A Lens Analysis of the Effects of Memory Load and Time Pressure on Static Judgment

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ABSTRACT

While the effects of time pressure on decision-making have been studied relatively extensively, the effects of a concurrent memory load have not. This paper presents a study of the effects of both time pressure and concurrent memory load on a static judgment task from the perspective of the lens model. Previous results indicating that time pressure results in less cognitive control and utilization of fewer cues was replicated, though negative bias was not. There was an effect of concurrent memory load which was not the same as that of time pressure. Concurrent memory load also decreased cue utilization, but did not affect cognitive control. Further work is necessary to more clearly understand the difference between time pressure and concurrent tasks.

INTRODUCTION

Human judgment, even in the most optimal of circumstances, is inexact. It is rare, however, that circumstances are optimal. In a seminal study, Wright (1974) used lens-style models to examine the effects of various forms of "harassment" on decision-makers. One of the forms of "harassment" used by Wright was time pressure. Since then, several studies have examined the effects of time pressure on decision-making. Strangely, other forms of harassment, such as concurrent memory load, have received little attention. This is in spite of the fact that working memory capacity is implicated as an important factor in a number of tasks that fall outside the traditional boundaries of decision-making research.

In Wright's (1974) seminal study, subjects judged the attractiveness of automobiles based on five cues: "(a) selling price, (b) ease of handling, (c) cost of maintenance, (d) styling, and (e) riding comfort" (p. 557). Attributes had values on seven-item scales, ranging from "greatly below average" to "greatly above average."Subjects were to assume that "average" price corresponded to $4000 in 1974. The data were analyzed with a lens model. There were two primary findings in the Wright study: subjects under time pressure used fewer cues to make the judgments, and they weighted negative evidence more heavily (more will be said about negative bias later). These effects were replicated on a similar task involving personal investment by Wright and Weitz (1977).

Another effect of time pressure is the reduction of what has been termed "cognitive control" (Dudycha & Naylor, 1966), which is the coefficient of determination (R^2) between cues and judgments. In a study on line-length prediction, Rothstein (1986) found that time pressure had a significant detrimental effect on cognitive control. Zakay and Wooler (1984) demonstrated that, even with training to explicitly use a compensatory additive rule, cognitive control decreased with the introduction of time pressure. It has been argued by many of the researchers cited above that time pressure causes subjects to shift from a compensatory strategy to a simpler conjunctive one, which decreases the predictive power of simple linear models.

One effect for which the evidence is mixed is that of what has been termed "negative bias." That is, under time pressure, decision-makers pay greater attention to negative information. Wright's (1974) study found that decision-makers under time pressure were better modeled if the cues were log-transformed. Log-transforming the cue values causes low values to be more "spread out" on the scale and high values to be "closer together," such that lower values for the cues should have a relatively greater effect on the decision. Negative bias has been replicated by Wright and Weitz (1977) and Svenson and Edland (1987). However, in a choice task where subjects had incomplete information about the values on all attributes, this effect was not observed and, in fact, a positive bias was found (Svenson, Edland, & Slovic, 1990). So, while evidence for the other effects of time pressure have been fairly well-established, an effect for information valence is tentative.

Understanding the effects of time pressure is certainly important, because decision-makers are often faced with such pressure. On the other hand, there are other possibilities. As Hammond (1986) might note, this is a poor sampling of potential treatments. In many everyday situations, decision-makers will be faced not with time pressure, but with memory or attentional overloads. For example, one might be trying to make a decision about which brand of tortilla chip to buy while simultaneously trying to remember the remainder of one's grocery list.

There is ample evidence (e.g. Just & Carpenter, 1992; Baddeley, 1986) that memory demands can affect performance in cognitive tasks, but to date, the question of how concurrent memory loads affect decision-making has not been addressed in the literature.

The preliminary study outlined here is an attempt to accomplish several things. First, it is an effort to asses the effects, if any, of a concurrent memory load on judgment. Second, it is an attempt to replicate previous research on the effects of time pressure. Third, it may be informative to compare the two effects. If preliminary evidence indicates that there is an effect of concurrent memory load and that this effect is distinguishable from that of time pressure, a more in-depth study would be warranted.

METHOD

Subjects. Subjects were 10 Georgia Institute of Technology graduate students who participated on a volunteer basis.

Judgment task. The judgment task in this experiment is similar to that used by Svenson, Edland, and Slovic (1990). Subjects were shown profiles of fictional graduate school applicants which contained values on the following attributes, all of which were presented in this order:

(1) letters of recommendation, on a ten-point scale
(2) grade-point average on a four-point scale
(3) extra-curricular involvement, on a ten-point scale
(4) Graduate Record Examination (GRE) score on the Quantitative section, range 200–800
(5) GRE Verbal score, range 200–800
(6) GRE Analytic score, range 200–800
(7) GRE Subject test score, range 200–800
(8) application essay, on a ten-point scale

Ranges listed above are the allowable ranges for each score, though the entire range was not used for each score. In particular, the bottom range for each score was not used so that all applicants were "good" applicants in an absolute sense, forcing the subjects to make fine distinctions about admissions. For each profile, the value of each cue was randomly selected from a uniform distribution. Cue values were not intercorrelated.

The subjects were asked to rate 48 applicants on a scale from 1–20, with 20 representing an optimal rating and 1 representing a "worst case" rating. Subjects were also encouraged to try to use the entire range of scores to "create variance for the admissions committee."

Design. The design was a one-way within-subjects design having three levels. One level consisted of the control problems, which were problems as described above in which the the subjects were given unlimited time to work and no concurrent task. In the time-pressure condition, subjects also received speeded trials in which they performed the same task as in the control problems, but were given only ten seconds in which to make each judgment.

The last level used was the concurrent memory load manipulation. Subjects performed the same judgment task with unlimited time, but before each judgment were presented with a 4 x 4 array in which five of the cells contained gray circles. Figure 1 shows one of the arrays used in the experiment. After the subject completed the judgment task, they were shown a blank array and asked to place X's in the cells that contained

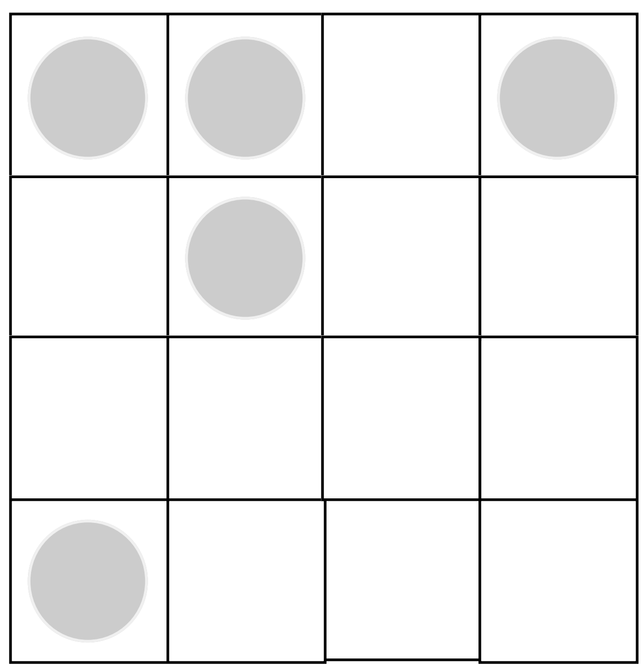

Figure 1. Example memory stimulus

circles in the preceding array.

Subjects performed 16 judgments of each type in single blocks. Subjects always received the control block first, and the order of the remaining two blocks was counterbalanced between subjects.

Procedures and stimuli. Subjects were run individually or in groups of two or three. All stimuli were presented on half-sheets of paper, with judgment responses circled on a scale presented at the bottom of the page. Subjects were first given a description of the general judgment task and the scales used, then a description of the requirements for each block immediately prior to beginning work on a block.

RESULTS

The data for each subject was analyzed via multiple regression of the judgment responses on the cue values for each application. However, unlike other lens-style work (e.g. Wright, 1974), not all cues were simultaneously entered into the regression equation. Instead, a forward selection procedure was used to determine more precisely how many (and which) cues were necessary to predict responses. Due to the preliminary nature of the research and the relatively limited degrees of freedom, the p-to-enter was set at .10. For each type of problem, the dependent measures for each subject were the cognitive control (R^2) for the block and the number of cues present in the final regression model. Means for the data are presented in Table 1.

Based on the raw data, the effect of problem type on cognitive control was marginally reliable, F(2,16) = 3.84, $p = .056$. At a marginal level, t-tests confirm that the source of this effect is the difference between the time pressure group and the other groups, with the other groups being indistinguishable from each other (control vs. time pressure t(9) = 2.15, $p = .060$; concurrent memory load vs. time pressure t(9) = 2.13, $p = .062$; control vs. memory load t(9) = .65, $p = .533$). That is, time pressure seems to adversely affect cognitive control while the concurrent memory load does not.

Problem type	Raw R^2	Raw Number of cues	Screened R^2	Screened Number of cues
Control	.76	3.3	.80	3.5
Concurrent Memory Load	.71	2.3	.71	2.3
Time Pressure	.56	2.2	.56	2.2

Table 1. Mean R^2 and number of cues in lens equations, raw and screened data

The result for number of cues is somewhat different. There is a reliable main effect for problem type, F(2,16) = 4.40, $p = .033$. This decomposes differently, however, with both the treatment groups differing marginally from the control but not from each other (control vs. time pressure t(9) = 2.18, $p = .057$; control vs. memory load t(9) = 2.12, $p = .063$; concurrent memory load vs. time pressure t(9) = .23, $p = .823$). There was also a reliable interaction between presentation order and problem type, F(2,16) = 3.84, $p = .046$.

While these data are suggestive, they are a bit noisy. In particular, there is an outlier in the data which is almost certainly an artifact of the small number of trials in each block. If the true β-weights of all variables are approximately equal, the forward selection procedure will rarely be able to add new variables since no single variable will account for a large enough variance on its own to make up for the sacrifice of an error degree of freedom. This is the case with this outlier: the full equation with all variables has an R^2 of roughly .80, yet only one variable was entered by the selection procedure yielding an R^2 of .41 and only one variable. If these observations are thrown out by correcting to the grand mean of the data, the conclusions are clearer (see the "screened" data in Table 1). Since the number of subjects was small, the effects of a single outlier are dramatic.

In this case, the main effect of problem type on cognitive control reaches the nominal alpha level, F(2,16) = 6.11, $p = .021$. The control vs. time pressure post hoc also reaches significance, t(9) = 2.95, $p = .016$. Similar changes occur for number of cues used: the main effect remains reliable, F(2,16) = 7.39, $p = .010$ and the conclusions about the source of difference are more clear (control vs. time pressure t(9) = 3.28, $p = .009$; control vs. memory load t(9) = 2.88, $p = .018$). Interestingly, the interaction with presentation order falls to marginal significance, F(2,16) = 2.96, $p = .096$.[1]

One other result, this one related to negative bias, should be discussed. The same forward selection

[1] Note that for all repeated-measures ANOVA, the Greenhouse-Geisser correction for non-sphericity was applied to the obtained *p*-value.

regression procedure was attempted with log-transformed cue values, in accord with the negative bias model proposed by Wright (1974). The net effect of using this model as compared to the normal linear model was negligible. The mean R^2 accounted for by the nonlinear model was, in fact, just slightly lower (about .02) than that for the linear model, which was consistent not only for the subjects as a whole but for nine of the ten individual subjects as well. The number of variables in the equation changed by 1 for one of ten subjects for one of the problem types. Thus, these data provide no support for inordinate weighting of negative information. On the other hand, this may simply be a result of not using the lowest end of the scales in the cues.

The general conclusions that can be drawn are rather straightforward. Time pressure seems to both adversely affect cognitive control and reduce the number of cues utilized, while concurrent memory load seems to reduce the number of cues used, but not the effectiveness of the cue usage.

DISCUSSION

This study, though preliminary, is quite suggestive. While successfully replicating the effects of time pressure, it further suggests that concurrent memory load has an effect on decision-making as well, and that this effect is not the same as that associated with time pressure. The data on time pressure seems to indicate that subjects switch from using a compensatory strategy to a more heuristic conjunctive strategy.

This does not seem to be the case with concurrent memory load. These data suggest that rather than switching to a conjunctive strategy, subjects continue to use a linear-additive rule, but they reduce the amount of input to this process, presumably to prevent interference between the decision process and the memory load.

Testing this hypothesis would require more complex methodology than the one used here. While lens-style regression analysis is useful for characterizing the results of a decision process, it does little to explain the process itself. To more clearly understand the effects of concurrent memory load and how they relate to time pressure, some form of process-tracing technique will likely be required.

Other important unresolved questions concern the effects on choice vs. judgments and static vs. dynamic environments. The study described called for judgments in a strictly static (i.e. non-changing) environment; it is not at all safe to assume that the effects of concurrent memory load will be the same in choice and dynamic environments.

These results also suggest that work needs to be done in areas where there are a very large number of cues. Most of the effects of time pressure have used relatively few cues (typically five or less). This study suggests that time and memory resource limitations are important and distinct, and this may differentially interact with the number of cues available for processing.

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