that do not involve ‘social exchange’ contexts. The results indicate that the solution rates for the isomorphic problems were higher than for the standard version of the problem. The results are supportive of our hypothesis.

There are two implications from the present findings. Firstly, the results indicate that there are situations in which the CDM has a negative influence. Secondly, there are cognitive constraints that emerge in adaptation to social environments.

## Purpose

Humans are better at solving concrete problems than abstract problems. In particular, reasoning ability is more effective in practical and social situations that involve human interaction. In such situations, social exchange heuristics affect the reasoning process. Cosmides (1989) suggested that human have a cognitive mechanism for detecting cheaters (Cheater Detection Module:CDM) in order to sustain collaborative relationships. We can solve a difficult reasoning task (for example, Wason’s selection task) easily when the heuristic works (Cosmides, 1989; Gigerzner & Hug, 1992; Hasegawa & Hiraishi, 2000). However, in insight problems, heuristics interfere with solving problems as a kind of cognitive constraint. We may, therefore, assume that social exchange heuristics will interfere when solving a problem that involves some social context. The purpose of this study is to examine whether the CDM can make a problem insightful when the CDM fulfils a constraint role.

## The Cheaters Detection Module

Recently, the importance of adaptability to social environments within the human reasoning process has been high-

lighted. Humans working together can confront problems that individuals alone cannot handle. In such a case, humans develop collaborative relationships, and handle the problem situation within the collaborative group. Accordingly, the development and maintenance of collaborative relationships can be seen as an important task in terms of human adaptability. One skill that is clearly important for developing collaborative relationships would be that of detecting a cheater early. Cosmides(1989) argued that humans must acquire the cognitive capabilities to detect cheaters. The CDM is one of these cognitive capabilities. Using the CDM, human can detect cheaters who violate the ‘social exchange’ rule of ‘If you receive some benefit, then you should bear the costs’. The CDM is a kind of heuristics in the sense that it is a fast and effective function for human reasoning. Humans can focus on some information for solving problem using the CDM.

## Insight Problem Solving

Humans use not only the CDM but many other heuristics in problem solving. Using heuristics allows us to answer a question efficiently and quickly. However, heuristics do not necessarily lead us to the correct answer. It is highly probably that heuristics can lead us in the wrong direction as forms of cognitive constraints or biases that effectively conceal some important information for insight problem.

The word “insight” is defined as the process by which the significance of the solution to a problem suddenly become clear. Previous studies have pointed out that the main difficulty factor in solving insight problems is our cognitive constraints. Such constraints include common sense, bias, and stereotypes. Heuristics can also be included. Generally speaking, we can solve a problem effectively by using some heuristics. However, in the case of insight problems, these heuristics can work as cognitive constraints in concealing some important bits of information necessary for solving the problem. Cognitive constraints not only filter out irrelevant information, but also important information(Hiraki & Suzuki, 1997; Knoblich et al., 1999).

Many studies of insight problem solving focus on cognitive constraints and their resolution process(Knoblich et al., 2001; Suzuki et al., 2001; Terai & Miwa, 2006). However, such studies have tended to conduct psychological experiments using only graphic puzzles or algebraic puzzles. The

puzzles used in previous studies are not practical problem situations. In other words, previous studies which focused primarily on cognitive constraints do not examine social and practical problem situations. What are the constraints on insight problems that involve social situation?

### Hypothesis

In this study, we hypothesize that in the case of an insight problem with a social context, the CDM will affect problem solving as a kind of constraints. The CDM is a kind of heuristics that enhances human reasoning in social exchange contexts. On the other hand, in insight problem solving, heuristics about a problem can make it difficult to find the correct answer. Thus, the CDM makes it difficult to find the correct answer to insight problems that have a social context.

To examine this hypothesis, it is necessary to use an insight problem that involves a social context. This study uses the '30-dollar room' problem, which is regarded as a kind of insight problem (Isaak & Just, 1995). Furthermore, this problem entails a 'social exchange' situation as an interaction between multiple characters. In this study, the problem description was adjusted for a Japanese context. The problem was described as an 'Accommodation fee problem', as follows:

Three travelers came to a motel and decided to share one room. The clerk registered them for 30,000 yen. Each of the travelers pitched in with 10,000 yen. After a while, the hotel manager realized that the special rate for that day was 25,000 yen, so he passed the clerk 5,000 yen and told him to return the money to the travelers. On his way to the room, the clerk decided to return only 3,000 yen to the travelers and he kept the other 2,000 yen. Therefore, each of the travelers wound up paying 9,000 yen for the room. As 9,000 yen times 3 equals 27,000 yen, and the clerk kept 2,000 yen, the total works out to be 29,000 yen. What happened to the other 1,000 yen?

It should be noted that most participants who attempt to solve this problem tend to locate the whereabouts of missing 1,000 yen (Yamazaki & Miwa, 2001). However, it is incorrect to seek the whereabouts of the missing 1,000 yen. The problem turns on a misleading description of the event. The incoherence is in the sentences "As 9,000 yen times 3 equals 27,000 yen, and the clerk kept 2,000 yen, the total works out to 29,000 yen". Actually, the amount of 27,000 yen that the travelers paid includes the 2,000 yen that was kept by the clerk. There is, however, a double counting error saying that another 2,000 yen should be added to the 27,000 yen.

This 'accommodation fee problem' does not require participants to use advanced knowledge or mathematic ability. Nevertheless, most participants overlook the double counting error in the problem description. This tendency is consistent with the notion advanced in previous studies (Suzuki et al., 2001; Terai et al., 2006) that participants overlook important information within a problem during the early stage

of insight problem solving. In order to solve the problem, participants need to identify the double counting error in the problem description. Discovering the double counting error makes it possible for participants to give the correct explanation to the question.

In this paper, we hypothesize that the CDM will conceal the double counting error. Due to the CDM, participants will focus on the description of the clerk's embezzlement. Thus, participants will try to explain the whereabouts of the 1,000 yen as a result of the clerk's embezzlement. In other words, participants will regard the purpose of this problem as being about identifying the criminal who has embezzled 1,000 yen rather than discover the problem with the description. Therefore, we hypothesize that participants will focus on the clerk's embezzlement, and will overlook the double counting error. In order to examine this hypothesis, we conducted a psychological experiment with an isomorphic problem to the 'accommodation fee' problem which does not have a social exchange context.

### Experiment 1

In order to examine our hypothesis that the CDM interferes with insight problem solving as a constraint, Experiment 1 compared performance for the 'accommodation fee' problem to that of an isomorphic problem called the 'old newspaper' problem, as follows.

One day, three residents of an apartment tried to dispose of some old newspapers. The janitor received 30 old newspapers from them. Each of the residents disposed of 10 newspapers. After a while, the disposal service said that while it would be possible to dispose of 25 of the old newspapers, it would not be possible to take the rest. So the disposal service returned 5 newspapers to the janitor and told him to take them back to the residents. However, the janitor just returned 3 newspapers to the residents and disposed of the other 2. Therefore, each of the residents disposed of 9 newspapers. As 9 times 3 is 27, and the janitor disposed of 2 newspapers, this works out to be 29. What happened to the other newspaper?

In this problem, the residents, janitor and the disposal service engage in the disposal of old newspapers, which does not involve any exchange of money or services. This problem description also contains the same calculation error as the 'accommodation fee problem'. In Experiment 1, the participants were asked to answer the following questions.

**Q1.** Where did the last 1,000 yen (1 copy) go?  
(Answer: There is no missing money (copy).)

**Q2.** Do you think the description of the problem is strange? Why do you think it strange?  
(Answer: The clerk's money (2 copies) should not be added to the 27,000 yen (27 copies); it should be subtracted.)

According to our hypothesis, in the ‘accommodation fee’ problem, the participants will attempt to locate the whereabouts of the missing 1,000 yen, focusing on the description of the clerk’s embezzlement as a clue. Therefore, in answer to Q1, participants will answer that the clerk has the missing 1,000 yen. Furthermore, in the answer to Q2, participants will refer to the embezzlement by the clerk.

On the other hand, because the ‘old newspaper’ problem does not contain a description of embezzlement like the ‘accommodation fee’ problem, the CDM will not interfere with the participants’ solving of the problem. Therefore, the participants in this problem will find it easier to discover the correct answer than the participants in the ‘accommodation fee’ problem.

**Method**

**Participants** In total, 198 undergraduate students participated, and 101 participants were assigned to the ‘accommodation fee’ group, while 97 participants were assigned to the ‘old newspaper’ group.

**Procedure** This experiment employed the questionnaire method. In order to examine the contents of the participants’ error, no time limit was set for the question in this experiment.

**Result**

Table 1 presents the solution rates. In this analysis, the participants who responded with the correct answers to both questions are defined as resolvers. The number of resolvers in the ‘old newspaper’ is significantly higher than in the ‘accommodation fee’ (see Table 1,  $Z = 2.29, p < 0.05$ ).

The pie charts in Fig.1 present the responses to Q1, ‘Where has the last 1,000 yen (1 newspaper) gone ?’. The right chart is the results for the ‘old newspaper’ group, while the left chart is the results for the ‘accommodation fee’ group. In the ‘old newspaper’ group, the participants answered ‘somebody has it’ (3%), ‘the residents have it’ (7%), ‘the disposal service has it’ (7%). The percentage of the answers mentioning the ‘janitor’, who corresponds to the ‘clerk’ in the ‘accommodation fee’ problem, was 2%.

On the other hand, in the ‘accommodation fee’ group, 9% of the participants answered the ‘clerk has the missing 1,000 yen’. Answers mentioning the ‘manager’ were given by 5% of participants, while 6% said the ‘travelers’, and 12% of the participants wrote nonsense words. In the ‘accommodation fee’ group, around 21% of participants tended to believe that someone had received the missing 1,000 yen.

These results indicate that ‘accommodation fee’ groups tended to seek an explanation for the whereabouts of the missing 1,000 yen in terms of the clerk’s embezzlement. How-

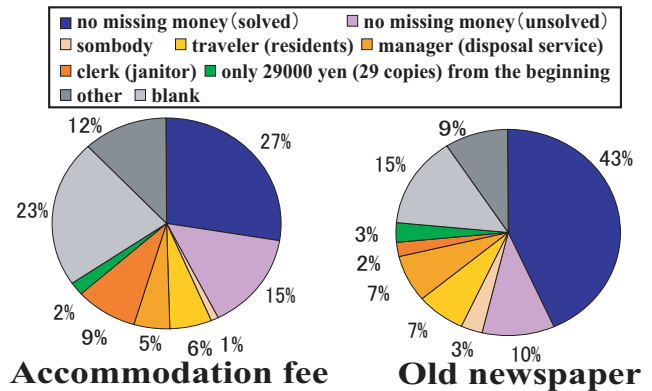


Figure 1: The responses to Q1 in Experiment 1

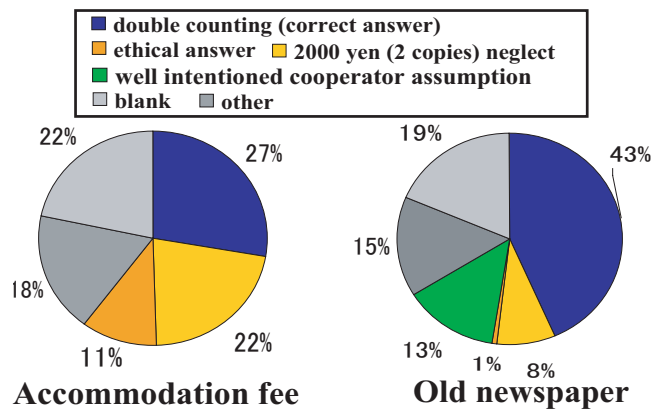


Figure 2: The responses to Q2 in Experiment 1

ever, in the ‘old newspaper’ group, the participants tended not to focus on the actions of the janitor, which would corresponded to the clerk’s embezzlement in the ‘accommodation fee’ problem.

The pie charts in Fig.2 present the responses to Q2, ‘Do you think there is something strange about the description of the problem? Why did you think it is strange?’. The right chart is the results for the ‘old newspaper’ group, while the left chart is the results for the ‘accommodation fee’ group. In the ‘accommodation fee’ group, 11% of the participants answered that ‘It is strange that the clerk embezzled the money, and he should not get the traveler’s money’ (in this paper, this type of answers are referred to as an ‘ethical answer’). Some of them (22%) answered that ‘The accommodation fee is 25,000 yen, 3,000 yen was returned to the travelers, so the total is 28,000 yen, and 28,000 divided by 3 is more than 9,000, so the description that each of the travelers wound up paying 9,000 yen for his room is wrong’ (this type of answers is referred to as ‘2,000-yen neglect’).

Table 1: The solution rate of experiment 1

Accommodation fee	Old newspaper
27%(28/101)	43%(42/97)

On the other hand, in the ‘old newspaper’ group, the participants tended to explain the disappearance of the old newspaper as being defraying by somebody (see Fig.2 ‘well-intentioned cooperator assumption’). The participants in the ‘old newspaper’ group tended to answer as follows: “The disposal service received 25 copies. Three copies were returned to the residents, so the total is 28 copies, and 28 divided by 3 is more than 9. So, the description that each of the residents disposed of 9 copies is wrong”. This type answer corresponds to the ‘2,000-yen neglect’ error which the ‘accommodation fee’ group made. However, most of the participants in the ‘old newspaper’ group were not suspicious about the disposal of newspapers by the janitor (see Fig.2 ‘ethical answer’).

The results of the Experiment 1 show that the ‘old newspaper’ problem that does not involve a social exchange context is easier to find correct answer than the ‘accommodation fee’ problem that contains a social exchange context. These results support our hypothesis that the CDM has a negatively influence on solving for insight problems that have a social exchange context.

In the ‘old newspaper’ group, most of the participants did not mention the janitor who corresponds to the clerk in the ‘accommodation fee’ problem. Rather, they tended to think that somebody had somehow undertaken the task of disposing of the extra one copy. This result suggests that the participants’ attention was focused not only on cheaters but also on the victims having to do some unjust labor. In other words, the participants tend to avoid any sense of inequity. In the second experiment, we used another version of the ‘accommodation fee’ problem, with an added description of the clerk paying compensation for his embezzlement. We compared performance for this second version of the ‘accommodation fee’ problem with the original ‘accommodation fee’ problem.

## Experiment2

In Experiment 2, in order to examine the effect of the inequity, we used the another version of the ‘accommodation fee’ problem added a description that the clerk paid a compensation for his embezzlement. Another version of the ‘accommodation fee’ problem was named ‘compensation version’.

Three travelers came to a motel and decided to share one room. The clerk registered them for 30,000 yen. Each of the travelers pitched in with 10,000 yen. After a while, the hotel manager realized that the special rate for that day was 25,000 yen, so he passed the clerk 5,000 yen and told him to return the money to the travelers. On his way to the room, the clerk forgot to return 2,000 yen to the travelers and only returned 3,000 yen. So, the clerk presented them with souvenirs to the value of 2,000 yen as compensation. Therefore, each of the travelers wound up paying 9,000 yen for the room. As 9,000 yen times 3 is 27,000 yen, and the clerk kept 2,000 yen, the total works out to be 29,000 yen. What happened to the other 1,000 yen?

While the ‘compensation version’ of the problem is based on the same situation as the ‘accommodation fee’ problem, it has the added description ‘So, the clerk presented them with souvenirs to the value of 2,000 yen as compensation’. Moreover the comment that ‘the clerk forgot to return 2,000 yen’ is without malicious intent. We assume that with this version that the participants do not experience as sense of inequity towards the clerk’s behavior because he makes compensation for the mistake. Thus, we expect that the participants who solve the ‘compensation version’ will tend not to focus on the mistake, and as a consequence, the solution rate for the ‘compensation version’ is expected to be better than for the original ‘accommodation fee’ problem.

## Method

**Participants** In total, 106 undergraduate students participated. and all were assigned to the ‘compensation’ group and required to solve the ‘compensation version’ of the problem.

**Procedure** This experiment was also conducted with the questionnaire method. The questionnaire consisted of the same questions used in Experiment 1. The participants were asked to complete the questionnaire without any time restrictions.

## Result

The solution rate was defined in the same way as in the Experiment 1. The solution rate for the ‘compensation’ group in Experiment 2 is significantly higher than that for ‘accommodation fee’ group in Experiment 1 ( $Z = 2.49, p < 0.05$ ). This result is consistent with our hypothesis that focusing participants’ attention on to the violation of the social exchange rule interferes with their problem solving.

Table 2: Comparison of the solution rates for the accommodation fee group in Experiment 1 and the compensation group in Experiment 2

Accommodation fee	Compensation
27%(28/101)	44%(47/106)

The pie charts in Fig.3 presents the responses to Q1. The right chart is result for the ‘compensation’ group, while the left chart is results for the ‘accommodation fee’ group in Experiment 1. In the ‘compensation’ group, the participants answered ‘somebody has it’(1%), ‘the travelers have it’(3%), or ‘the clerk has it’(3%). The answers saying that ‘the hotel manager has it’ represented 7%. However, 11% of the participants answered that there is no missing money, even though they did not point the double counting error.

The pie charts in Fig.4 present the responses to Q2, showing that 17% of the participants in the ‘compensation’ group made the ‘2,000-yen neglect’ error. However, 5% of the participants in the ‘compensation’ group answered that ‘It was unfair for the clerk to compensate the travelers in souvenirs

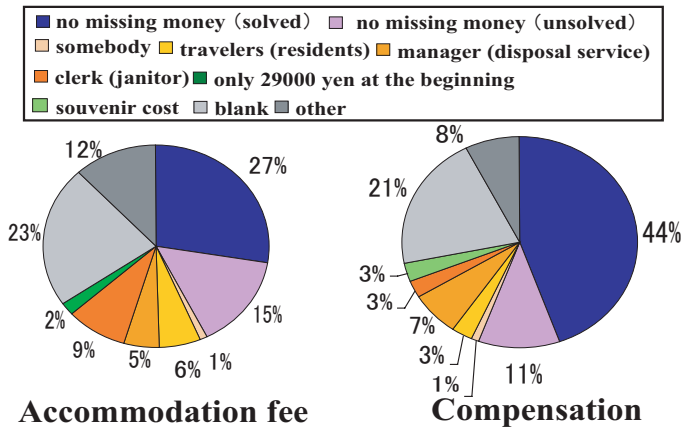


Figure 3: Responses to Q1 in Experiment 2

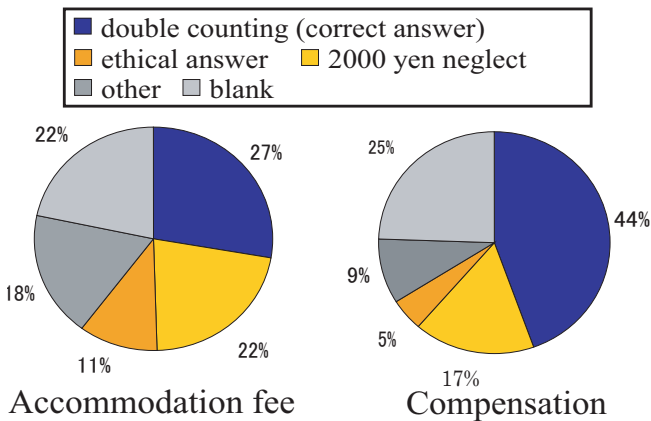


Figure 4: The responses to Q2 in Experiment 2

rather than money’, writing that ‘the clerk should return the 2,000 yen to the travelers’ (see “ethical answer” in Fig.4).

In the ‘compensation’ version, the description of the clerk’s embezzlement in the original version is presented as a careless mistake. Moreover, the description about compensation being made is also added. As a result, the participants in the ‘compensation’ group were significantly better at solving the problem than the ‘accommodation fee’ group in Experiment 1. This result suggests that hearing that the clerk made some compensation lowered the level of participants’ distrust towards him, and in not becoming focused on an act of embezzlement, more of the participant in the ‘compensation’ group were able to detect the double counting error.

### General Discussion

In Experiment 1, participants failed to detect the double counting error that is the key to solving the ‘accommodation fee’ problem. However, in the ‘old newspaper’ problem that does not involve a social exchange situation, the participants were better at noticing the double counting error. The participants who failed to solve the ‘accommodation fee’ problem

tended to mention the clerk’s embezzlement. Some of participants tried to explain incoherencies in the problem description, but ignoring the embezzled 2,000 yen.

In Experiment 2, we employed a different version of the ‘accommodation fee’ problem which we called the ‘compensation version’. In the description for the ‘compensation version’, the clerk makes compensation in the form of souvenirs for the money that he failed to return. The solution rate for the participants in the ‘compensation’ group was higher than that of the participants in the ‘accommodation fee’ group in Experiment 1. This result indicates that if the situation does not involve an unfair cheater, the participants are more likely to find the correct answer, even when the problem description does involve some social exchange context.

These results suggest that the CDM lead the participants to focus on the clerk’s embezzlement. The participants overlooked the double counting error which is the key to the problem because they focused the attention on the act of embezzlement. Thus, these results are consistent with our hypothesis that the CDM has a negative influence on insight problem solving involving social contexts.

### Conclusions

This paper has used the ‘accommodation fee’ problem in order to examine our hypothesis that CDM interferes with problem solving in insight problem involving social contexts. The CDM is useful in daily problem solving situations. However, there are situations where the CDM exerts a negative influence on problem solving as a form of cognitive constraint.

Two suggestions emerge from this study. First, the CDM has a negative effect as a constraint on the insight problem solving process. Second, there are constraints that functions within social insight problems. Some recent studies of insight problem solving have postulated that constraints are created by short-term cognitive tasks and training within experimental setting (Terai, Miwa 2006; Wajima, Nakagawa, Abe, 2007). However, it is probable that humans acquire some forms of constraint without special prior training. If we regard constraints as a form of adaptive function within our daily cognitive activities, it makes sense to conceive of such constraints as developing through daily, social cognitive activities. The CDM is one kind of constraint that can facilitate some forms of daily problem solving, but can also interfere with some kinds of social insight problems.

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