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by

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Abstract

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. In the experiment, the following three information search constraints conditions were arranged: (1)An upper-limited-search(UL) condition in which the same piece of information for the decision task could not be examined more than once, (2) A lower-limited-search(LL) condition in which every piece of information for the decision task had to be examined more than once, and (3)A non-limited-search(NL) condition in which the numbers of information examined were not constrained. Subjects 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, it was found that the subjects in the UL condition more often used non-compensatory simplifying decision strategies and slower checked for information than in the LL and NL conditions. Moreover, in line with the homeostasis hypothesis of the perceived inner states, it was revealed that there was a slight difference between such inner states among the three conditions. Theoretical implications of the findings were discussed from various theoretical points of view with regard to the decision making process.

Key Words: decision making process, choice, information search, constraints, process tracing.

Previous research on human decision making has indicated that its 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 and Koele 1994), or by time pressure (Payne et al. 1993). 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 and Maule 1993; Wright 1974; Zakay 1985), and in studies manipulating the numbers of alternatives or attributes(e. g., Biggs et al. 1985; Billing and Marcus 1983; Kerstholt 1992; Lohse and 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. Among others, those are Contingent Theory (Beach and Mitchell 1978), Image Theory(Beach 1990; Mitchell and Beach 1990), Dominance Structure Theory(Montgomery 1983, 1989), Perspective Theory (Montgomery 1994), The Theory of Adaptive Decision Making(Payne et al. 1992, 1993), The Differentiation and Consolidation Theory(Svenson 1992, 1996), 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 the 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.

Moreover, The Differentiation and Consolidation Theory(Svenson 1992, 1996) specially suggests that decision makers have a psychological tendency to keep the perceived inner states stable, and that they change decision strategies contingently based on psychological reasons. The perceived inner states can be defined as the psychological states which are subjectively evaluated by a decision maker during the decision making process, for example, processes of confidence, conflict, memory-load, regret and so forth. If that kind of psychological evaluation is used by the decision makers, the change of the perceived inner states would antedate change of the decision strategies. Thus, the perceived inner states would be less influenced by the search constraints than would be the decision strategies.

Almost as the physiological states of a biological organism tend to be stable

over different environmental conditions due to the homeostasis mechanism(Cannon 1939; Selye 1985), decision makers' perceived inner states may in some situations be stable in the same way due to a similar mechanism. This reasoning has emanated from the homeostasis hypothesis of perceived inner states during the decision making process (Takemura 1996). The concept of the homeostasis was originally proposed by Cannon(1939). He labeled the concept "homeostasis", building on the Greek "*homeoios*", meaning similar, and "*stasis*", meaning the position for the coordinated physiologic processes which maintain most of the steady states in the organism(Cannon 1939, p. 333.). The homeostasis might roughly be regarded as synonymous with "staying power" and with the physiological mechanism of adapting to environmental conditions(Selye 1985). In the present study, we use a metaphor of this homeostasis concept in order to explain the psychological ability of subjects to maintain a stability of the inner states during the decision making process.

However, as previous research has indicated(Wright 1975; Takemura 1988), decision maker's perceived inner states may some times differ if subjects are forced to use different decision strategies. It is therefore an open ended question whether the homeostasis hypothesis holds in the free use of decision strategies under constraints set for the amount of information searched.

Thus, the main purpose of this study is to investigate the nature of decision strategies and perceived inner states under conditions of information search constraints. 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 and Park 1980; Gertzen 1992; Montgomery and 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, it has been revealed that 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. In several studies (Selart 1996; Selart et al. 1994, 1998, 1999), manipulations of the task (by manipulating different response procedures)have been revealed to influence the construction of preference. Also, the manipulation of process tracing method itself has been reported to influence participants preferences (Lohse and 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 and Nye 1992; Selart 1996). In addition, some studies also report that there are cases in which time pressure are not influencial in this respect(Kerstholst 1992; Parquett

and 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.

Hypotheses

Most of the theories or explanations on the decision process assume that decision makers asses the availability of their own cognitive resources and their task demands(e. g., Beach and Mitchell 1978; Maule and Hockey 1993; Montgomery 1983, 1989; Payne et al. 1992, 1993; Svenson 1992, 1996; Svenson and 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 would be to decrease the demanded resource, which can be decreased through using a simplifying decision strategy. The second possible response would be to increase the available resource through using a mobilization strategy of resource. It is expected that the demanded resource would exceed the restricted available resource if the amount of information searched is restricted up to a lower level. Then it is expected that the decision maker would change the decision strategy in order to cope with the situation. On the other hand, it is also expected 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, the following three information search constraints conditions were introduced 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. The constraint is defined as a condition where the same piece of information for the decision task can not be examined 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. This constraint is defined as a condition where every piece of information for the decision task has to be examined more than once.

(3)A non-limited-search condition(NL): In this condition, no search constraint concerning the amount of information is introduced. The non-limited-search is defined as a condition where the number of information examined is not constrained.

Thus, it is expected 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 and in the non-limited-search(NL) condition. This is because the UL condition would require the subjects to use more cognitive resource for mental operations such as memorizing information searched and comparing alternatives or attributes. Therefore, it is predicted 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.

Simplifying Hypothesis: It is assumed that 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. The hypotheses are as follows:

Hypothesis 1a. It is assumed that the proportion of alternative-wise search for the UL condition would be higher than for the other two conditions.

Hypothesis 1b. It is assumed that the proportion of attribute-wise search for the UL condition would be higher than for the other two conditions.

Hypothesis 1c. It is assumed that the amount of variability among alternatives in the UL condition would be higher than in the other two conditions.

Hypothesis 1d. It is assumed that the amount of variability among attributes in the UL condition would be higher than in the other two conditions.

Mobilizing hypothesis: In this hypothesis, it is assumed that decision makers in the upper-limited-search (UL) condition would cope with the situation through mobilizing cognitive resource under the restricted information where it would be very difficult to compare alternatives. Apart from the problem of information search constraints, it has been found that 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 and Breznitz 1981; Maule and Hockey 1993; Maule and 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 subjects 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, subjects in the UL condition are considered to 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 considered to be a mobilization of resource under the simplified strategy use. Such a mobilization would be executed through slower examination under the use of simplified strategies. The hypotheses are as follows:

Hypothesis 2a: It is assumed that 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: It is also assumed that the time spent for choosing one piece of information in the UL condition would be longer than in the other two conditions (Choosing time is defined as the remaining time when the examination time has been subtracted from the overall searching time on each period). A difference in choosing time among the conditions could therefore be interpreted as a difference in time for considering how to search information among the conditions.

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 and Park 1980; Gertzen 1992; Montgomery and Svenson 1989; Takemura 1985, 1993). In this study, this tendency of multi-stage use of decision strategies is also tested. The hypotheses are as follows:

Hypothesis 3a: It is assumed that 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: It is assumed that the proportion of attribute-wise search in all conditions would be the highest in the early decision stage and be lowest in the final decision stage.

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

Hypothesis 3d: It is also assumed that 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.

Homeostasis Hypothesis: The Differentiation and Consolidation Theory(Svenson 1992, 1996) suggests that decision makers try to stabilize their inner psychological states in order to cope with the change of task situations. In line with the theory, it is predicted that the perceived inner states would not differ in a situation where the resource needed exceeds available resource and the situation where resource needed does not exceed available resource. Using a metaphor of the biological homeostasis concept(Cannon 1939; Selye 1985), decision makers' inner subjective states would tend to be stable over the different information search constraints conditions(Takemura 1996). Thus, the predictions of the homeostasis hypothesis for the perceived inner states are as follows:

Hypothesis 4a. It is assumed that the degree of confidence for final decision would not differ among the three conditions.

Hypothesis 4b It is assumed that the degree of subjective conflict during the decision process would not differ among the three conditions.

Hypothesis 4c. It is assumed that the degree of task difficulty during the decision process would not differ among the three conditions.

Hypothesis 4d It is assumed that the degree of confusion during decision process would not differ among the three conditions.

Hypothesis 4e. It is assumed that the degree of regret for final decision would not differ among the three conditions.

Hypothesis 4f It is assumed that the degree of subjective memory-load during the decision process would not differ among the three conditions.

Hypothesis 4g It is assumed that the degree of perceived risk at the final decision would not differ among the three conditions.

Hypothesis 4h It is assumed that the degree of positive-negative mood during the decision process would not differ among the three conditions.[1]

Method

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

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 and students were asked to put down moderately important attributes for the choice of a rental apartment. 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 (Payne, 1976) no alternative would completely dominate another alternative on all the available attributes. The attribute values were also selected so that each alternative would a priori have both positive and negative qualities.

Information acquisition, response time, and choice were monitored by the use of a software system which basically have the same functions as the Mouslab System (Payne, Bettman, and Johnson 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 subjects. At the corner of the screen, a box was introduced in which subjects 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 subjects 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, only one box could be opened by the subject 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, information about subjective inner state variables such as confidence, regret, and subjective memory load was subsequently collected in a booklet. This booklet was distributed to subjects after having completed the decision task.

Procedure. Each subject was run individually in a session which lacked for about 40 minutes. Subjects were told that the purpose of the experiment was to understand how people make housing decisions, and that there were no objectively right or wrong choices. They were also informed that the data obtained only was used for scientific purposes and would accordingly analyzed anonymously.

Subjects were then instructed by the software system to acquire information. They were told that each alternative represented a rental apartment and that they 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. Subjects were instructed to work at their own pace and were also informed that there was no time constrains set to the fulfillment of the task. In order to habituate the subjects to use of the software system, subjects were asked to practice on a sample information matrix of automobiles which was expected to be irrelevant to the decision task.

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

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

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

After the decision was made, the subjects were asked to rate the items tied to their perceived inner states by the use of the seven point scales. The items of the questionnaire were reformulation of items of the perceived inner states created by Takemura and Takagi (1987). The questionnaire consisted of items related to subjective evaluation for (1)confidence, (2)subjective conflict, (3)task difficulty, (4)confusion, (5)regret, (6)subjective memory load, (7)perceived risk, and (8)positive-negative mood during the decision making process. Concerning the mood rating, we prepared two items, that is, a mono-polar pleasantness rating item and a bipolar good-bad mood item were constructed.

Results

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 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 subjects in the lower-limited search (LL) condition searched for the largest number of pieces of information and that the subjects in the upper-limited search (UL) condition searched the least number of pieces of information among the three conditions.

Insert Fig. 1 about here

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 subjects in the LL condition generally spent the most overall time and that the subjects in the UL condition spent the least overall time among the three conditions.

Insert Fig. 2 about here

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

Direction of search

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. For each decision period of each subject, 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 subject, 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.

Insert Fig. 3 about here

Insert Fig. 4 about here

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 subjects 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 higher 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 subjects 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 lower 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.

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 subject, 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.

Insert Fig. 5 about here

Insert Fig. 6 about here

Firstly, concerning the variability among alternatives, main effects were found for 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 subjects 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. 6, the differences among decision periods seems to be 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 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 subjects in the UL condition showed the lowest 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 lower 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.

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 subject 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 could be 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.

Insert Fig. 7 about here

Insert Fig. 8 about here

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 subjects in the UL condition showed the lowest speed for looking, 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 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 highest in the early decision period and was lowest 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 subjects in the UL condition showed the highest 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 2a predicting that the time spent for looking at 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 lowest in the early decision period and that there was no significant difference between the middle and the late decision periods in this respect

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. These results were supportive of the homeostasis hypothesis (4a, 4b, 4c, 4d, 4f, 4g, and 4h). 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. Hence, the result did not support one of the homeostasis hypothesis(Hypothesis 4e).

Insert Table 1 about here

Final choice pattern

Concerning the final choice data among the three conditions, a chi-square test was performed. However, this test did not detect any differences. However, a non-significant difference of choice pattern among the conditions were observed($\chi^2(10)= 10.55$, ns).

Discussion

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. The findings on the perceived inner states using a questionnaire also seemed to be almost supportive of the homeostasis hypothesis.

Insert Fig. 9 about here

Towards a process model of decision making

In order to clarify and to integrate the obtained findings, an interpretation model for decision making under information search constraints is presented in line with the interpretation schema presented in Fig. 9. As shown in Fig. 9, the information search constraint variable is considered to be 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 would be difficult to compare alternatives and store 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. The available resource would also be a monotone increasing function of processing ability which might be varied among individuals. On this basis, the available resource (AR) can be described as a real-valued function such that AR(Ability, Search Constraints) $\in$ R, where R is defined as a one dimensional real number space. Hence, it is assumed that, for a decision maker, AR can be represented by a real number.

The demanded resource (DR) is expected to be 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 and Park 1980; Gertzen 1992; Montgomery and Svenson 1989; Takemura 1985, 1993). Hence, the demanded resource (DR) can be described as a real valued function such that DR(Strategy, Task Complexity) $\in$ R.

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 space 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. Assuming a certain threshold δ, this tendency would be represented by a constraint condition, such that AR $-$ DR $\geqq \delta$. This constraint condition implies that DR can not exceed the value of AR plus a certain value δ. The simplifying and the mobilizing hypothesis would then hold under the condition such that AR(Ability, Search Constraints) $-$ DR(Strategy, Task Complexity) $\geqq \delta$. If Ability, Search Constraints, and Task Complexity are assumed to be constants and for simplicity Strategy is assumed to be the only variable, then it would be clear that the difference between AR and DR is a function of Strategy.

As mentioned in the homeostasis 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. Suppose that the degrees of perceived inner states are assumed to be a vector $I \in R^N$ of a multi-dimensional space, in a N-dimensional real number space. This implies that each dimension in the N-dimensions each corresponds to the degree of the perceived inner state as exemplified in confidence, subjective conflict, subjective memory load, and so forth, for the N inner states. It also implies that each of the degrees of the perceived inner states can be represented by a real number. The homeostasis hypothesis thus states that the choice function of decision strategies, $C(S) \in S$ would have a solution subject to $LB \leqq I \leqq UB \in R^N$, where S is a set of decision strategies, LB is a lower bound vector of perceived inner states, and UB is a upper bound vector of perceived inner states. S is here considered to be an evoked set of available decision strategies for the decision maker. The homeostasis hypothesis thus assumes that a certain strategy would be selected among the available strategies which are elements of S, so that the perceived inner states would hold within certain ranges from LB to UB. More precisely, the perceived inner states would be a vector function of Ability, Search Constraints, Task Complexity, and Strategy, which were listed above. That is, the perceived inner states can be described as I(Ability, Search Constraints, Task Complexity, Strategy) $\in R^N$.

Overall, a solution of $C(S) \in S$ would be determined subject to $LB \leqq I \leqq UB$, and $AR - DR \geqq \delta$. This means that the use of decision strategy would be determined in the direction to keep the perceived inner states stable within certain ranges and to let the available resource exceed the resource needed for a given strategy. Moreover, if a certain function of decision accuracy for a decision strategy, UA, exists, the choice function of decision strategy, C(S) could be represented as follows:

$$C(S) = \arg\max_{\text{Strategy} \in S} UA\ (\text{Strategy})$$

Subject to:

$AR(\text{Ability, Search Constraints}) - DR(\text{Strategy, Task Complexity}) \geqq \delta$,

$LB \leqq I(\text{Ability, Search Constraints, Task Complexity, Strategy}) \leqq UB$.

The above representation implies that a decision strategy which will maximize the accuracy of the decision would be chosen under the constraints concerning the resource($AR-DR \geqq \delta$) and the perceived inner states($LB \leqq I \leqq UB$).

Empirical findings

This study firstly focused on the influence of information search constraints on decision strategies. The findings with regard to the process tracing data were almost supportive to the simplifying hypothesis and the mobilizing hypothesis. The subjects 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 subjects in the UL condition tended to show higher variability of search among alternatives and attributes than the subjects in the LL and the NL conditions. It was also found that the subjects 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.

To interpret these findings 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. At the first stage, DR would be almost at the same level among the three conditions. In the UL condition, the inequality of resource, AR-DR$\geqq \delta$, would not hold under the compensatory and alternative-wise strategy which is considered to be a default strategy. Therefore, the subjects would adopt the decision strategy to reduce DR by more extensively using the non-compensatory and attribute-wise strategy. Based on the decreased DR, the subjects in the UL condition would try to optimize accuracy by using more of the mobilizing strategy such as the slower checking of information. However, in the LL and the NL conditions, the inequality of resource, AR-DR$\geqq \delta$, would hold under the compensatory and alternative-wise strategy which is considered to be a default strategy. Therefore, the subjects 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.

In this study, the use of the multi-stage decision strategies was also examined. The results indicated that the subjects 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 and Park, 1980; Gertzen, 1992; Montgomery and Svenson, 1989; Takemura, 1985, 1993). The result may be interpreted as follows: In the early decision period, the inequality of resource, AR-DR$\geqq \delta$, would not hold under the compensatory and alternative-wise strategy which is considered to be a default strategy. Therefore, the subjects would use the decision strategy to reduce DR by using the non-compensatory and attribute-wise strategy more extensively. On the other hand, in the late decision period, the inequality of available resource, AR-DR$\geqq \delta$, would hold under the compensatory and alternative-wise strategy which is considered to be a default strategy. The default strategy would maximize the UA under the condition , AR-DR $\geqq \delta$.

This study also focused on the influence of the information search constraints on the perceived inner states. The result of the questionnaire on the perceived inner states indicated that there were non-significant differences on 8 out of 9 scales among the three conditions. This seemed to be almost supportive to the homeostasis hypothesis.[2]

From the findings, we interpret that a certain strategy would be selected among the available decision strategies which are elements of S, so that the perceived inner states hold within certain ranges from LB to UB (LB $\leqq$I$\leqq$ UB). This interpretation would be plausible for providing a satisfactory explanation of the inconsistency between the different uses of strategies and non-differences of the perceived inner states. However, we do not insist that the homeostasis mechanism of the

perceived inner states is operating generally in all of the conditions. As a matter of fact, the result of the regret rating violated the Homeostasis hypothesis, although the violation was observed only in one scale out of 9. As the homeostasis of an organism sometimes is disturbed by severe environmental changes, the stability of the perceived inner states also therefore might be disturbed by strong task demands. The change of the perceived inner states might therefore more often occur in conditions where more rechecking information is demanded than in the lower-limited search condition.

Relation to other theories and empirical findings

The present findings may also be interpreted as 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 and Mitchell 1978; Maule and Hockey 1993; Montgomery 1983, 1989; Payne et al. 1992, 1993; Svenson 1992, 1996; Svenson and Benson 1993; Takemura 1985, 1996). Especially, Differentiation and Consolidation Theory (Svenson 1992, 1996) seems to be compatible with our empirical findings as well as with our model concerning the homeostasis hypothesis. This theory suggests that decision makers have a psychological tendency to keep the perceived inner states stable, and that they change decision strategies based on psychological reasons.

Although Svenson and his collaborators (e.g., Svenson 1992, 1996;Svenson and Benson 1993) have not made any references of the homeostasishypothesis, their experimental study of time-pressure and decision making (Svenson and Benson 1993) seemed to be in support of our homeostasis hypothesis. In their study, they did not find any significant effects of their time-pressure manipulation on either mood, task difficulty, or satisfaction, although they found a significant strategy change under the time-pressure instruction. However, it must be noted that the manipulation of time pressure that they were using was based on pure instruction.

On the other hand, Zakay(1985) used a manipulation of real objective time pressure. He also found a significant strategy change under the time pressure, whereas no significant effect of time pressure on the confidence rating was observed. These results were compatible with our findings and seem also to be in line with the homeostasis hypothesis.

However, the results obtained in the present study, and in the ones mentioned above (Zakay, 1985; Svenson and Benson, 1993), may be able to be interpreted in line with an alternative methodological explanation. Hence, it is possible that the scales used to assess the perceived inner states were too insensitive to their nature to be able to detect changes of the perceived inner states. Although Zakay (1985) did not suggest any reason for the lack of an effect of time pressure on confidence ratings, Svenson and Benson (1993) provided a comment on why it perhaps did not influence their mood scales: "This may indicate that the instructions did not produce effects strong enough to affect mood and experience arousal, differentiating the two groups or that scales were not sensitive enough (p. 162.)".

Svenson and Benson (1993) suggested that their mood scales were not sensitive enough to detect the mood change under their instruction. But, interestingly, previous research which examined the effects of the use of forced decision strategies on the perceived inner states suggested that the scales concerning perceived inner

states including mood states were not insensitive (Wright 1975; Takemura 1988). That is, these studies on forced decision strategies showed that different use of decision strategies produced the significant differences of perceived inner states towards the same decision problem. Still, due to the fact that basically the same scales assessing the perceived inner states were used in the present study as in the study of Takemura (1988), this alternative methodological explanation does not seem to hold.

The findings obtained by Wright (1975) and Takemura(1998) indicated that decision strategies influenced the perceived inner states to a large extent. The use of compensatory decision strategies increased the degree of task difficulty or subjective conflict, whereas the use of non-compensatory strategies decreased the task difficulty or subjective conflict. On the other hand, as suggested by Zakay together with Svenson and Benson, if the decision makers were free to choose the decision strategies, their perceived inner states did not differ with regard to time pressure. In the present study these results have been replicated in the sense that the perceived inner states were not influenced by the information search constraints . Taken together, all these results suggest that the homeostasis hypothesis may provide a useful explanation of the empirical results.

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 and Breznitz 1981; Maule and Hockey 1993; Maule and Mackie 1990; Payne et al. 1988). On the other hand, in the present study, it was 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 are considered to be effective in their own task environments, respectively.

Finally, 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, it has been revealed that different process tracing methods (information boards and eye-gaze recording) may have an influence on how final preferences are constructed (Lohse and Johnson, 1996).

Conculusion

In conclusion, it was found that the simplifying hypothesis, the mobilizing hypothesis, the multistage hypothesis, and the homeostasis hypothesis were either supported or almost supported. In line with the hypotheses, it was revealed that the subjects 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. It was also revealed that there was a slight difference between the perceived inner states among the three conditions.

In order to integrate the findings, an interpretation model for decision making with information search constraints was proposed. In this model, it was interpreted that the decision maker had to cope with the decreased available resource which caused by information search constraints, and hence that the decision maker changed a decision strategy in line with the simplifying hypothesis, the mobilizing hypothesis, and the multistage hypothesis. In line with the homeostasis hypothesis, it was also interpreted that the decision maker had a psychological tendency to maintain a stability of the perceived inner states through changing the decision strategy. Thus, the model in this paper have 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).

However, the interpretation of the results are based on a restricted experimental situation. Inversely, the manipulation of the information search constraints in this experiment was fairly mild. Therefore, there is a possibility that the homeostasis hypothesis was supported partly due to this fact. Nevertheless it could be violated in a stronger manipulation of the constraints conditions. In other words, the findings in this study might be most critical to generalize to decision situations which are considered highly important. Furthermore, the homeostasis hypothesis might be more relevant for every day decisions that are performed sequentially. Although we do not think that the homeostasis hypothesis always holds and thus predict that a disturbance of the homeostasis could occur caused by larger change of environment such as the introduction of restricted search constraints, the limitation of the explanation should be known. Secondly, 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.

References

Bailey, D. E., 1971. Probability and statistics: Models for research. New York: Wiley.

Beach, L. R., 1990. Image theory: Decision making in personal and organizational contexts. Chichester: Wiley.

Beach, L. R., and T. R. Mitchell, 1978. A contingency model for the selection of decision strategies. Academy of Management Review, 3, 439-449.

Ben Zur, H. and S. J. Bresnitz, 1981. The effects of time pressure on risky choice behaviour. Acta Psychologica, 47, 89-104.

Bettman, J. R. and C. W. Park, 1980. Effect of prior knowledge and experiences and phase of the choice process on consumer decision processes: A protocol analysis. Journal of Consumer Research, 7, 234-248.

Biggs, S. F., J. C. Bedard, B. G. Garber, and T. J. Linsmier, 1985. The effects of task size and similarity on the decision behavior of bank loan officers. Management Science, 31, 970-987.

Billing, R. S. and S. A. Marcus, 1983, Measures of compensatory and non-compensatory model of decision behavior: Process tracing versus policy capturing. Organizational Behavior and Human Performance, 31, 331-352.

Cannon, W. B. 1939, 1963. The wisdom of body. New York: Norton.

Gertzen, H., 1992. Component processes of phased decision strategies. Acta Psychologica, 80, 229-246.

Kerstholt, J. H., 1992. Information search and choice accuracy as a function of task complexity and task structure. Acta Psychologica, 80, 185-197.

Lohse, G. L. and E. J. Johnson, 1996. A comparison of two process tracing methods for choice tasks. Organizational Behavior and Human Decision Processes, 68, 28-43.

Maule, A. J. and G. R. J. Hockey, 1993. 'State, stress, and time pressure'. In O. Svenson and A. J. Maulo (Eds.), Time pressure and stress in human judgment and decision making (pp. 83-101). New York: Prenum Press.

Maule, A. J. and P. M. Mackie, 1990. 'A componential investigation of the effects of deadlines on individual decision making'. In K. Borcherding, O. I. Larichev, and D. M. Messick (Eds.), Contemporary issues in decision making (pp. 449-461.). Amsterdam: North Holland

Mitchell, T. R., and L. R. Beach, 1990. " Do I love thee? Let me count...". Toward an understanding of intuitive and automatic decision making. Organizational behavior and Human Decision Processes, 47, 1-20.

Montgomery, H. 1983. 'Decision rules and the search for a dominance structure: Towards a process model of decision making'. In P. C. Humphreys, O. Svenson, and A. Vari (Eds.), Analyzing and aiding decision processes (pp. 342-369). Amsterdam: North Holland.

Montgomery, H., 1989. 'From cognition to action: The search for a dominance structure: Towards a process model of decision making'. In H. Montgomery and O. Svenson (Eds.), Processes and structure in human decision making (pp. 23-49). Chichester: Wiley.

Montgomery, H., 1994. Towards a perspective theory of decision making and judgment. Acta Psychologica, 87, 155-178.

Montgomery, H. and O. Svenson, 1989. A think aloud study of dominance structuring in decision process. In H. Montgomery and O. Svenson (Eds.), Processes and

structure in human decision making(pp. 135-150). Chichester: Wiley.
Olshavsky, R. W., 1979. Task complexity and contingent processing in decision making: A replication and extension. Organizational Behavior and Human Performance 24, 300-316.
Paquette, L. and T. Kida, 1988. The effects of decision strategy and task complexity on decision performance. Organizational Behavior and Human decision Processes, 41, 128-142.
Payne, J. W., 1976. Task complexity and contingent processing in decision making: An information search and protocol analysis. Organizational Behavior and Human Performance, 16, 366-387.
Payne, J. W., 1982. Contingent decision behavior. Psychological Bulletin, 92, 382-402.
Payne, J. W., J. R. Bettman, E. Coupey, and E. J. Johnson, 1992. A constructive process view of decision making: Multiple strategies in judgment and choice. Acta Psychologica, 80, 107-141.
Payne, J. W., J. R. Bettman, and E. J. Johnson, 1993. *The adaptive decision maker.* New York: Cambridge University Press.
Selart, M., 1996. Structure compatibility and restructuring in judgment and choice. Organizational Behavior and Human Decision Processes, 65, 106-116.
Selart, M., O. Boe, and T. Gärling, 1999(in press), Reasoning about outcome probabilities and values in preference reversals. Thinking and Reasoning.
Selart, M., T. Gärling, and H. Montgomery, 1998. Compatibility and the use of information processing strategies. Journal of Behavioral Decision Making, 11, 59-72.
Selart, M., H. Montgomery, and J. Romanus, and T. Gärling, 1994. Violations of procedure invariance in preference measurement: Cognitive explanations. European Journal of Cognitive Psychology, 6, 417-36.
Selye, H., 1985. History and present status of the stress concept. In A. Monat and R. S. Lazarus(Eds.), Stress and coping: An anthology, 2nd ed (pp. 17-29). New York: Columbia University Press.
Simonson, I., and P. Nye., 1992. The effect of accountability on susceptibility to decision errors. Organizational Behavior and Human Decision Processes, 51, 416-446.
Sundstrom, G. A., 1987. Information search and decision making: The effects of information displays. Acta Psychologica, 65, 165-179.
Svenson, O., 1992. Differentiation and Consolodation Theory of human decision making: A frame of reference for the study of pre- and post-decision processes. Acta Psychologica, 80, 143-168.
Svenson, O., 1996. Decision making and search for fundamental psychological regularities: What can be learned from a process perspective ? Organizational Behavior and Human Decision Processes, 65, 252-267.
Svenson, O. and L. Benson, III, 1993. On experimental instructions and inducement of time pressure behavior. In O. Svenson and A. J. Maule(Eds.), Time pressuure and stress in human judgment and decision making(pp. 157-165). New York: Prenum Press.
Svenson, O. and A. J. Maule(Eds.), Time pressuure and stress in human judgment and decision making. New York: Prenum Press.
Takemura, K., 1985. A Meta-cognitive model for the implementation of decision

strategies. Doshisha Psychological Review, 32, 16-22. (In Japanese with English abstract)

Takemura, K., 1988 Effects of decision strategies on the decision making processes: A case of consumer behavior, Japanese Journal of Psychology, 59, 83-90. (In Japanse with English abstract)

Takemura, K., 1993 Protocol analysis of multistage decision strategies. Perceptual and Motor Skills, 77, 459-469.

Takemura, K., 1996. Psychology of decision making: Investigation of its process. Tokyo: Fukumura Shuppan. (In Japanese)

Takemura, K. and O. Takagi, 1985. An analysis of decision making process in prosocial behavior. Research in Social Psychology, 1, 35-44. (In Japanese with English abstract)

Takemura, K. and O. Takagi, 1987. Information seeking strategies and inner states in the decision making processes: A case of donating behavior. Japanese Journal of Experimental Social Psychology, 26, 105-114. (In Japanese with English abstract)

Westernberg, M. R. M. and P. Koele, 1994. Multi-attribute evaluation processes: Methodological and conceptual issues. Acta Psychologica, 87, 65-85.

Wright, P. L., 1974. The harased decision maker: Time pressures, distractions, and the use of evidence. Journal of Applied Psychology, 59, 555-561.

Wright, P. L., 1975. Consumer choice strategies: Simplifying vs. optimizing, Journal of Marketing Research, 11, 60-67.

Zakay, D., 1985. Post-decisional confidence and conflict experienced in a choice process. Acta Psychologica, 58, 75-80.

Footnotes.

[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. In spite of this, the above hypothesis seems to be producing psychologically meaningful statements. Taking this into account, we adopted ordinary statistical significant tests in order to examine the hypothesis.

[2] However, a statistical interpretation problem of the null hypothesis still remains as mentioned in the section of the introduction to the hypothesis. This implied that we can not know the probability of Type II error and the statistical power from all the aspects. The probability of Type II error, β, is defined as the probability of misjudgment when the null hypothesis is accepted and the null hypothesis is false. The statistical power is defined as the probability of correct judgment when the null hypothesis is rejected and false, which is equivalent to $1-\beta$. We could thus only mention the probability of Type I error which is equivalent to an ordinary significance level. In spite of the problem, we can calculate β and $1-\beta$ from some plausible assumptions. Let us assume the significance level of Type I error to be 5 percent, a level that we usually are adopting. Then let the alternative hypothesis be that any two conditions of the three have the same effects but that one condition exceeds the other two conditions by one standard deviation, or else the effects are more widely dispersed. According to the formula and the figure shown in Bailey (1971, pp. 432-440, p. 674.), the probability of Type II error, β, is less than 1 percent, and the statistical power , $1-\beta$, is more than 99 percent. Moreover, assuming the significant level of Type I error to be 5 percent, let the alternative hypothesis against the null hypothesis be that any two conditions of the three have the same effects but one condition exceeds the other two conditions by a half of standard deviation or the effects are more widely dispersed. In this case, the probability of Type II error, β, is less than 5 percent, and the statistical power , $1-\beta$, is more than 95 percent. This result would be more supportive to the homeostasis hypothesis.

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.

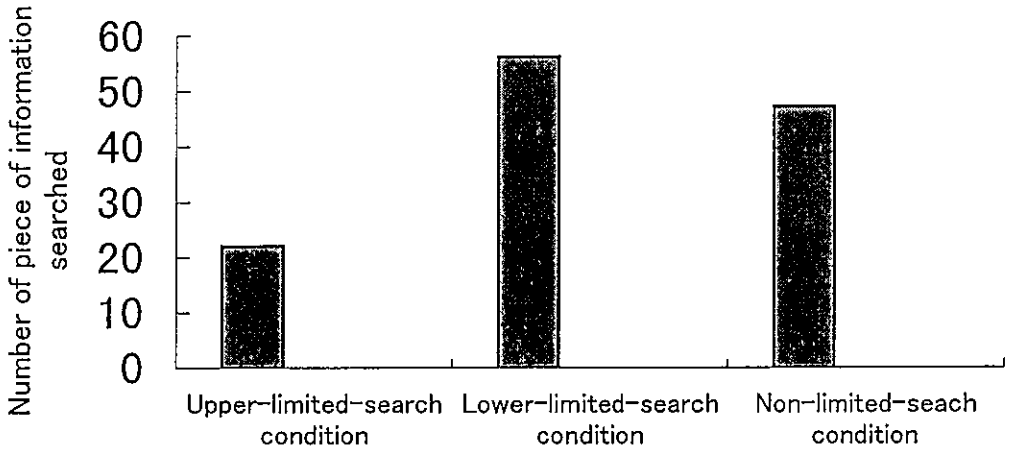

Fig. 1. Number of piece of information searched

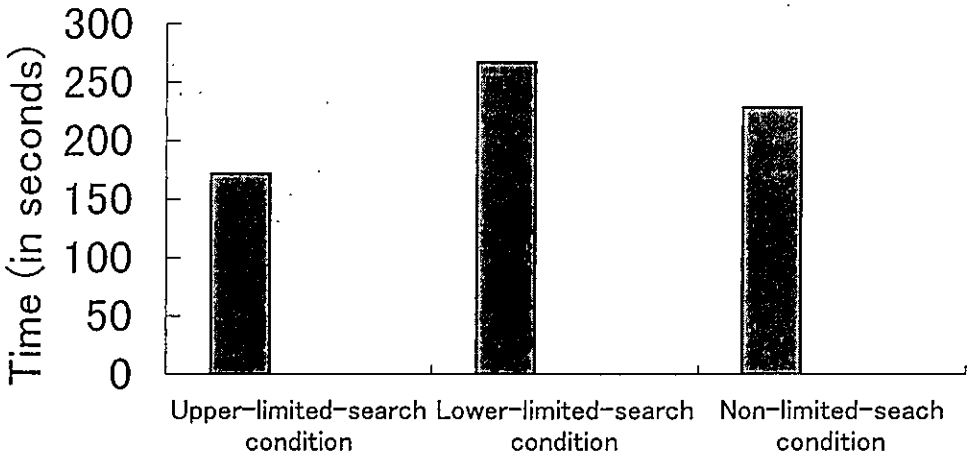

Fig. 2. Time taken for decision making

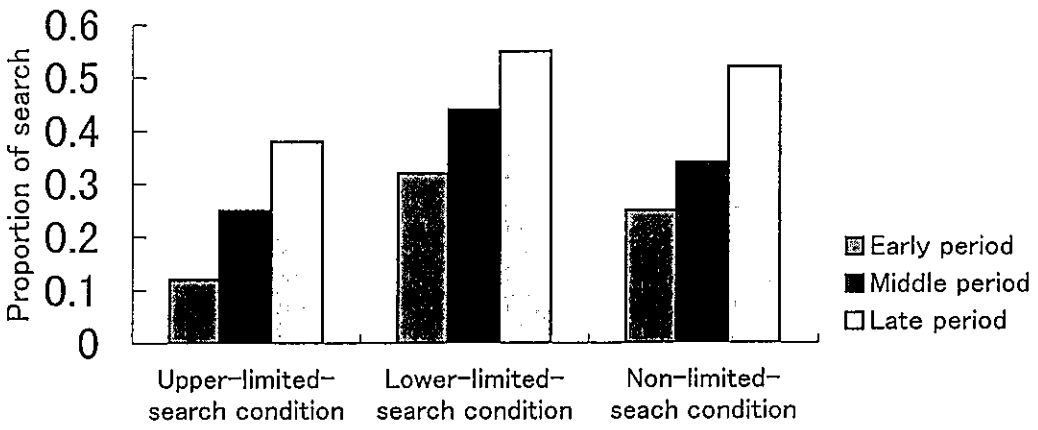

Fig. 3. Proportion of alternative-wise search

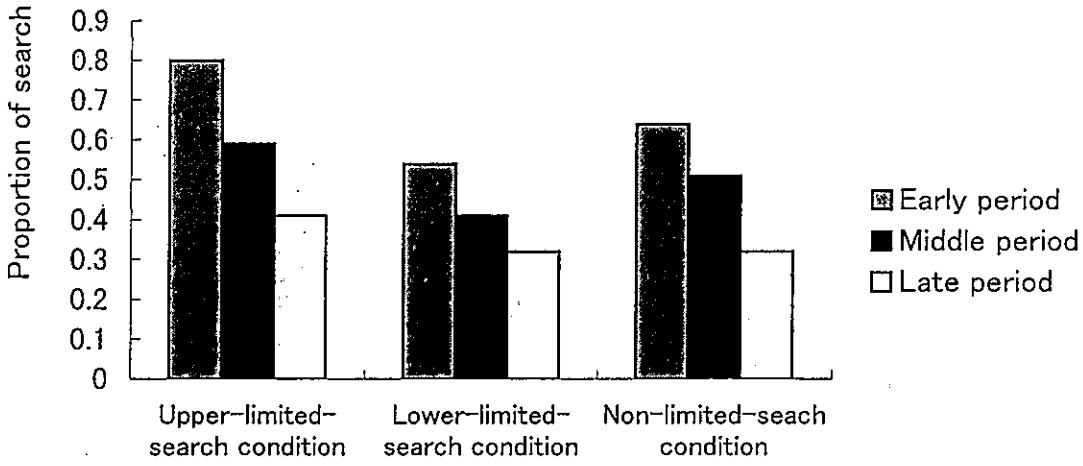

Fig.4. Proportion of attribute-wise search

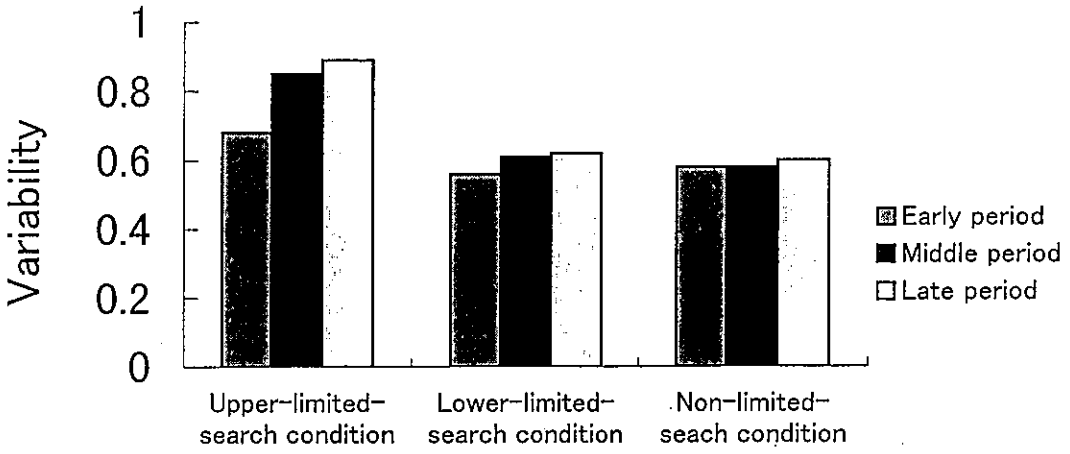

Fig. 5. Variability among alternatives

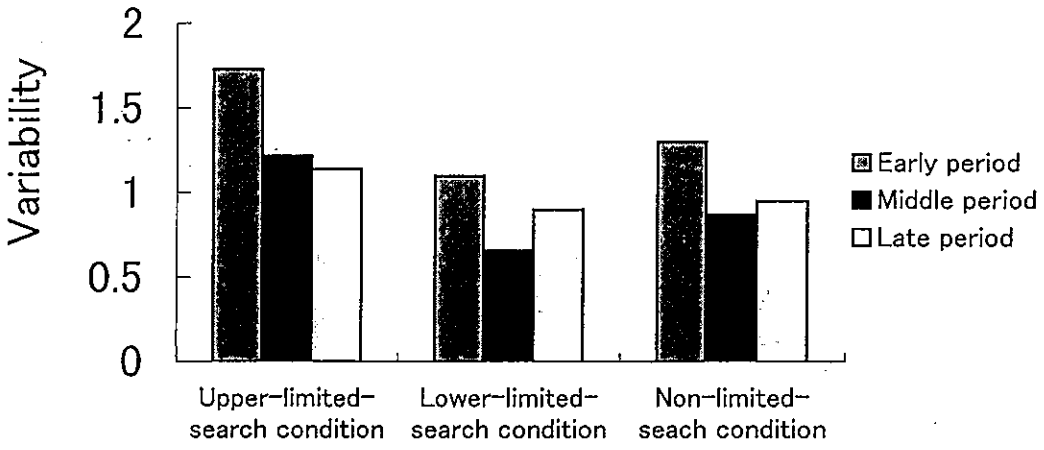

Fig. 6. Variability among attributes

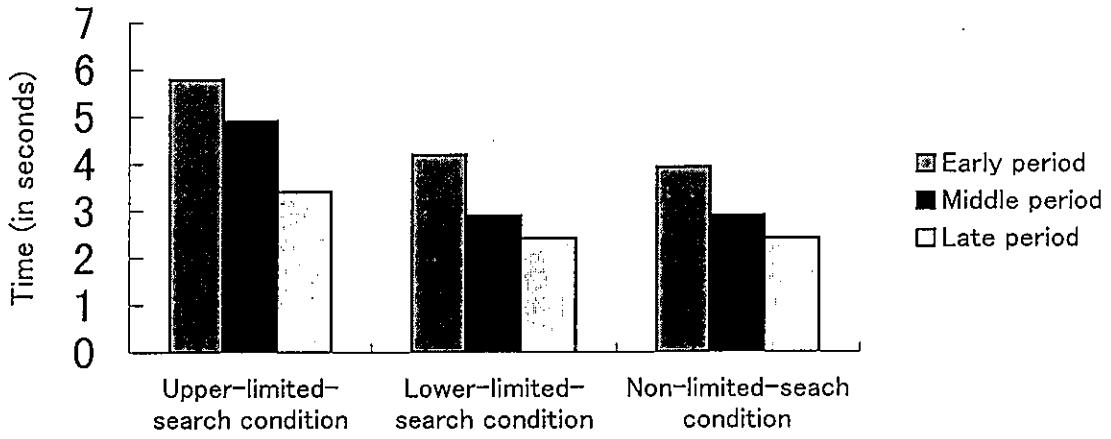

Fig. 7. Time taken for looking at one piece of information

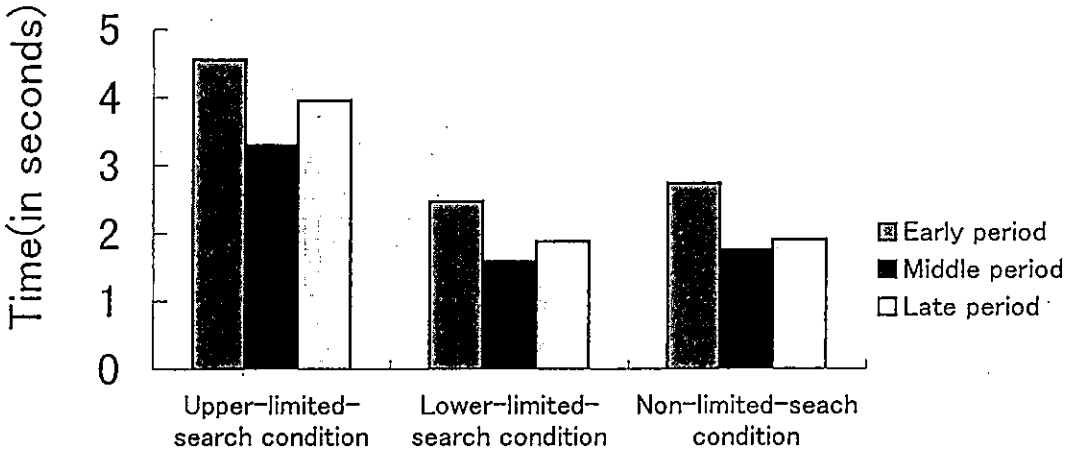

Fig. 8. Time taken for choosing one piece of information

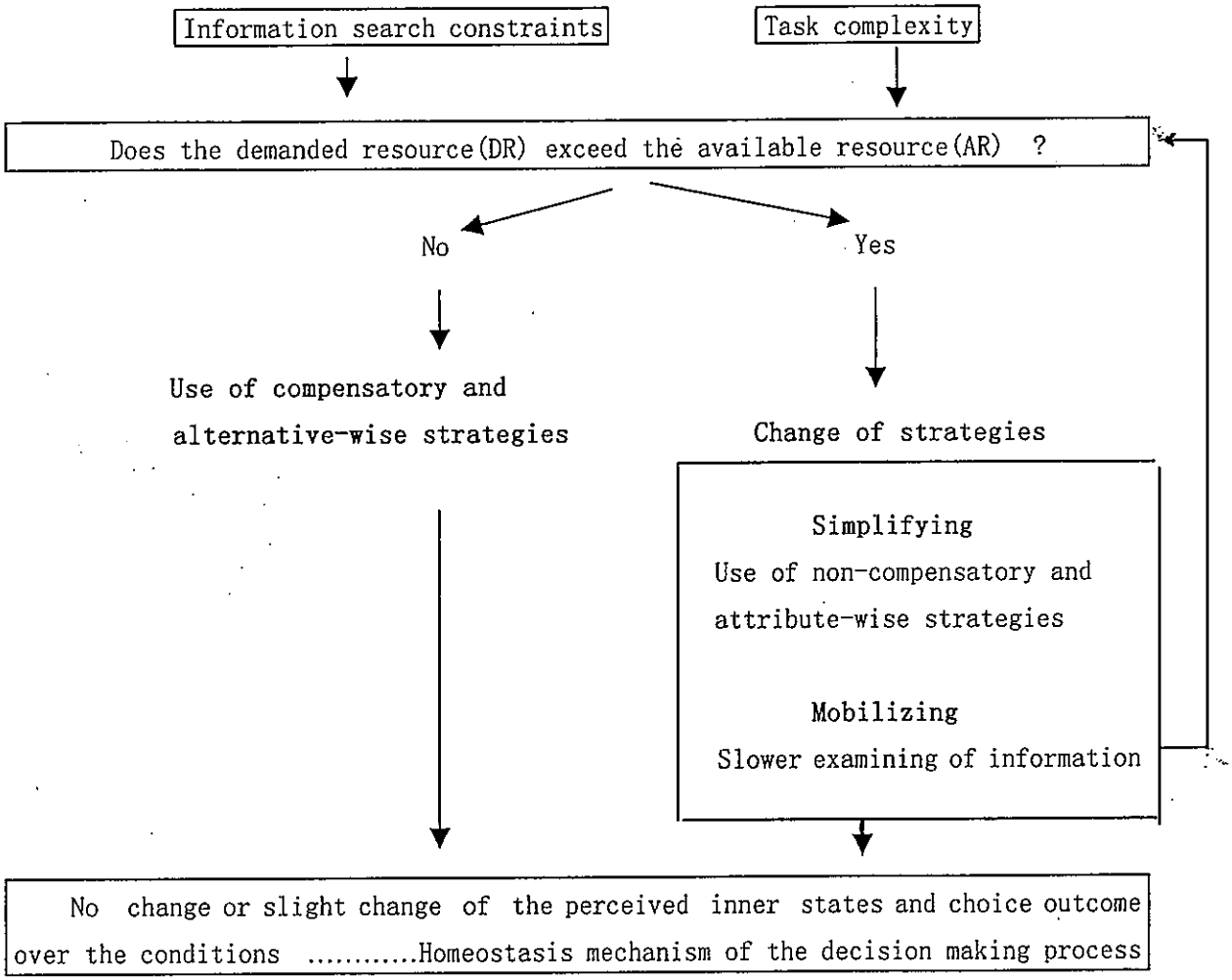

Fig. 9. An interpretation model of the decision making process