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Cognitive Choice Processes for Sequentially or Simultaneously Presented Alternatives[1]

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Abstract. Although decision makers use dimensional processing strategies when choosing between simultaneously presented and multidimensionally described alternatives, Tversky (1969) has conjectured that alternative based processing would occur when the same alternatives are presented one after the other. This hypothesis was elaborated upon with effort—quality considerations. The first experiment which was a replication of a previous study only partially supported the above hypothesis. As predicted, longer latencies indicated more judgment based processing for the sequential presentation than for the simultaneous presentation. However, memory measures did not indicate any differences. Think aloud protocols of a second experiment revealed that for sequentially presented alternatives dimensional comparisons are applied in addition to judgment based processing. The application of the two processing components can be described by a Markov model which specifies a hybrid decision strategy.

In his 1969 paper, Tversky demonstrated that decision makers use dimensional processing strategies when choosing between multidimensional alternatives. Although the choice alternatives were simultaneously presented in Tversky's experiments, he conjectured that alternative based processing would occur for the same alternatives when they are presented one after the other.

Tversky's conjecture is intuitively appealing. For example, when shopping for a product, the products which are offered by one store are simultaneously available and can thus be processed by dimensional strategies. The products of different stores must be inspected in sequence, and therefore it is quite likely that alternative based processing occurs.

While Tversky elaborated upon dimensional processing strategies in considerable detail, he referred quite generally to the additive model with respect to alternative based processing. The additive model, however, does not capture the underlying cognitive processes, i.e., the procedural character of judgment formation (Lopes, 1982). Cognitive choice processes for choosing between two alternatives when they are sequentially or simultaneously presented to a subject were described by Schmalhofer and Gertzen (1986). Their description was

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based upon the framework of criterion dependent choice models, whose empirical validity has been shown in several studies. Aschenbrenner, Albert and Schmalhofer (1984) have shown that such models can account for the information processing of dimensionally described and simultaneously presented choice alternatives: The models not only predicted choices better than the additive model, there was also a positive relation between choice latencies and the number of processing steps predicted by the models. Using a process–tracing method, Schmalhofer, Albert, Aschenbrenner and Gertzen (1986) have shown that the criterion dependent choice models adequately describe the decision maker's selective and adaptive information utilization.

Since the current research builds upon these models, we will first describe the generic criterion dependent choice model as well as the two specific models for dimensional and alternative based processing. Next, we will present an experiment which replicated a previous investigation in order to test the stability of the results of that experiment. As a second experiment, a think aloud study will be reported. The verbal protocols will be used for a detailed exploratory analysis of the information processes for sequentially presented alternatives revealing a hybrid decision strategy which can be described as a Markov model.

Criterion dependent choice models

The basic assumption of criterion dependent choice models is that the information processing of an alternative or choice pair continues until some evidence criterion is surpassed. This evidence criterion is specified by a number k, which is the only free parameter in a criterion dependent model. Thus, decision making is assumed to be a selective sequential process. The criterion dependent choice models postulate that the availability (and importance) of the choice alternatives' features determines both which features will be processed and the order in which they will be processed. The processing of a feature yields an attractiveness value for that feature. For attractive and unattractive features, positive or negative attractiveness values are obtained, respectively. The attractiveness values are combined according to some rule. This rule may specify dimensional comparisons or the formation of overall judgments as component processes of choices.

Dimensional comparisons as component processes. It is assumed that at the beginning of the choice process neither alternative is favored. Therefore, at the beginning the evidence value is assumed to be zero. In the first processing step, the features on the most important dimension are evaluated, and the difference of the two attractiveness values is calculated. This calculated value represents the evidence value after the processing of the first dimension. Then the second most important dimension is processed. After the processing of the second dimension, the evidence value is updated by adding the attractiveness difference determined for the second dimension. This process continues until all dimensions have been processed or one of two criteria is surpassed, i.e., the evidence value is larger than k or the evidence value is smaller than $-k$. A positive evidence value determines the choice of one alternative, and a negative evidence value determines the choice of the other alternative. For a more detailed description see Albert, Aschenbrenner and Schmalhofer (in press).

This dimension based processing strategy may be difficult to apply for sequentially presented alternatives, because the features of the first alternative would have to be stored in memory until the next alternative becomes available. To decrease the demands upon working memory, subjects could however use judgment as a component decision process in this case. Thus, subjects would make an overall judgment of the first alternative and store it in memory rather than a list of its features. A second overall judgment is then made for the second alternative, and the decision would be based upon a comparison between the two overall judgments. For such a strategy, the criterion dependent processing occurs for the formation of the judgments of the two choice alternatives.

Judgments as component processes. The present conception about the formation of judgments assumes that the feature evaluations, which may be positive or negative, are summed up. In particular, it is assumed that at the beginning of the judgment process the evidence value for an alternative is zero, i.e., there is no bias toward a positive or negative judgment. In the first processing step, the feature of the most important dimension is evaluated and represents the evidence value after the processing of the first dimension. Then the second most important dimension is processed. After the processing of the second dimension, the evidence value is updated by adding the new attractiveness value. This process continues until one of two criteria is surpassed or all features have been processed. If the boundary k is surpassed the alternative is considered to be attractive. If the boundary $-k$ is surpassed the alternative is unattractive. A judgment about the choice alternative is obtained by dividing the evidence value, i.e., the sum of the attractiveness values, by the number of processed features. A judgment of the second alternative presented is derived in the same way. The alternative which received the better judgment will be chosen.

Effort – Quality Relations

In order to assess the advantages of applying dimension versus judgment based processing, Schmalhofer and Gertzen (1986) performed an effort – quality analysis for the two choice situations of simultaneous or sequential presentation of the alternatives. This analysis was based upon the two described versions of the criterion dependent choice models. For the two strategies, the effort and quality of a choice have been analyzed under the conditions of simultaneous or sequential presentation of the choice alternatives.

These effort – quality analyses showed that dimension based processing requires less computational effort, but that because of memory load, judgment based processing should be more economical for sequentially available alternatives. Since judgment based processing requires more accumulation operations than dimensional processing and these accumulations are probably more difficult and therefore more time consuming than dimensional comparisons (Klayman, 1982; Russo & Dosher, 1983), longer choice latencies should be observed for sequentially presented alternatives than for simultaneously presented alternatives. Furthermore, an experimental investigation of Tversky's hypothesis indicated that for sequentially presented choice alternatives decision makers are more likely to apply judgment based processing, but not necessarily to the complete exclusion of any dimension based processing. In particular, overall judgments obtained from the subjects after their choices were in moderately better agreement with the observed choices for sequentially presented alternatives than for simultaneously presented alternatives. In addition, choices between sequentially available alternatives, which supposedly require more computational effort due to judgment based processing, actually required more time than choices between simultaneously available alternatives. While these results are consistent with the effort – quality analysis, they also showed that the specific criterion dependent choice models may be too simple to account for the experimental findings in any detail.

In the present research we will further examine the stability of the reported findings by an experiment with only two minor modifications to the previously used experimental procedure. Also, a larger number of subjects will be employed in this study.

Experiment 1

The same experimental setup and materials as in Schmalhofer and Gertzen were used. Several pairs of multidimensional descriptions of word processors served as choice alternatives. There were three between – subjects conditions in the experiment: The two alternatives of a choice pair could be presented either (1) simultaneously, (2) sequentially, i.e., one after the other, or (3) one after the other with an interfering task in between.

Method

Subjects. Fifty – four students of the University of Heidelberg who were paid 10 German marks per hour for their participation in the experiment served as subjects.

Apparatus. The experiment was run under the control of Apple II computers. Learning materials and choice alternatives were presented on the video screen of the computer. A button box with two response buttons and a lever which could be moved in two dimensions was used for collecting the subjects' responses.

Materials. Eight fictitious word processors, which were described by their features on eight dimensions, served as choice alternatives. For every description of an alternative, a meaningless name (cvc – trigram) was introduced. A sample choice pair with the respective meaningless names is shown in Table 1.

Table 1: English translation of a sample pair of word processors

Dimensions	Alternatives	
	TAF	BID
Correction facilities	optimal	quite poor
Graphics facilities	moderate	optimal
Accessibility	poor	medium
Reliability	quite poor	very good
User friendliness	good	quite good
Learnability	optimal	moderate
Maintenance costs	good	very good
Printing speed	quite good	medium

In order to familiarize the subjects with the relevant dimensions, a text was constructed which explained the eight dimensions and the range of possible features of the word processors. In this text, the features on each dimension (e.g., printing speed 80 characters per second) were specified together with their respective evaluation (e.g., "quite good"). Furthermore, the text described an importance ranking of the eight dimensions which was obtained in a prior study in which 32 subjects ranked the eight dimensions by their importance. Since the dimensions were displayed in decreasing order of importance from top to bottom, the importance ranking can be seen in Table 1.

Procedure. The experiment consisted of four major segments: a study task, decision tasks, memory tasks, and rating tasks. Each of these segments began with instructions which were displayed on the video screen. Every subject first acquired knowledge by studying the explanatory text about word processors, thus making all subjects about equally knowledgeable about word processors. A subject was then randomly assigned to one of the three experimental conditions.

The three conditions differed in how the multidimensional descriptions of the alternatives were presented: simultaneously, sequentially, or sequentially with an interpolated task to be performed between the presentations of the two alternatives. The interpolated task involved remembering a 5-digit number for 30 seconds. In the simultaneous and sequential conditions, the interpolated task was performed after a choice pair. In the third condition the interpolated task was presented between the alternatives of a choice pair. In order to reduce the number of times an alternative had to be presented in a complete paired comparison, the eight alternatives were divided into two sets of four alternatives each. For both sets, a complete paired comparison was performed. Since every alternative of a pair was presented in the first as well as in the second position, every choice pair had to be presented twice, yielding a total of 24 choices per subject.

Under simultaneous presentation both alternatives remained on the screen for 40 seconds. After 20 seconds a signal appeared at the bottom of the screen indicating that a choice could be made at any time from then on by pressing either the right or the left button. The subjects' attention was directed to the alternatives' names in the following way: The position of the dimensional description of the alternative on the left or right side of the screen was not necessarily identical to the position of the name of the alternative displayed at the bottom of the screen to indicate the respective choice button. In order to press the button associated with their preferred alternative, the subjects thus had to pay attention to the name of an alternative and could not rely on spatial position. This is one of the two differences to the previously reported experiment.

In the other two conditions (i.e., sequential presentation with or without the interpolated task between the alternatives of a pair) each alternative remained visible for 20 seconds. In these two conditions a choice could be made as soon as the second alternative was presented. Thus, in all three conditions the alternatives could be inspected for 40 seconds and a choice could be made after 20 seconds of inspection.

The second modification to the previous experiment was that the dimensions were always displayed in the order of their importance, i.e., they were not presented in a new random order for each trial.

Choices and choice latencies were collected. The latency timer was started 20 seconds after the onset of the two alternatives (simultaneous presentation) or concurrently with the onset of the second alternative (sequential presentation). It was stopped by the subject's button press.

After the decision tasks, subjects judged the attractiveness of the alternatives from memory as well as from multidimensional descriptions. In the memory judgment task, subjects were only presented with the name of the alternative. In the (regular) judgment task, the respective multidimensional descriptions were shown to the subjects without the alternative's name (cvc – trigram). The memory judgment task, which was separated from the (regular) judgment task by an interfering activity of about 30 minutes duration, indicates the judgments about the alternatives which are stored in the decision maker's memory after several choices. The regular judgments were collected to compare them to the memory judgments. The judgments were obtained by having the subjects move a lever so that the cursor was moved to a respective judgment category on a 9 – point rating scale. As soon as the desired category was reached, the subject pressed a button. In both judgment tasks the categories ranged from poor (–4) to optimal (+4).

Results

If subjects indeed used an overall judgment as an intermediate result of the decision process rather than dimensional comparisons to derive a choice, these judgments should have become incidentally stored in memory. In this case, the collected memory judgments should be suitable for predicting a decision maker's choice. To derive such predictions it was assumed that the alternative with a higher memory judgment would be chosen. The results are given in Table 2.

Table 2: Relative frequency of correct choice predictions by judgments from memory, and correlations between judgments from memory and regular judgments

	Presentation of alternatives		
	Simultaneous	Sequential	With interpolated task
Predictions	.71	.63	.69
Correlations	.25	.23	.36

All predictions significantly differ from chance. However, there is no difference between conditions (Chi-square $(2,n=877)=2.26$, $p > .25$). The same applies for the correlations.

It can be seen from Table 3 that choices between sequentially presented alternatives required more time than choices between simultaneously presented alternatives, $F(2,51) = 8.32$, $p < .001$. In this analysis homogeneity of variance was achieved by a log-transformation of the latencies.

Table 3: Average choice latencies and standard deviations (in parentheses) for the three experimental conditions

Presentation of alternatives		
Simultaneous	Sequential	With interpolated task
7.77 (6.89)	11.76 (4.03)	11.46 (5.58)

Discussion

The longer choice latencies for both sequential conditions were consistent with expectations. Presumably, the longer latencies are due to the higher computational effort of judgment based processing as compared to dimension based processing of the simultaneously presented alternatives. Whereas the previous research has found the predicted differences in memories for overall judgments to be significant but small, no effect was obtained in this study. The lack of this effect was due to the simultaneous presentation condition in which memory judgments were more predictive than in the previous experiment.

The difference in the results of the two studies may be caused by the subjects' attention being more strongly directed to the alternatives' names in the present experiment. The predicted differences in processing time are more robust than the differences in memories. Tversky's hypothesis received only partial support. In order to find the reasons why subjects did not remember more overall judgments of the sequentially presented alternatives, and to explore the processing components in more detail, a think aloud study was conducted. It could be that for sequentially presented alternatives judgment **and** dimensional comparison components are both used and form a hybrid strategy.

Experiment 2

Subjects were instructed to verbalize their thoughts while choosing one of two multidimensionally described word processors which were sequentially presented.

Method

Subjects. Three students of the University of Heidelberg who were paid 10 German marks per hour participated in the experiment.

Materials. Similar choice alternatives were used as in the first experiment. Nine word processors were described on 12 dimensions. The names of the dimensions were always visible to the subject. The features of each alternative were printed on a card and could be placed side by side to the respective dimensions. In contrast to Experiment 1, the features (e.g., printing speed 80 characters per second) rather than the values of the features (e.g., "quite good") were presented. The order in which the dimensions were presented was random and remained constant across trials and subjects.

Procedure. Subjects received an oral instruction followed by a text which explained the significance of the 12 dimensions and respective features. Subjects then rank-ordered the dimensions by their importance. Initial practice trials were used to familiarize the subjects with choice materials and procedure. After a standard think aloud instruction (Ericsson & Simon, 1984) and two more choice trials with the think aloud procedure, the nine alternatives were administered in a complete paired comparison. Think aloud data were collected for a block of 20 pairs who were randomly selected out of the 36 pairs. This block of 20 pairs was presented twice with an exchanged order of alternatives within pairs. Thus, think aloud data of 40 choice trials were tape-recorded for each subject. In each trial the experimenter placed the first alternative in front of the subject and removed it as soon as the subject requested the second alternative. A choice trial was ended by the subject's choice which was recorded by the experimenter. A session lasted about three hours.

Results

The transcribed protocols were scored according to the categories employed by Schmalhofer and Schäfer (1986). In the present study the following categories were sufficient for classifying all verbalizations:

- verbalization of a single feature (VSF), e.g., "30 pages storage capacity is quite good" or "it is always accessible at home";
- verbalization of a dimensional comparison (VDC), e.g., "printing speed of this one is very much slower" or "I just notice that it is cheaper, and has less storage capacity";
- verbalization of an overall judgment (VJ.) for the first (VJ1) or second (VJ2) alternative, e.g., "this one is also rather poor" or "seems like a reasonable machine".
- mentioning of a dimension, e.g., "graphics facilities don't matter", and
- a rest category consisting of inferences, elaborations, etc. A unit was coded as belonging to only one of the categories.

Table 4 shows the result of the scoring as percentage scores.

Table 4: Percentage of four different verbalizations and a rest category for the first and secondly presented choice alternative

	First alternative	Second alternative	Total
Single features (VSF)	43%	23%	70%
Dimensional comparisons (VDC)	-	11%	11%
Overall judgments (VJ.)	7%	5%	12%
Mentioning of dimensions	1%	1%	2%
Rest category	1%	4%	5%

Note: For the 120 choice trials, the total number of verbalizations was 870.

There was a relatively high percentage of overall judgments (12%). Nearly half of the presented alternatives received an overall judgment (42.5% of the 240 alternatives presented). On the other hand, there was also a considerable amount of dimensional processing. Obviously, dimensional processing has to occur when the second alternative is presented.

As postulated by criterion dependent choice models, the processing of features and dimensions was selective. Because the alternatives were rather similar, it is difficult to decide whether it was also adaptive to characteristics of alternatives or pairs of alternatives.[2] Figure 1 shows the relative frequencies of verbalizations of single features on the first alternative, the second alternative, and for dimensional comparisons, as a function of the importance of the dimensions. As can be seen, some dimensions are hardly ever verbalized, and the clear majority of verbalizations occurs for the three most important dimensions. On average, only about three dimensions were processed for an alternative which reveals highly selective processing.

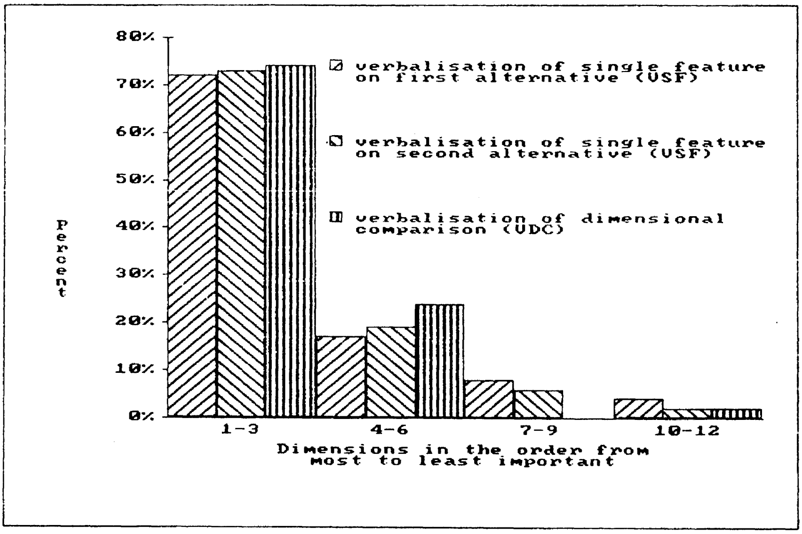

Figure 1: Percentage of different verbalizations as a function of the importance of dimensions

Contingencies of verbalizations. The following analyses are based upon the 120 choice pairs. It can be seen from Table 5 which shows conditional frequencies whether or not there is a relation between the formation of an overall judgment and the occurrence of dimensional comparisons. It appears that the formation of an overall judgment for the first alternative does not influence the likelihood of dimensional comparisons, while the formation of a judgment for the second alternative leads to reduced application of dimensional comparisons. The (unconditional) relative frequency of at least one verbalization of a dimensional comparison was .48.

2) For those choices where an overall judgment of the second alternative indicated judgment based processing (see description of hybrid decision strategy), alternatives were classified as extreme (i.e., very good or very bad), or medium. The average number of processed features was 2.1 and 2.7 for extreme and medium alternatives, respectively. For the other choice pairs where supposedly dimension based processing occured, pairs were classified as dissimilar or similar. The average number of processed features per choice pair was 6.0 and 6.1 for dissimilar and similar choice pairs, respectively.

Table 5: Conditional relative frequencies of at least one dimensional comparison for a choice pair when there was:

An overall judgment for the 1st alternative:	.47
No overall judgment for the 1st alternative:	.50
An overall judgment for the 2nd alternative:	.33
No overall judgment for the 2nd alternative:	.56

The conditional relative frequencies given in Table 6 show that if no overall judgment is derived for the first alternative, there most likely will not be an overall judgment of the second alternative either. The relative frequency of forming an overall judgment for the first presented alternative was .52, while the relative frequency of forming a judgment for the second alternative was .33.

It is striking that the probability of the verbalization of a judgment for the first alternative (VJ1) is equal to the probability of verbalizing a judgment for the second alternative after a VJ1 had occurred. That is:

$$P(VJ1) = P(VJ2|VJ1) = .52 \qquad (1)$$

Table 6: Conditional relative frequency of an overall judgment for the secondly presented alternative when there was:

An overall judgment for the 1st alternative:	.52
No overall judgment for the 1st alternative:	.14

A hybrid decision strategy

The reported results were used to revise the previous processing assumptions for sequentially presented alternatives.

Model assumptions. Subjects may use both alternative and dimension based processing. When presented with the first alternative, the subject processes the alternative's features and keeps them in short-term memory. With a certain probability α an overall judgment of the first alternative is formed and also stored in short-term memory. When the second alternative is presented, the decison maker may employ dimensional comparisons for deriving a choice in the way described at the beginning of the paper. In a dimensional comparison a feature stored in short-term memory is compared to the feature of the second alternative on the respective dimension. The dimensional comparison strategy is thus restricted to the set of dimensions for which features of the first alternative were held in short-term memory.

If, in addition, an overall judgment of the first alternative has been held in short-term memory, the previously discussed judgment based strategy will be applied with probability a.

The first steps of each of the two processing strategies may thus be performed together for a given pair whose alternatives are presented sequentially. Only after the second alternative is presented will either the judgment based or the dimension based strategy be applied.

The described application of the two strategies may be stated more formally by a Markov model with four states: a start state (ST), the state of forming and storing an overall judgment of the first alternative in short-term memory (J1), and the two absorbing states of applying the dimension based (DB) or the judgment based strategy (JB). Obviously, the process always begins in ST. The transition matrix is:

	ST	J1	DB	JB
ST	0	a	$1-a$	0
J1	0	0	$1-a$	a
DB	0	0	1	0
JB	0	0	0	1

An exploratory application. The subjects' verbalizations may indicate the state in which they are. Instead of using the subjects' choices to determine the parameter of the model we may thus use the reported verbalizations of overall judgments. Suppose that the formation of an overall judgment is verbalized with probability v. The probability of verbalizing a judgment on the first alternative would thus be

$$P(VJ1) = a*v \quad (2)$$

The probability of verbalizing a judgment of the second alternative would be

$$P(VJ2) = a^2*v \quad (3)$$

The probability of verbalizing a judgment of the first and the second alternative of a pair is

$$P(VJ1 \wedge VJ2) = (a*v)^2 \quad (4)$$

From $P(VJ1)=.52$ and $P(VJ2)=.33$ the parameters are estimated to be $a=.63$ and $v=.83$. Because of the conditional independence expressed in Equation (1), these parameters also satisfy (4).

According to the exploratory model application, subjects would verbalize 83% of their judgments. For sequentially presented alternatives a dimension based strategy would be applied in 60% (i.e., $(1-a)+a(1-a)$) of the cases and a judgment based strategy in 40% (i.e., a^2) of the cases. These percentages may explain why differences in the remembered overall judgments between simultaneously and sequentially presented alternatives were either small (Schmalhofer and Gertzen, 1986) or nonexistent (Experiment 1).

Discussion

The considerable number of verbalizations of dimensional comparisons clearly demonstrate that even for sequentially presented alternatives dimensional comparisons are performed. Table 5 shows that dimensional comparisons are more likely to occur when no overall judgment is verbalized for the second alternative. Thus dimensional comparisons do not occur at random but may indeed be a component of the subject's decision making process. With a similar argument we can derive that judgment based processing is a component of the subject's decision making process.

Dimensional comparisons and overall judgments are consequently both component processes for deciding between sequentially presented alternatives whose application can be specified by a Markov model. For estimating the model parameter, only the verbalizations of overall judgments were used rather than including all verbalizations (e.g., VDCs).

As seen from Table 5, the VDCs do not fit the model predictions as well. In particular, if no overall judgment is formed for the first alternative, the dimension based strategy should always be employed. Even if not all results of cognitive processing (judgments or comparisons) are verbalized, P(VDC|Not VJ1) should be considerably higher. Since this experiment was designed for exploration rather than testing a model, any assessment of its empirical validity should be left to appropriately designed experiments.

General Discussion

Tversky (1969) conjectured that choices between alternatives which are presented one after the other are derived by judgment based processing. Effort–quality analyses supposedly support this hypothesis. In testing the hypothesis, Schmalhofer and Gertzen (1986) showed that in comparison to simultaneously presented alternatives decision makers were indeed more likely to apply judgment based processing. However, they concluded that dimension based processing may occur as well, thus suggesting that things are not as simple as the original conjecture suggests.

Experiment 1, which was basically a replication of their previous study supported this suggestion: Although the latencies indicated more judgment based processing for the sequential presentation than for the simultaneous presentation, the memory measures did not indicate any differences.

Effort–quality analysis reconsidered. Effort–quality considerations do not unanimously support the conjecture: Although judgment based processing puts considerably lower demands on working memory, its computational effort is higher than the respective measures of dimension based processing (see Schmalhofer & Gertzen, 1986, Table 1). In performing the reported effort–quality analysis, the differences between the two strategies in memory effort were considered more crucial than the differences in computational effort. But whether this is true or not, really depends upon whether memory or processing resources are more scarce. If processing resources are scarce, dimension based processing should even be applied for sequentially presented alternatives.

The judgment based strategy does not exhaust the capacity of working memory which is limited but constant. Thus available resources would remain unused. This is in contrast to the generally held assumption that the whole capacity of working memory is used and information is only lost by replacement (Atkinson & Shiffrin, 1968). A more reasonable assumption would therefore be that in addition to the overall judgment of the first alternative some of its features are also kept in working memory when the second alternative is presented. The stored features can be employed in dimensional comparisons with the respective features of the second alternative. This could yield choices based upon dimensional processing without excessive or any additional demands on working memory, while demanding less computational effort than judgment based processing. Dimension based as well as judgment based processing would thus be applied.

In order to explore these processing components for sequentially available alternatives in more detail in the second experiment, a process–tracing method was employed for this presentation mode. Think aloud protocols showed that in addition to the judgment based processing, subjects indeed frequently employed dimension based processing. Since this requires the processing of the first alternative's features, they must have been stored in working memory. Spare memory capacity was thus utilized for storing features, allowing for dimension based processing. However this processing is restricted to a subset of dimensions which may obviously reduce choice quality. Depending on which features are lost choice quality decreases more or less strongly. Under such conditions it is therefore difficult to say whether alternative or dimension based processing should be applied when the second alternative is presented.

The application of a Markov model indicated that 60% of the choices were derived by dimension based processing and 40% by judgment based processing. This is approximately consistent with the result that for 48% of the choice pairs at least one verbalization of a dimensional comparison was observed. In agreement with the model, the verbalizations also showed that the decision makers used a hybrid strategy consisting of judgment and dimensional comparison components. An exploratory study thus yielded a plausible model which deserves to be tested by future experiments.

Contrary to Experiment 1, only sequentially presented alternatives were investigated by a process–tracing method (think aloud) in Experiment 2. By no means does the study imply that a hybrid strategy would also be used for simultaneously presented alternatives. For this presentation mode all features are externally available at once, so that dimensional processing requires less computational as well as memory resources than judgment based processing. The study by Schmalhofer and Schäfer, in which think aloud data were collected for similar and simultaneously presented alternatives, yielded 35.5% verbalizations of dimensional comparisons (VDC), but only 2.9% verbalizations of judgments of alternatives (VJ.). Dimensional processing thus seems to be predominant for simultaneously presented alternatives.

References

Albert, D., Aschenbrenner, K.M. & Schmalhofer, F.: (in press). Cognitive choice processes and the attitude–behavior relation. In: A. Upmeyer (Ed.). Attitudes and behavioral choice, New York: Springer

Aschenbrenner K.M., Albert, D. & Schmalhofer, F.: 1984. Stochastic choice heuristics. Acta Psychologica, 56, 153–166

Atkinson, R.C. & Shiffrin R. M.: 1968. Human memory: A proposed system and its control processes. In: K. W. Spence and J. T. Spence (Eds.), The psychology of learning and motivation: Advances in Learning and Motivation. New York: Academic Press

Ericsson, K.A. & Simon, H.A.: 1984. Protocol Analysis. Cambridge, Mass.:MIT–Press

Klayman, J.: 1982. Simulations of six decision strategies: Comparisons of search patterns, processing characteristics, and response to task compexity. Working paper, University of Chicago

Lopes, L.L.: 1982. Toward a procedural theory of judgment. Technical Report, University of Wisconsin

Russo, J. & Dosher, B.A.: 1983. Strategies for multiattribute binary choice. Journal of Experimental Psychology: Learning, Memory, and Cognition, 9, 676–696

Schmalhofer, F., Albert, D., Aschenbrenner, K. M. & Gertzen, H.: 1986. Process traces of binary choices: Evidence for selective and adaptive decision heuristics. The Quarterly Journal of Experimental Psychology, 38A, 59–76

Schmalhofer, F. & Gertzen, H.: 1986. Judgment as a component decision process for choosing between sequentially available alternatives. In: B. Brehmer, H. Jungermann, P. Lourens, & G. Sevon (Eds.), New directions in research on decision making. Amsterdam: North–Holland, 139–150

Schmalhofer, F. & Schäfer, I.: 1986. Lautes Denken bei der Wahl zwischen benannt und beschrieben dargebotenen Alternativen. Sprache & Kognition. 2, 73 – 81

Tversky A.: 1969. Intransitivity of preferences. Psychological Review, 76, 31 – 48