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DECISION MAKING WITH INFORMATION SEARCH CONSTRAINTS: A PROCESS TRACING STUDY

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The present study examined the influence of information search constraints both on the information search pattern and on the perceived inner states during the decision making process. We arranged the following three information search constraints conditions: (1) An upper-limited-search (UL) condition in which a decision maker could not examine the same piece of information for the decision task more than once, (2) A lower-limited-search (LL) condition in which a decision maker had to examine every piece of information for the decision task more than once, and (3) A non-limited-search (NL) condition in which a decision maker could examine any number of information. Participants consisted of 76 female and male university students, which were randomly assigned into one out of three conditions. In line with the simplifying and the mobilizing hypotheses, the participants in the UL condition more often used non-compensatory simplifying decision strategies and more slowly checked for information than participants in the LL and NL conditions.

1. Introduction

Previous research on human decision making has indicated that it's process is contingent on task characteristics. One of the most eminent task characteristics is task complexity which is usually defined by the number of alternatives, and by the number of attributes (Payne, 1982; Westenberg & Koele, 1994), or by time pressure (Payne, et al., 1988). Generally, when a decision task is comparatively complex, decision makers tend to use simplifying decision heuristics such as non-compensatory decision strategies in which low attribute values cannot be compensated for by any high value on another attribute. On the other hand, when a decision task is comparatively simple, decision makers tend to use more complex and effortful decision heuristics such as compensatory decision strategies in which a low value on one attribute can be compensated for by a high value on another attribute. These findings were obtained in studies manipulating time pressure (e.g., Payne et al., 1988; Svenson & Maule, 1993; Wright, 1974; Zakay, 1985), and in studies manipu-

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lating the numbers of alternatives or attributes (e.g., Biggs et al., 1985; Billing & Marcus, 1983; Kerstholt, 1992; Lohse & Johnson, 1996; Olshavsky, 1979; Payne, 1976; Sundstrom, 1987; Takemura, 1993).

In order to explain these phenomena, many theories on decision making processing have been proposed. Such theories include Contingent Theory (Beach & Mitchell, 1978), Image Theory (Beach, 1990; Mitchell & Beach, 1990), Dominance Structure Theory (Montgomery, 1983, 1989), Perspective Theory (Montgomery, 1994), The Theory of Adaptive Decision Making (Payne et al., 1992, 1993; Payne & Bettman, 2004), The Differentiation and Consolidation Theory (Svenson, 1992, 1996, 2005), and Meta-Cognitive Theory (Takemura, 1985, 1996).

All of these theories stress that decision makers are adaptive to task situations and contingently use some decision strategies in accordance with task demands. According to the theories, if the decision makers are adaptive to the task demands, they would change their decision strategies even in a situation where the amount of information searched is constrained. There are many ordinary decision situations where the amount of information searched is constrained even under no time pressure. Hence, the present study mainly focuses on the effects of such information search constraints on decision strategies. If the information search is constrained, the task demand would require more cognitive resource of memorizing, comparing, and so forth. If this is the case, the decision makers would more often use non-compensatory attribute-wise strategies as most of the decision process theories assume. However, this is empirically an open ended question.

The main purpose of this study is to investigate the nature of decision strategies and participants' perceived inner states under conditions of information search constraints using a process tracing method (Payne, 1976; Payne, Johnson, & Bettman, 1989, 1993; Russo & Dosher, 1983). Moreover, the present study re-examines whether multi-phased decision strategies are observed in line with previous results. Previous research has revealed that the decision strategies generally are more attribute-based early in the process such that only two or three alternatives remain for further consideration, and that more alternative-based search is present later in the process (Bettman & Park, 1980; Gertzen, 1992; Montgomery & Svenson, 1989; Takemura, 1985, 1993).

Apart from the above hypotheses, this study also examine the effect of information constraints on the final choice pattern. According to Payne (1982), there is numerous empirical evidence suggesting that a distinction between task and context effects could be made. For instance, the manipulation of task variables, such as time pressure and information complexity (number of alternatives/attributes), often influence the preference pattern. On the other hand, manipulation of context variables such as value ranges and similarity between alternatives often produce weaker influences. Characteristic to the latter form of manipulation is that, in most cases, only the attribute levels are subject to manipulation. Recent research on information structure compatibility in cognition and decision to some extent confirm the influence of task environment. Manipulations of the task (by manipulating different response procedures) have been revealed to influence the construction of preference in several studies (Selart, 1996; Selart et al., 1994, 1998, 1999). Also, the manipulation of process tracing method itself influences participant's preferences

(Lohse & Johnson, 1996). However, there are also studies reporting the lack of an effect of task environment on final choices. For instance, the introduction of accountability has not proved to significantly influence how final preferences are constructed (Simonson & Nye, 1992; Selart, 1996). In addition, some studies also report that there are cases in which time pressure is not influential in this respect (Kerstholst, 1992; Parquett & Kida, 1988). Hence, building on these empirical findings, it seems difficult to predict whether or not constraining the information search will have an impact on the construction of preference.

1.1 Hypotheses

Most of the theories or explanations on the decision process assume that decision makers assess the availability of their own cognitive resources and their task demands (e.g., Beach & Mitchell, 1978; Maule & Hockey, 1993; Montgomery, 1983, 1989; Payne et al., 1992, 1993; Payne & Bettman; Svenson, 1992, 1996, 2005; Svenson & Benson, 1993; Takemura, 1985, 1996). The decision makers might make a comparison between the demanded resource connected to the decision problem and the available resource for solving a decision problem. If the demanded resource exceeds the available resource, the decision maker has to cope with the situation. As Svenson and Benson (1993) have pointed out, the first possible response is to decrease the demanded resource, which can be decreased through using a simplifying decision strategy. The second possible response is to increase the available resource through using a mobilization strategy of resource. We expect that the demanded resource would exceed the restricted available resource if the amount of information searched is restricted up to a lower level. Then we expect that the decision maker would change the decision strategy in order to cope with the situation. On the other hand, we also expect that the demanded resource would not exceed the available resource if the amount of information searched is not restricted or is required to exceed to a certain level, and then that the decision maker would not change the default decision strategy.

In this vein, we introduce the following three information search constraints conditions in this study:

(1) An upper-limited-search condition (UL): In this condition, the constraint has an upper limit for the amount of information examined. There are many ordinary situations where decision makers can not search all piece of information for the decision problems such as the case of time pressure or limited resources. This condition represents such a case. This constraint is defined as a condition where a decision maker can not examine the same piece of information for the decision task more than once.

(2) A lower-limited-search condition (LL): In this condition, the search constraint has a lower limit for the amount of information examined. There are many ordinary situations where decision makers have to examine all pieces of information for the decision problems such as the case where decision accuracy is needed. This condition represents such a case. This constraint is defined as a condition where a decision maker has to examine every piece of information for the decision task more than once.

(3) A non-limited-search condition (NL): In this condition, no search constraint con-

cerning the amount of information is introduced. This condition is a control condition for the two conditions described above. The non-limited-search is defined as a condition where the number of information examined is not constrained.

Thus, we expect that the demanded resource would exceed the available resource in the upper-limited-search (UL) condition, but not in the lower-limited-search (LL) condition or in the non-limited-search (NL) condition. This is because the UL condition would require the participants to use more cognitive resource for mental operations such as memorizing information searched and comparing alternatives or attributes. Therefore, we predict that the use of decision strategies in the UL condition would differ from the LL and the NL conditions. Thus, a decision maker in the UL condition would more often use simplifying and mobilization strategies than in the LL and the NL conditions as described in the simplifying hypothesis below.

The Simplifying Hypothesis: Decision makers in the upper-limited-search (UL) condition would use more non-compensatory attribute-wise strategies and less compensatory, alternative-wise strategies than in the other two conditions.

According to Paynes' (1976) classification, the direction of search was determined by examining the alternative and attribute associated with the piece of information in line to be searched. If the subsequent piece of information searched for was within the same alternative, but involved a different attribute, then that transition of search was defined as an alternative-wise search. On the other hand, if the forthcoming piece of information searched for was within the same attribute but tied to a different alternative, then that transition of search was defined as an attribute-wise search.

The connected sub-hypotheses are as follows:

Hypothesis 1a: The proportion of alternative-wise search for the UL condition would be lower than for the other two conditions.

Hypothesis 1b: The proportion of attribute-wise search for the UL condition would be higher than for the other two conditions.

Hypothesis 1c: The amount of variability among alternatives in the UL condition would be higher than in the other two conditions.

Hypothesis 1d: The amount of variability among attributes in the UL condition would be higher than in the other two conditions.

In addition to the simplifying hypothesis we also intend to explore the consequences of an additional hypothesis which build on the mobility of cognitive resources. We label it the mobilizing hypothesis (see description below):

The Mobilizing Hypothesis: Decision makers in the upper-limited-search (UL) condition would cope with the situation through mobilizing cognitive resource under the restricted information in this condition where it would be very difficult to compare alternatives. Apart from the problem of information search constraints, decision makers under time pressure tend to mobilize cognitive resource through speeding up their mental activity, for example, by increasing the rate of information search (Ben Zur & Breznitz, 1981; Maule & Hockey, 1993; Maule & Mackie, 1990; Payne et al., 1988). However, quite contrary, we expect that decision makers in the UL condition more remarkably would use slower checking strategies in order to mobilize cognitive resource than in the LL and the NL

conditions. As mentioned in the simplifying strategy hypothesis, the participants would use more simplifying attribute-wise processing such as the lexicographic or the elimination by aspects strategies in order to cope with the constrained use of information. In that situation, participants in the UL condition would take more time into account in order to examine a piece of information to be able to cope with the absence of an optimizing strategy under the restricted use of information. This tendency is a mobilization of resource under the simplified strategy use. Such a mobilization would be executed through a slower examination under the use of simplified strategies. The connected sub-hypotheses are as follows:

Hypothesis 2a: The time spent for looking at one piece of information in the UL condition would be longer than in the other two conditions.

Hypothesis 2b: The time spent for choosing one piece of information in the UL condition would be longer than in the other two conditions (time for choice is defined as the remaining time when the examination time has been subtracted from the overall searching time on each period).

Finally, in addition to exploring the simplifying hypothesis and the mobilizing hypothesis, we intend to investigate a hypothesis which makes assumptions about stage-based differences in decision processing over time. We label it the Multi-stage hypothesis (see below).

Multi-stage hypothesis (Replication): Previous research has indicated that decision makers often use multi-phased decision strategies. Specifically, the decision makers have tended to use non-compensatory attribute-wise strategies in the early decision stage and have also tended to use compensatory alternative-wise strategies in the final decision stage (Bettman & Park 1980; Gertzen 1992; Montgomery & Svenson 1989; Takemura 1985, 1993). In this study, we also examine this tendency of multi-stage use of decision strategies. The connected sub-hypotheses are as follows:

Hypothesis 3a: The proportion of alternative-wise search in all conditions would be the lowest in the early decision stage and be highest in the final decision stage.

Hypothesis 3b: The proportion of attribute-wise search in all conditions would be highest in the early decision stage and be lowest in the final decision stage.

Hypothesis 3c: The variability for search among alternatives in all conditions would be lowest in the early decision stage and be highest in the final decision stage.

Hypothesis 3d: The variability for search among attributes in all conditions would be highest in the early decision stage and be lowest in the final decision stage.

2. Method

2.1 Participants

A total of 78 undergraduate and graduate university students at University of Tsukuba served as participants (59 males and 22 females). Participants earned course credit as a reward for their participation. They were randomly assigned to each of the three experimental conditions.

2.2 Material

The material consisted of 6 alternatives which described different rental apartments. Each alternative offered 6 attributes: (1) the monthly rent, (2) the location of the apartment, (3) the size of the rooms, (4) parking facilities, (5) bath and shower room facilities, (6) the brightness of the rooms. The attributes used in the experiment were determined through examining the result of a preliminary survey completed by 47 university students. The design of the preliminary survey was open-ended. The participants answered moderately important attributes for the choice of a rental apartment. For the material, there were either two or three levels on each attribute. The attribute values for the monthly rent and for the size of the rooms were expressed quantitatively, whereas the other attribute values were expressed qualitatively. The values of an alternative on various attributes were chosen such that no alternative would completely dominate another alternative on all the available attributes (Payne, 1976). The attribute levels were also selected so that each alternative would a priori have both positive and negative qualities.

In order to examine the information search pattern, we used a process tracing method (Payne, 1976; Payne et al., 1988; 1993; Russo & Dosher, 1983). We monitored information acquisition, response time, and choice by the use of a software system which basically have the same functions as the Mouslab System (Payne et al., 1988, 1993). The applied system was handled by an NEC personal computer, or its equivalent, which was equipped with a mouse for moving a cursor around the display screen of the computer.

The material was presented on the display in the form of a matrix of available information. The first row of the matrix represented alphabetically-numbered names of alternatives. The six columns of the matrix contained information associated with different attributes of each alternative, respectively. Thus, 36 boxes (6 attributes by 6 alternative) appeared in the screen to be searched by the participants. At the corner of the screen, a box was introduced in which participants were instructed to state their choices.

When a set of alternatives first appeared on the screen, the values of the attributes for the alternatives were hidden. In order to open a particular box and examine the information, the participants had to move the cursor into the box and click on the right button. The box immediately opened and remained open until the left button of the cursor once again was clicked. Hence, in this system, each participant could open only one box at a time.

The software system recorded the order in which the boxes were opened, the amount of time the boxes were open, the chosen option, and the total elapsed time after the display first had appeared on the screen.

In addition, the participants evaluated subjective inner state variables such as confidence, regret, and subjective memory load using seven point scales in a booklet. The booklet was distributed to participants after having completed the decision task.

2.3 Procedure

Each participant was run individually in a session. The experimenter told that the pur-

pose of the experiment was to understand how people make housing decisions, and that there were no objectively right or wrong choices. The experimenter also informed that the data obtained only was used for scientific purposes and would accordingly analyzed anonymously.

The experimenter instructed the participants how to use the software system to acquire information, and then told that each alternative represented a rental apartment and that the participants should choose the apartment they would prefer for themselves on the basis of the information provided about each apartment. No time constraints were applied in any condition. The experimenter instructed to work at their own pace, and also informed that there was no time constraints set to the fulfillment of the task. In order to habituate the participants to use of the software system, participants practiced on a sample information matrix of automobiles which was expected to be irrelevant to the decision task.

In the upper-limited-search condition, the experimenter asked not to exceed one search per piece of information for the decision task. Thus, the experimenter asked the participants in this condition could search only 36 (6 attributes times 6 alternatives) pieces of information at most. The experimenter told that the participants could not examine the same piece of information twice, and that the maximum numbers of search summed up to 36. The experimenter also informed that the participants were free to look at as little information as they required.

In the lower-limited-search condition, the experimenter asked the participants to exceed one search per piece of information for the decision task. Thus, the participants in this condition had to search at least 36 pieces of information. The experimenter informed that the participants should examine all the pieces of information at least once, and that the minimum numbers of search were 36. The experimenter also informed that there was no upper limit of search.

In the non-limited-search condition, the experimenter asked the participants to search the amount of pieces of information for the decision task freely. Thus, the participants in this condition could search any amount of information. The participants in this condition were allowed to investigate as much information as they preferred. The experimenter told them that they also were free to look at as little or as much information as they wanted to.

After the decision was made, the experimenter asked the participants to rate the items tied to their perceived inner states by the use of the seven point scales. The items of the questionnaire were reformulated from items of the perceived inner states created by Takemura and Takagi (1987).

3. Results

3.1 Amount of information searched

The means of the overall amount of pieces of information searched for are shown in Fig. 1. A one way analysis of variance (ANOVA) was conducted for the overall amount of

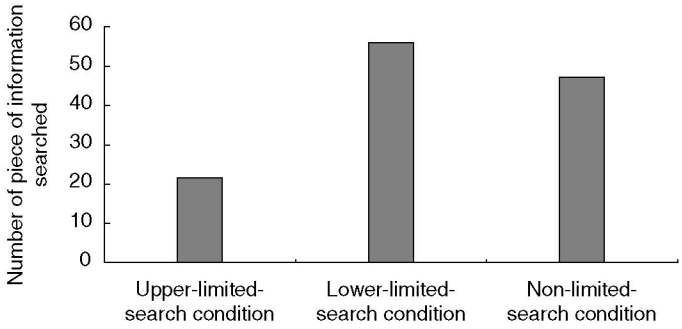

Figure 1: Number of piece of information searched

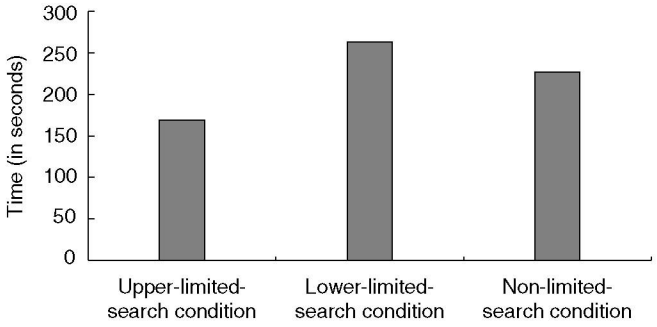

Figure 2: Time taken for decision making

pieces of information searched. A main effect of the constraints conditions proved to be significant, $F(2, 75) = 19.86$, $p < .001$. The multiple comparison as assessed by Tukey's tests (for the 5 percent significant level) indicated that the participants in the lower-limited search (LL) condition searched for the largest number of pieces of information and that the participants in the upper-limited search (UL) condition searched the least number of pieces of information among the three conditions.

3.2 Overall time taken for decision

The means of the overall time taken for the decisions are shown in Fig. 2. A one way ANOVA was conducted for the overall time taken for the decision. The main effect of the constraints conditions proved to be significant, $F(2, 75) = 6.38$, $p < .01$. The multiple comparison as measured by Tukey's tests indicated that the participants in the LL condition generally spent the most overall time and that the participants in the UL condition spent the least overall time among the three conditions.

3.3 Setting decision periods

The information search data were analyzed with respect to the decision periods in order to clarify the search process more in detail. The decision periods were subdivided into: (1)

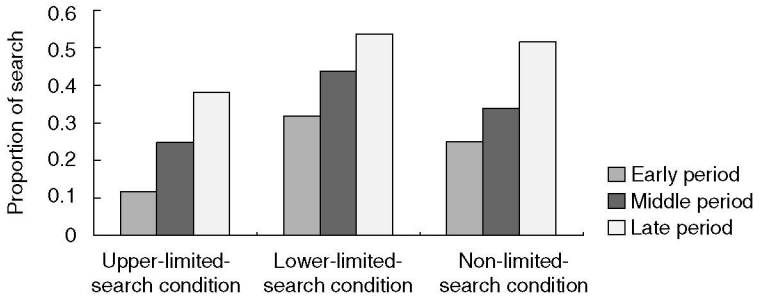

Figure 3: Proportion of alternative-wise search

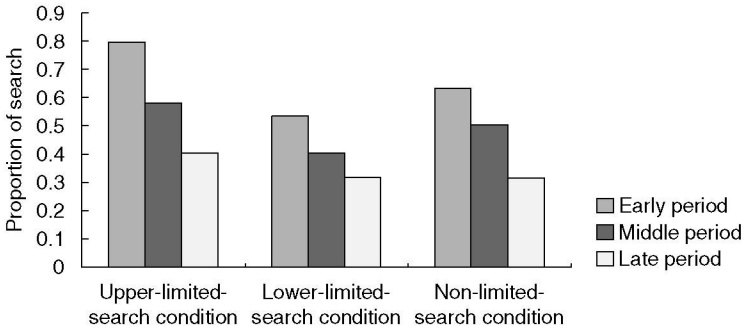

Figure 4: Proportion of attribute-wise search

the early decision period, (2) the middle decision period, and (3) the late decision period that was accomplished through division of the over-all decision time into three periods. These periods were treated as a within-participants factor in the analysis, whereas the information search conditions were treated as a between-participants factor.

3.4 Direction of search

For each decision period of each participant, a measure of alternative-wise search was computed as the proportion given by the number of alternative-wise single-step transitions divided by the sum of every single-step transition. The sum of every single-step transition was computed as the total numbers of alternative-wise search, the total numbers of the attribute-wise search, and the total numbers of the residual type of search. Hence, in the latter kind of search the forthcoming piece of information searched for involved both a different alternative and a different attribute. Likewise, for each decision period of each participant, a measure of attribute-wise search was computed as a proportion given by the number of attribute-wise single-step transitions divided by the sum of every single-step transitions. We used these two measures separately, because they were not mathematically dependent and they were expected to include more information of each information search pattern.

The means of the two measures for the direction of search are shown in Fig. 3 and 4,

respectively. A couple of two way ANOVAs (3 search constraints conditions by 3 decision periods) were conducted including the two measures of direction as the dependent variables, respectively.

Firstly, concerning the alternative-wise search, main effects were found for the search constraints conditions, $F(2, 75) = 4.10$, $p < .05$, and for the decision periods, $F(2, 150) = 36.94$, $p < .001$, although the interaction was not significant. The multiple comparisons assessed by Tukey tests revealed that the participants in both the LL and NL conditions used more alternative-wise search than in the UL condition, but that there was no significant difference between the LL and the NL conditions. This result is supportive to Hypothesis 1a predicting that the proportion of alternative-wise search for the UL condition would be lower than for the other two conditions. The multiple comparisons for the decision periods revealed that the alternative-wise search was the least often used in the early decision period and that this search was the most often used in the late decision period. This result is supportive to Hypothesis 3a predicting that the proportion of alternative-wise search in all conditions would be the lowest in the early decision period and be the highest in the late decision period.

Secondly, regarding the attribute-wise search, the analysis also revealed significant main effects of the search constraints conditions, $F(2, 75) = 3.21$, $p < .05$, and of the decision periods, $F(2, 150) = 44.00$, $p < .001$, although a non-significant interaction was obtained. The multiple comparisons assessed by Tukey tests revealed that the participants in the UL condition used more attribute-wise search than in the LL condition, but that there was no significant difference observed between the LL and the NL conditions, nor between the UL and NL conditions. This result is only partly supportive to Hypothesis 1b predicting that the proportion of attribute-wise search for the UL condition would be higher than for the other two conditions. This is because the multiple comparisons did not show a significant difference between the UL and the NL conditions although the predicted significant difference between the UL and the LL condition was in line with Hypothesis 1b. The multiple comparisons for decision periods revealed that the attribute-wise search was the most often used in the early decision period and that this search was the least often used in the late decision period. This result is supportive to the Hypothesis 3b predicting that the proportion of attribute-wise search in all conditions would be the highest in the early decision period and be the lowest in the late decision period.

3.5 Variability

For each decision period, a measure of variability for the search among the alternatives was computed as the ratio given by the standard deviation of information search among alternatives divided by the mean number of information search. Likewise, for each decision period of each participant, a measure of variability for search among attributes was computed as a ratio given by the standard deviation of information search among attributes divided by the mean number of information search. The means of these two measures are shown in Fig. 5 and 6, respectively.

Firstly, concerning the variability among alternatives, main effects were significant for

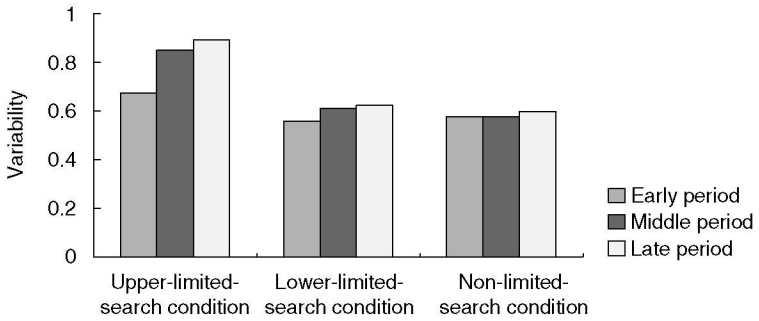

Figure 5: Variability among alternatives

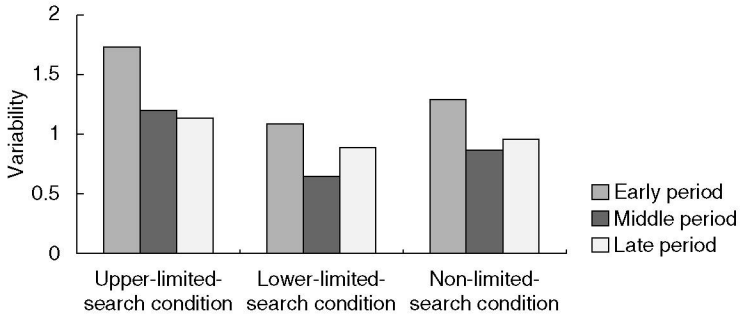

Figure 6: Variability among attributes

the search constraints conditions, $F(2, 75) = 7.00$, $p < .01$, and for the decision periods, $F(2, 150) = 21.43$, $p < .001$, although the interaction was not significant. The multiple comparisons measured by Tukey tests revealed that the participants in the UL condition showed the highest variability among alternatives, but that there was no significant difference between the LL and the NL conditions. This result is supportive to Hypothesis 1c predicting that the value for variability among alternatives in the UL condition would be higher than in the other conditions. The multiple comparisons for the decision periods revealed that the variability among alternatives was lowest in the early decision period and that there was no significant difference between the middle and the late periods. This result is only partly supportive of Hypothesis 3c predicting that the variability among alternatives in all conditions would be lowest in the early period and be highest in the late decision period. The multiple comparisons did not show a significant difference between the middle and the late decision periods although the significant difference between the early and the middle decision periods in line with Hypothesis 3c. Moreover, as shown in Fig. 5, the differences among decision periods were comparatively small in the LL and the NL conditions although there was no significant interaction. It thus seems that the variability data for the alternatives did not strongly support the multi-stage hypothesis, although there was a significant main effect of decision periods observed.

Secondly, regarding the variability among attributes, the analysis also revealed significant main effects of the search constraints conditions, $F(2, 75) = 12.79$, $p < .001$, and of

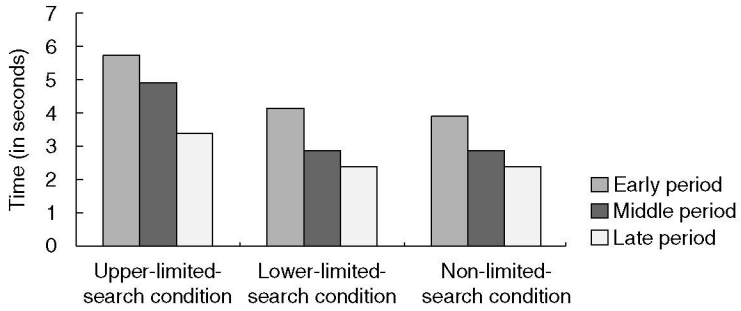

Figure 7: Time taken for looking at one piece of information

the decision periods, $F(2, 150) = 78.82$, $p < .001$, although a non-significant interaction was obtained. The multiple comparisons by Tukey tests revealed that the participants in the UL condition showed the highest variability among attributes, but that there was no significant difference between the LL and the NL conditions. This result is supportive of Hypothesis 1d predicting that the value for variability among attributes in the UL condition would be higher than in the other conditions. The multiple comparisons for decision periods revealed that the variability among attributes was highest in the early decision period and that there was no observed significant difference between the middle and the late periods. This result is only partly supportive to Hypothesis 3d predicting that the variability among the attributes in all conditions would be highest in the early period and be lowest in the late decision period: The multiple comparisons did not show a significant difference between the middle and the late decision periods although the significant difference between the early and the middle decision periods was in line with Hypothesis 3d.

3.6 Speed of search

As mentioned in Hypothesis 2, the time spent for looking at one piece of information, and the time spent for choosing such a piece of information were also participant to measurement. "Choosing" time consisted of the residual time which remained when the attention time was subtracted from the overall searching time on each period. A difference in choosing time between the conditions is interpreted as a difference of time for considering how to search the information among the conditions. The means for these measures are shown in Fig. 7 and 8 respectively.

Firstly, concerning the time spent on looking at a piece of information, main effects were found for the search constraints conditions, $F(2, 75) = 7.70$, $p < .001$, and for the decision periods, $F(2, 150) = 26.39$, $p < .001$, although the interaction was not significant. The multiple comparisons assessed by Tukey tests revealed that the participants in the UL condition used the longest time for looking at one piece of information, but that there was no significant difference observed between the LL and the NL conditions. This result is supportive of Hypothesis 2a predicting that the time spent for looking at one piece of

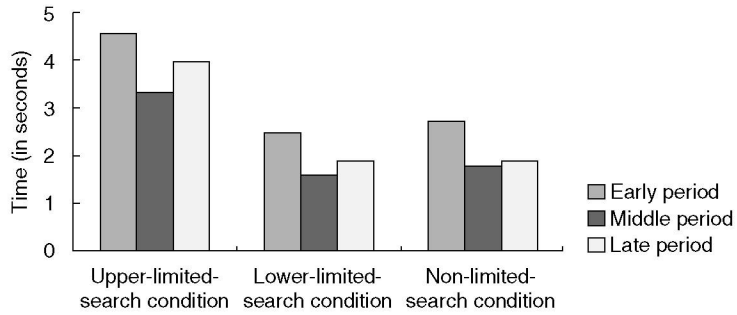

Figure 8: Time taken for choosing one piece of information

information in the UL condition would be longer than in the other two conditions. The multiple comparisons for decision periods revealed that the time taken for looking at one piece of information was longest in the early decision period and was shortest in the late decision period.

Secondly, regarding the time spent for choosing one piece of information, the analysis revealed significant main effects of the search constraints conditions, $F(2, 75) = 13.67$, $p < .001$, and of the decision periods, $F(2, 150) = 4.92$, $p < .01$, although a non-significant interaction was obtained. The multiple comparisons assessed by Tukey tests revealed that the participants in the UL condition used the longest time for choosing one piece of information, but that there was no significant difference between the LL and the NL conditions. This result is supportive to Hypothesis 2b predicting that the time spent for choosing one piece of information in the UL condition would be longer than in the two other conditions. The multiple comparisons for decision periods revealed that the time taken for choosing one piece of information was longest in the early decision period and that there was no significant difference between the middle and the late decision periods in this respect.

3.7 Perceived inner states

The seven point rating scale for the perceived inner states scored from 1 to 7 in the sense that higher points indicated a higher degree of a given subjective inner state (e.g., a higher mood rating, indicated a more positive mood). The means of the perceived inner states are shown in Table 1. A one way ANOVA was conducted on each of the scales. Concerning the measures of confidence, subjective conflict, task difficulty, confusion, subjective memory load, perceived risk, and positive-negative mood (pleasantness and good-bad mood ratings), there were no significant differences observed among the three conditions. However, a significant difference was detected on the regret rating among the three conditions, $F(2, 75) = 4.16$, $p < .05$. The multiple comparisons assessed by Tukey tests revealed that the subjects in the UL condition indicated more regret after the completion of decision than the subjects in the NL condition, but that there was no significant difference between the LL and the NL conditions, nor between the UL and LL conditions, in this respect.

Table 1: Mean rating scores of the subjective inner states among the three search constraints conditions.

	UL condition	LL condition	NL condition
Confidence	4.73 (1.12)	4.58 (1.30)	4.88 (1.40)
Subjective conflict	4.19 (1.50)	4.23 (1.34)	3.65 (2.10)
Task difficulty	4.19 (1.13)	4.27 (1.25)	3.81 (1.67)
Confusion	4.08 (1.29)	3.88 (1.24)	3.58 (1.72)
Regret	2.92 (1.02)	2.69 (0.93)	2.19 (0.85)
Subjective memory load	4.23 (1.31)	4.12 (0.82)	4.15 (1.12)
Perceived risk	4.35 (1.52)	4.31 (1.41)	3.69 (1.57)
Mood (pleasantness)	4.96 (1.08)	4.85 (1.16)	4.92 (1.32)
Mood (good–bad)	4.77 (0.91)	4.62 (1.13)	4.77 (1.14)

Note. Parentheses indicate the standard deviations.

3.8 Final choice pattern

Concerning the final choice data among the three conditions, a chi-square test was performed. However, a non-significant difference of choice pattern among the conditions were observed ($\chi^2(10) = 10.55$, ns).

4. Discussion

4.1 Empirical findings

This study focused on the influence of information search constraints on the decision making process. The findings with regard to the process tracing data seemed to be almost supportive of the simplifying hypothesis, the mobilizing hypothesis, and the multi-stage hypothesis. In line with the hypotheses, the result revealed that the participants in the upper-limited-search (UL) condition more often adopted non-compensatory simplifying decision strategies and a slower checking for information than in the lower-limited-search (LL) and non-limited-search (NL) conditions. The participants in the UL condition tended to use more attribute-wise strategies and to use less alternative-wise strategies than in the LL and the NL conditions. At the same time, the participants in the UL condition tended to show higher variability of search among alternatives and attributes than the participants in the LL and the NL conditions. This study also found that the participants in the UL condition to a higher extent used slower checking strategies in order to mobilize cognitive resource than what was observed in the LL and the NL conditions.

4.2 Relation to other theories and empirical findings

The present findings may also be a psychological phenomenon designed to cope with the relative lack of available resource towards the demanded resource as many decision process theories and explanation assume (e.g., Beach & Mitchell, 1978; Maule & Hockey, 1993; Montgomery, 1983, 1989; Payne et al., 1992, 1993; Payne & Bettman, 2004; Svenson, 1992, 1996, 2005; Svenson & Benson, 1993; Takemura, 1985, 1996). Especially, Differentiation

and Consolidation Theory (Svenson 1992, 1996, 2005) is compatible with our empirical findings.

Although our results may not contradict the findings of the previous process tracing studies, the present study seems to have pinpointed different aspects of decision strategies. For instance, decision makers under time pressure tend to mobilize cognitive resource using speeding up of mental activity, for example, by increasing the rate of information search (Ben Zur & Breznitz, 1981; Maule & Hockey, 1993; Maule & Mackie, 1990; Payne et al., 1988). On the other hand, the present study found that decision makers in the UL condition more extensively used slower checking strategies in order to mobilize cognitive resource than in the LL and the NL conditions. It seemed that slower checking and faster checking are working in opposite directions to each other. However, both activities would be effective in their own task environments, respectively.

Concerning participants' decisions, no reliable effect of the experimental manipulation was obtained. This result seems to be consistent with previously obtained results by Kerstholt (1992), Parquette and Kida (1988), and by Payne et al. (1988). All these studies indicate that the use of different decision strategies do not influence the final choices. The obtained results from the present study also seems to be in line with the results provided by Simonson and Nye (1992), and by Selart (1996) indicating that the manipulation of task accountability has a limited ability to influence preference reversals. Still, some other research indicate that there may be procedural effects attached to the use of process tracing technique. Hence, different process tracing methods (information boards and eye-gaze recording) may have an influence on how final preferences are constructed (Lohse & Johnson, 1996).

4.3 Towards a process model of decision making

In order to integrate the findings, we propose an interpretation model for decision making with information search constraints. In this model, it is interpreted that the decision maker has to cope with the decreased available resource which is caused by information search constraints, and hence that the decision maker changes a decision strategy in line with the simplifying hypothesis, the mobilizing hypothesis, and the multistage hypothesis.

It is also interpreted that the decision maker has a psychological tendency to maintain a stability of the perceived inner states through changing the decision strategy. Thus, the model in this paper has a potential to provide a consistent explanation for influence of information search constraints as well as for the influence of task complexity on the decision making process. Taking the other theories into account, our model to some extent is consistent with the Differentiation and Consolidation Theory (Svenson, 1992, 1996, 2005).

As shown in the interpretation schema (Fig. 9), we interpret the information search constraint variable as a factor which affects the available cognitive resource. Thus, the available resource (AR) is a function of the states of information search constraints. In the situation where the information search has an upper limit which is equal to the lower bound such as was the case in the upper-limited-search (UL) condition, the available resource would be decreased, because it is difficult to compare alternatives and store

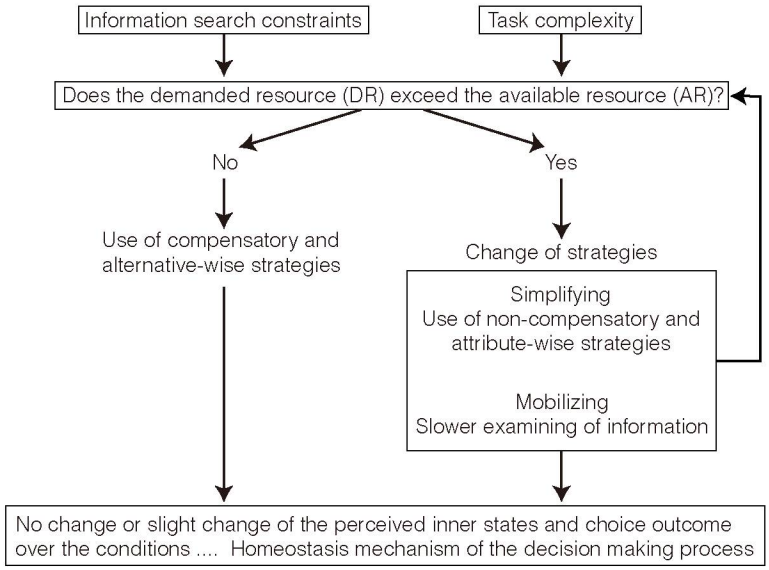

Figure 9: An interpretation model of the decision making process

memory for alternatives to reach a decision under the information search constraints. On the other hand, in the situation as specified by the non-limited-search (NL) condition and the lower-limited-search (LL) condition, the available resource would not be decreased.

We expect that the demanded resource (DR) is a function of a given decision strategy. If a given decision strategy is compensatory, the demanded resource to solve a problem would be comparatively large. On the other hand, if a given decision strategy is non-compensatory, the demanded resource to solve a problem would comparatively be small. The demanded resource (DR) is also expected to be a monotone increasing function of task complexity such as the number of alternatives and attributes. In most of the cases, a given strategy at the final decision would by default be compensatory, as previous research on multi-phased decision strategies has suggested (Bettman & Park, 1980; Gertzen, 1992; Montgomery & Svenson, 1989; Takemura, 1985, 1993).

If AR exceeds DR in some extent, a given default strategy would be used. Therefore, as supposed above, the compensatory alternative-wise strategies would more often be used in this situation. However, if DR exceeds AR, the strategy change would occur. As hypothesized in this study, decision makers would more often use non-compensatory attribute-wise strategies in order to reduce DR. At the same time, decision makers would adopt a mobilizing strategy such as examining information more slowly in order to compensate for simplifications. However, this mobilizing strategy would be executed so that AR exceeds DR.

According to our model, if an execution of decision strategies occurs, the task complexity of the decision problem would be reduced, and hence, DR would be decreased. If this is the case, AR exceeds DR and then a compensatory alternative-wise strategy would be used. This hypothetical process also provides an explanation of multi-phased decision

strategies: Decision makers tend to use non-compensatory attribute-wise strategies in the early decision period because DR exceeds the AR for given compensatory alternative-wise strategies, and they tend to use compensatory alternative-wise strategies in the late decision period because AR would exceed DR for the given strategy. Thus, we could assume that decision makers try to maintain DR in order not to exceed AR through changing the decision strategies.

To interpret the findings of this study from the above mentioned model, the amount of AR in the UL condition would be the least among the three conditions. This is due to that it is most difficult to compare alternatives or attributes and to store memory for alternatives to reach a decision under the UL constraints. On the other hand, in the LL conditions, AR would not decreased because the available resource would hold at almost the same level as the NL condition.

Based on the decreased DR, the participants in the UL condition would try to optimize accuracy by using more of the mobilizing strategy such as the slower checking of information. However, the participants in the NL and the LL conditions would not to a larger extent use of non-compensatory, attribute-wise strategy, and slower mode of checking.

This study also examined the use of the multi-stage decision strategies. The results indicated that the participants tended to adopt more non-compensatory attribute-wise strategies in the early decision period and also tended to adopt more compensatory alternative-wise strategies in the late decision period. Although the results did not indicate a clear difference among the early, middle, and late decision periods as predicted in the multi-stage hypothesis, the results almost replicated the previous findings on the multi-phased decision strategies (Bettman & Park, 1980; Gertzen, 1992; Montgomery & Svenson, 1989; Takemura, 1985, 1993).

Lastly, let us interpret the finding of perceived inner states. As shown in the Table 1, decision makers' perceived inner states tend to be stable among the three conditions. This stability may be in the same way due to a similar mechanism of organic homeostasis. This reasoning has emanated from the homeostasis hypothesis of perceived inner states during the decision making process (Takemura, 1996). According to the hypothesis, a change of strategies and an implementation of strategies would be undertaken in the direction to keep the perceived inner states stable within certain ranges[1)].

5. Conclusion

This study focused on the influence of information search constraints on the decision making process. The findings with regard to the process tracing data seemed to be almost supportive of the simplifying hypothesis, the mobilizing hypothesis, and the multi-stage hypothesis. In order to integrate the findings, we proposed an interpretation model for decision making with information search constraints.

[1)] From the point of view of the statistical hypothesis testing, the above statements concerning the homeostasis hypothesis may appear problematic because in general it could be difficult to define the null hypothesis for such statements. Therefore, we did not include this hypothesis as a experimental hypothesis.

However, the interpretations of this study are based on a restricted experimental situation. The experimental environment in this study differs from naturalistic decision situations due to that an artificial information acquisition system applied on a personal computer was used in the experiment. Further research should therefore be conducted in order to validate the model presented above. This could be achieved by more strongly manipulating the information search constraints, and by examining the decision making process under different information constraints in more naturalistic situations.

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