ARI Research Note 96-30

Enhancing Cognitive Performance by Information Management Techniques

Shlomo Breznitz, Hasida Ben-Zur, and Naomi Vardi
University of Haifa

Research and Advanced Concepts Office
Michael Drillings, Acting Director

March 1996

ARMY RESEARCH INSTITUTE

United States Army
Research Institute for the Behavioral and Social Sciences

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Director

Research accomplished under contract
for the Department of the Army

University of Haifa

Technical review by

Joseph Psotka

NOTICES

REPORT DOCUMENTATION PAGE

1. REPORT DATE 1996, March	2. REPORT TYPE Final	3. DATES COVERED (from. . . to) January 1995-November 1995
4. TITLE AND SUBTITLE Enhancing Cognitive Performance by Information Management Techniques		5a. CONTRACT OR GRANT NUMBER DAJA45-91-C-0024 5b. PROGRAM ELEMENT NUMBER 0601102A
6. AUTHOR(S) Shlomo Breznitz, Hasida Ben-Zur, and Naomi Vardi (University of Haifa)		5c. PROJECT NUMBER B74F 5d. TASK NUMBER 2901 5e. WORK UNIT NUMBER C61
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) R. D. Wolfe Centre for Study of Psychological Stress University of Haifa Mount Carmel, ISRAEL 31999		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences ATTN: PERI-BR 5001 Eisenhower Avenue Alexandria, VA 22333-5600		10. MONITOR ACRONYM ARI 11. MONITOR REPORT NUMBER Research Note 96-30

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

COR: Michael Drillings

14. ABSTRACT *(Maximum 200 words)*:

Ten experimental groups totaling 200 subjects were given free recall tasks with different information about list length. Manipulations consisted of exact information, discouraging information, and no information, as well as information on route, and encouraging and discouraging disconfirmation during the task proper. Information management principles that were effective in enhancing endurance of stressful tasks were successfully applied to the area of free recall. Information conditions significantly affected performance. The conceptual framework focusing on the role of information in determining expected effort, resource mobilization, and within tasks resource allocation, was found useful in generalizing from earlier studies that enhanced endurance, to the present one. It suggests a variety of potentially effective interventions aiming at maximizing performance.

15. SUBJECT TERMS

Memory Enhancing performance Coding tasks
Recall Endurance Management

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified	Unlimited	70	

ACKNOWLEDGMENT

The steadfast support and good counsel of Dr. Michael Kaplan, Director of Basic Research of ARI, is something that one learns to take for granted. The combination of his boundless good will with uncompromising scientific rigor is not only unique, but was invaluable in carrying out this study. Dr. Milton Katz, Chief of the European Research Office, was always helpful in solving the many problems, both technical and substantive. His broad experience with ARI associated research proved a major asset.

The work of the research group at the Ray D. Wolfe Centre for Study of Psychological Stress is highly appreciated: Shlomo Hareli and Dikla Sharl, who spent endless hours in recruiting subjects, testing them and coding the data. Tomer Wasserman, who desinged and programmed the computerized tasks. Special thanks to Rachel Ben-Yishai and Ruth Maos for their dedicated help in the preparation of this report.

CONTENTS

THEORETICAL BACKGROUND

Information concerning the future is one of the main determinants of the arousal, duration, and termination of psychological stress. Consequently, it must be given a major consideration in any attempt to understand the processes and dynamics inherent in stressful encounters. Information provides the material for cognitive appraisal processes considered central to the initiation of emotional, as well as behavioral consequences of stress (Lazarus, 1966; Lazarus & Launier, 1978; Goldberger & Breznitz, 1982).

In view of the proliferation of stress literature, the paucity of systematic research of temporal variables is quite striking. Whereas stress onset variables were given some attention, information about stress termination has been 22virtually neglected. The "tour of duty" phenomenon, described by Janis (1949) provides a dramatic illustration of the potential power of information to impact coping and performance. During World War II, crews of American bombers were engaged in nightly flights over Germany. Planes and crews were lost each night, and had to be replaced by new ones. At some point, many members of these crews developed major symptoms of stress, resulting in severe impairment of functioning, often making them unable to complete their missions. The psychological analysis of these soldiers indicated that they felt caught in a no hope situation, and that they thought it was only a matter of time until their turn would come. The U.S. Air Corps dealt with this problem by informing the crews that their tour of duty consisted of forty missions, after which they would be relocated to a safer type of operation. Although forty missions were not fewer than they were flying before, and although planes and crews were still lost due to enemy action just as before, psychologically the situation altered dramatically, with beneficial effects in terms of symptom reduction and prevention.

Although the "tour of duty" intervention successfully reduced a major problem, the underlying psychological mechanisms of this phenomenon were systematically studied only recently (Breznitz, 1990). In a comprehensive investigation, including controlled laboratory and field studies, Breznitz' (1988, 1989, 1990) research focussed on the enhancement of physical endurance by changing the information on the expected duration of various stressful tasks. This research established the generalizability of the findings, and provided the basis for the formulation of some practical guidelines to information management under stress. The discovery of the main parameters that optimize information management can now aid decision makers with general policy considerations, as well as provide particular tactical guidelines in a variety of military settings.

The motivational power of information about task duration need not be confined to difficult and stressful situations. The same principles can prove effective in mobilizing cognitive effort in many tasks performed in the military context, and involving cognitive operations such as perception, memory and decision making. Hence, **the main objective of the present research was to investigate whether performance on basic cognitive tasks can be enhanced by information about their duration.**

There are several sources of background information relevant to the present research: a) general information on time-related variables b) research on goal-setting behavior c) research on the effects of information about duration of stressful tasks on endurance and performance, and d) and finally, in view of the fact that our research deals with recall, that domain has to be covered as well.

(a) Time-related information and psychological stress.

McGrath (1970), Appley and Trumbull (1967), and Breznitz and Goldberger (1982) suggest that time may be one of the most important parameters of stressful situations. Lazarus and Folkman (1984) discuss the role of "temporal uncertainty" and "imminence" in affecting the stress reaction. It is of some interest to note, however, that both temporal uncertainty and imminence have been studied in the past exclusively in relation to the onset of stress, and not in relation to its termination. Thus, in spite of the fact that duration of stress is widely considered to be a major factor in dysfunction and disease, (most notably Selye 1950, 1956) information considering the termination of a stressful episode did not receive sufficient emphasis in human studies which centered on affective reactions and coping strategies in stressful situations.

In contrast to the lack of research on the duration of a stressful episode, information about the imminence of the anticipated danger, (or otherwise stressful event), was extensively stúdied in the past, to investigate its effects on emotional reactions, as well as a host of cognitive and behavioral outcomes. Thus, quality of decision making is particularly sensitive to indications of time pressure due to imminent stress (e.g., Ben-Zur & Breznitz, 1981; Janis & Mann, 1977). In situations that provide the person with full information about the onset of danger, and he/she is objectively helpless, duration of anticipation increases the stress reaction, especially when the stressful encounter gets closer, and under conditions in which exact information on time is given. Breznitz (1967) used the concept "incubation of threat" to describe this phenomenon which has been by now replicated in several studies (e.g., Breznitz 1968, 1971, 1984; Folkins, 1970; Mansueto & Desiderato, 1971; Nomikos, Opton, Averill & Lazarus 1968). On the basis of this effect alone there is good reason to expect that information about the anticipated duration of the stress itself will have significant effects on stress level and performance.

Studies of 'warning systems' clearly indicate that the frequency and pacing of information can determine the exact function plotting fear levels over time (Breznitz 1972, 1984). Depending on its serial position and timing, each warning signals differential levels of danger and/or safety. (See also the 'safety signal hypothesis' in attempting to explain preference for signalled as opposed to surprise stressor (Badia, Harsh & Abbott, 1979; Weinberg & Levine, 1980). This suggests that in addition to telling people when the stress will be over, it might be important to control the frequency and timing of ongoing feedback. In the case of the 'tour of duty' phenomenon described earlier, the World War II pilots could simply count their missions, and thus had full and continuous information about the remaining duration of their ordeal.

Finally, another critical variable studied in threatening situations is that of credibility of information. In a systematic experimental program Breznitz (1984) studied the effects of false alarms on fear levels, task performance and self protection during subsequent similar threats. This body of research indicates that credibility is highly sensitive to information management strategies. Considering the possibility that information about duration of stress is often subsequently challenged, the effects of false promises and false threats on task performance and endurance ought to be investigated.

(b) <u>Goal setting.</u>

An accumulating body of evidence suggests that definitive goals tend to increase performance. This is of some relevance to our present analysis, in view of the fact that information about the duration/length of a task may, in principle, be viewed as a case in which the goal is to persist until its completion. The basic argument is one of increased motivation, although other benefits of goal setting have been mentioned. In an important review of the evidence, Locke (Locke & Shaw, 1981), a leading contributor and in this field, reached the following conclusions:

"Results....on the effects of goal setting on performance show that in 90% of the studies, specific and challenging goals led to higher performance than easy goals, "do your best" goals, or no goals. Goals affect performance by directing attention, mobilizing effort, increasing persistence, and motivating task performance." (p.125).

Three main features of goal-setting studies deserve special attention in the present context: Firstly, there appears to be overwhelming evidence that specifically set goals are better than no goals. Secondly, the best results are obtained if the people concerned participate in the definition of the goal (e.g., Hannafin, 1981; Latham, Mitchell & Dossett, 1978; Maher, 1981; Willer & Miller, 1976). Finally, knowledge of results is a key factor in any potential benefit of goal setting (e.g., Becker, 1978; Erez, 1977).

(c) <u>Effects of information on endurance</u>.

The Cold Pressor Test (CPT) is particularly useful as a paradigm for the investigation of pain tolerance within a controlled setting. Typically, the subject is required to immerse one hand in water mixed with ice, maintained at 0-1 degrees C. In our laboratory, we used it to study the effects of information about its expected duration on endurance (Breznitz, 1990).

On the basis of results from this extensive experimental program it was possible to formulate a series of principles concerning the complex effects of information on endurance. Most notably, it was concluded that information about the expected duration of a stressful task enhances endurance in all instances in which the information is within the constraints of what appears to be "reasonable" duration. In addition, it was suggested that information impacts endurance directly, without the mediation of appraised difficulty of the task. Furthermore, lack of information induces conflict about the task, and such conflict reduces endurance, while information itself facilitates the distribution of effort. The "Law of Expected Duration on Start" (EDS) reads that: **The shorter the EDS, the greater the endurance of a stressful task.** When information concerning duration is changed during the task itself, the relative rather than the absolute change determines endurance, and the earlier the change in information, the more influential it is. The impact of EDS on endurance is greater than that of the corrective information. Finally, experience interacts with information: Change of information reduces the credibility of information on subsequent tasks, and **successful endurance of one task increases the chances of endurance of the next task.**

Similar results were obtained in a field experiment (Breznitz, 1990) in which soldiers marched under different information conditions. Morale was significantly lower in the "no information" group, as was mutual assistance among the soldiers. There were also more unauthorized stops during the march itself. At the end of the march, soldiers in this condition reported a much higher level of subjective stress than those in the "full information" condition. In a subsequent march, the impact of initially discouraging information dramatically reduced performance (33% dropouts), with subsequent correction changing the number of dropouts into 0. These results indicate the potential usefulness of information management as a tool for enhancing endurance. Not only can the information produce fatigue, but it can also reduce it rather quickly. **The high cost-effectiveness of information management manipulations warrants the study of their potential application in other contexts as well**.

Haslam (1985) investigated the effects of information about termination of a long sleep deprivation period in relation to cognitive performance. Ten trained infantrymen participated in the experiment in which they experienced 90 hours of wakefulness. After 3 nights without sleep, subjects' performance on encoding or decoding tests was 55% of their control values. However, before a 2-hour nap, and after being told that they were going to be allowed a nap, performance improved by 30%, to 85% of control values. The author interprets these effects in motivational terms, suggesting "...a reserve and manipulative mental capacity even in the presence of severe sleep deprivation" (p.50).

Thus, Haslam (1985) demonstrated the effects of information about the termination of a stressful situation (sleep deprivation) on cognitive performance. This raises the question whether the expected duration, or length of cognitive tasks can affect performance directly? This leads us to the last source of relevant background information.

(d) Information about list length in memory research.

The main factors affecting performance in the free recall paradigm are: duration of exposure, meaningfulness of the items, their familiarity, total number of the items, and their serial position (e.g., Ashcraft, 1989; Baddeley, 1986, 1990; Brown, 1976; Glanzer, 1972; Murdock, 1962). Thus, better recall is found under longer exposure conditions, when meaningful or frequent items are used as stimuli, and when the list is short. A special attention was given in the past to recall as function of the serial position of the items, which results in two main effects: a recency effect -- denoting better recall of the last items presented, and a primacy effect -- denoting the high-level recall of the first items presented on the list; the middle items are recalled least.

The initial theoretical explanations of recency and primacy effects were in terms of storage: The primacy effect was the result of items' storage in long-term memory, or secondary memory, while recency was based on items' storage in short-term memory, or primary memory. This explanation was subsequently extended to the type of encoding involved: The first items on the list are encoded by using a deep semantic code, that leads to durable memory traces, while the last items are coded superficially, probably using a phonological code. It was also suggested that storage of recency items is passive and automatic. On the other hand, a retrieval-based explanation suggested that the retrieval of the last items is based on temporal aspects, ordinal position, etc., while the first are retrieved using semantic cues.

The following experiments used information about list length in order to learn more about the nature of the processes involved in recall. Watkins and Watkins (1974) presented subjects with mixed orders of 7 lists of 8,10,12,14,16,18, and 20 words under informed or non-informed conditions. Immediate free recall as well as final free recall were tested, and subjects were specifically instructed to recall first the last items in each list. Knowledge of list length enhanced the immediate free recall of recency items but depressed the final free recall of the same items. There was no effect on the primacy items in either immediate or final free recall tests. The authors conclude: "When the end of the list is thought imminent, secondary memory registration is reduced in order to increase primary memory capacity. The result is that recall of recency items is maximized in an immediate test, but at the expense of being reduced in a subsequent test in which secondary memory is operative." (p. 493).

The Watkins and Watkins (1974) results were, in general, repeated in other studies (e.g., Engle, Clark & Cathcart, 1980; Hanley & Thomas, 1984; Penny, 1985): Accurate knowledge about list length, when contrasted with no such knowledge, enhances recall of recency items, but has no effect on earlier items.

Shallice's (1975) study, using a paradigm in which subjects were informed or uninformed by a signal during list presentation indicating that only five words were left, is of particular relevance to our own interests. This manipulation enhanced the free recall of the last items, suggesting that information may change the subjects' rehearsal strategy on the last items: Thus, they may switch from elaborative to maintenance rehearsal at the last portion of the list, using the articulatory loop (see Hanley & Thomas (1984) below for a direct test of this possibility).

Hanley and Thomas (1984) replicated the Watkins and Watkins (1974) results in a situation in which half of the subjects in either the informed or uninformed group, were instructed to repeat the word "the" out loud continuously throughout each list presentation (i.e., articulatory suppression condition). The fact that articulatory suppression reduced recall from all serial positions, but there was no interaction between articulatory suppression and knowledge of list length, suggests that maintenance rehearsal may not depend on articulation.

It should be noted, that all recall experiments that manipulated information on list length used only two conditions, namely: No information vs. Exact information. The results suggest that the effect of exact information is to improve the recall of recency items, although this may be the direct result of instructions to start recalling the last items first (e.g., Watkins & Watkins, 1974). The recency effect was also found in one serial recall experiment (Penney, 1985), though the number of items used in the lists was comparatively small. Since most of the research cited above instructed subjects to start recalling the last items first, the results are equivocal: Such an instruction may affect subjects' strategy in regard to differential rehearsal of primacy or recency items, but only in a condition in which **end of list is predictable**, so that such a strategy is in accord with retrieval processes.

Furthermore, none of the recall experiments referred to the possible effects of information on **mobilization of mental resources** (e.g., Haslam, 1985). Thus, exact information on list length may have certain effects not only on processing strategies, but also on distribution of effort (Breznitz, 1990): Firstly, knowledge of list length may affect the distribution of effort in such a way that the number of expected items will determine how much rehearsal or encoding manipulations will be carried out. It may also affect inter-item chunking. However, the above argument predicts **primacy rather than recency** effects of information. At the same time, knowledge of list length may affect the recency part, since when subjects know that the end of the list is approaching, they may **mobilize** whatever remaining resources they have, and perform better.

The notion that effective resource allocation is important in performing stressful tasks (Breznitz, 1990) can be also found in cognitive research. For instance, Kahneman (1973) has proposed that attentional resources are "elastic" in that increasing the task load may lead to an increase in the subject's arousal, which in turn makes additional mental resources available. This idea was also discussed by Eysenck (1982), and is expressed in the goal-setting context as well: "There are at least four mechanisms by which goals affect task performance: by directing attention and action, mobilizing energy expenditure or effort, prolonging effort over time (persistence), and motivating the individual to develop relevant strategies for goal attainment." (Locke & Shaw, 1981, p.145). Thus, the quest for application of information management techniques that have been found to be useful in stress research to the area of learning, memory, and complex cognitive tasks, has some theoretical foundation.

SPECIFIC RESEARCH QUESTIONS AND HYPOTHESES

The following questions and hypotheses are formulated on the basis of our previous research with the CPT and other stressful tasks (Breznitz, 1990). As the various tasks used increase in number, it appears useful to formulate hypotheses in the most general terms possible, to facilitate generalization across different task domains. Thus, the following hypotheses apply to any task which has an expected length that can be operationalized in terms of either task duration, or the number of trials, items, distance, etc., that define successful performance.

(a) Expected length at start.

The simplest independent variable is information about the length of a task available at its onset. We hypothesize that having information about task length that is judged manageable leads to better performance than its absence, or having discouraging information.

(b) Information en route.

Information en route to the goal can be given continuously, in a pattern of discrete signals, or not given at all. The availability of such information will increase the impact of the expected length at start. Thus, we predict that an item to item monitoring during task performance may further enhance task performance if the information at start was encouraging, or reduce performance if it was discouraging.

(c) Disconfirmation en route.

If the new information about length leads to encouragement, performance will increase. If, on the other hand, it is discouraging, performance will deteriorate.

CORE EXPERIMENT.

Design.

Following the successful development of special software for a computer-controlled experimental program, we could embark on an extensive investigation of the effects of information about list length on performance in free recall and subsequent recognition performance. In order to be able to utilize the power of a combined between and within groups design, it was necessary to give subjects yet another task to separate the two recall tasks. By choosing a coding task for this purpose, we could at the same time pretest the impact of information management on coding itself.

On both recall tasks there were basically three different information conditions: No Information, Exact Information (20 items), and Discouraging Information (40 items). On the coding task the same three types were used, with the Exact Information consisting of 100 items, and the Discouraging Information of 300 items, respectively.

The Core Experiment consisted of 6 groups of subjects. Table 1 presents the design, indicating the information subjects received at the start of each session.

Table 1. Design of Core Experiment.

Group	Recall 1	Coding	Recall 2
A	No info.	No info.	20
B	No info.	No info.	40
C	20	100	40
D	40	300	No info.
E	No info.	No info.	No info.
F	20	100	20

All subjects were presented with 20 items on both recall tasks, irrespective of the initial information condition. Correspondingly, in the coding task all subjects were given 100 items irrespective of their initial information condition.

Design rationale. Since subjects in the Discouraging Information condition may eventually find out that the task is shorter than they expected, it is important to avoid any effects due to reduced credibility of the information (Breznitz, 1984). For this reason the coding condition always mirrored the first recall condition, and only one group (Group D) experiences false information on the first trial. Its potential impact on subsequent tasks should be guarded against. Groups E and F were given the same information on the two trials in order to measure training effects. In order to pretest the effects of a counter on performance, in the coding task subjects in Groups A and B were further subdivided into two subgroups indicating counter no-counter conditions.

Subjects. One-hundred and twenty subjects participated in the Core experiment, 20 subjects in each group. All were students at the University of Haifa or the Technion, responding to a call for subjects offering IS30.00 (approximately $12.50) for taking part in the experiment. The university guidelines concerning human subjects were followed. The sample consisted of 60 men and 60 women, with an average age of 24.15 (SD = 2.31, range = 21-34). All subjects had normal or corrected vision and their mother tongue was Hebrew.

Stimuli. Two different recall lists of 20 Hebrew words each were used. The items for each list were chosen from an initial pool of 100 high-frequency, concrete and unemotional words denoting objects, with 2-4 syllables. The pool was based mainly on a pool of 80 words used by Druch (1988) and additional 20 words collected from other sources. Ten judges were asked to rate the 100 words on frequency, emotionality, and concreteness using 1-7 rating scales. In addition they screened them for possible double meanings. Based on these ratings, 80 words, all highly concrete, frequent, and non emotional, were used to create 4 parallel lists, each list containing 20 words, with each word belonging to a different semantic category. The same 20 categories were represented in each of the 4 lists. The lists were carefully screened and chances of intralist clustering were minimized by avoiding obvious associates. Two lists were used for the recall task, and the items of the other two as distractors in subsequent recognition tests, performed after the subject finished the recall of each list.

On the basis of the above lists, two recall tasks were presented to each subject. The words in each list were randomly mixed so that 20 different orders were used in each group of subjects. In addition, order of lists was counterbalanced. Each recognition test included the words used in the recall task and 20 distractors, all printed on paper in random order.

The coding task was prepared on the basis of the coding task of WAIS and WISC-R. Subjects are presented with the digits 1-9 and each digit is paired with a particular graphical sign. The task itself consists of a list of digits that have to be translated into their respective codes.

Apparatus. A PC AT computer was used for instructions and stimulus presentation for both recall and coding tasks, and for data registration. The words used in recall tasks were presented in the middle of the screen, their size being 5 x 5 mm. The data recorded included subject demographics, experimental conditions, lists presentation orders during recall tasks, and reaction times (RTs) as well as type of responses during the coding tasks. Reaction times were measured in milliseconds. In addition, a tape recorder was used for recording subjects' recall and a stopwatch for measuring recognition and total coding task performance durations.

Procedure. The experiment took place in a room consisting of a computer for presentation of stimuli and recording of responses, and two tables separated by a screen behind which the experimenter monitored the tape recorder and the stopwatch. Subjects were run individually, and were allocated to groups so that each group included 10 men and 10 women. Two groups were always run in parallel (e.g., A and B, C and D, G and F), and subjects were allocated to groups in subsamples of 5 subjects each.

Upon entry of the subject the experimenter entered the personal data: age, sex, telephone number, place of study, and subject number into the computer. This was followed by general instructions:

"During the course of the experiment instructions will appear on the screen in front of you. Read them carefully even if they may seem familiar at certain times. At the bottom of each screen you will be told whether to proceed on your own, or wait for additional instructions from the experimenter. Don't press any key before being told to do so either by the experimenter or by the computer."

At this point the subject is instructed to press a key, and several screens containing specific instructions concerning the recall task according to groups follow:

"You are participating in an experiment on memory. We will present you with a list of (words)/(twenty words)/(forty words) on the screen in front of you. Read each word carefully, and rehearse it until the presentation of the next word. When the screen shows a line with the following signs

???

start recall by saying out loud the words that were presented to you. Say each word that you remember loud and clear since we are recording your responses. Throughout recall the ??? sign will remain on the screen. When the time allotted for recall is over the sign will disappear and you will hear a beep. The allotted time is fixed and limited but there is ample time to recall the words. If you finish recall before the allotted time is over, wait patiently for the beep.

Do you have any questions?

If you don't have any questions, press any key for the rest of the instructions and for practice."

These instructions were followed by a brief practice session:

"We shall now do some practice on the task. We shall present to you a short practice list containing several words. Following the list, upon the appearance of the ??? line, start saying immediately all the words that you recall from the list. Press any key for the practice to start".

After a short practice session consisting of 5 words, the instructions about the first recall trial were briefly repeated:

"The task is now about to begin. We shall present you with a list of (words)/(twenty words)/(forty words), read each word carefully and rehearse it. When a line appears with the following signs ??? start to recall the words in a loud and clear voice. Don't start to recall before you see the above signs on the screen." This was followed by the experimenter repeating the instructions verbally, emphasizing the number of words to appear in the list.

Next, each of the 20 words of the first list appeared in the middle of the screen for 3 seconds, with the ??? signs appearing immediately following the last word. The subject then started to recall the items of the first list. Upon completion of the first recall task (90 seconds) there was the sound of a beep, and on the screen appeared the 'end of task' instructions:

"End of task -- stop the recall and wait for the next task." At this stage the experimenter presented the subject with a recognition test consisting of the 20 list words mixed with 20 distractors that did not appear in the original list, all printed on paper. The instructions were (in writing and repeated orally):

"In the following pages you will be presented with all words that you were asked to recall, in addition to new words. Read each word and decide whether or not it appeared before. Do not spend too much time on each word -- read it, decide, and circle your answer." Subjects were explicitly asked not to skip words, and to follow the order of as it was presented.

The recognition test lasted for 80 sec on average (measured without subject's knowledge by the experimenter). Following a thirty second rest period, subjects were given the coding instructions: "The task to be performed now is a coding task. We shall present you with two lines of squares, one above the other: The first line will include the digits 1-9 and the second certain graphical signs. Press any key to see this origin display. (after having observed the display, press any key for continuation of the instructions)."

At this stage the display for the coding task appeared on the screen.

1	2	3	4	5	6	7	8	9
—	⊥	)	L	U	O	^	X	=

4	9	2	3	6	1	4	7	8

Following the above display, the instructions continued: "You will be presented with a line of (digits)/(100 digits)/(300 digits), and the task is to fill in under each digit the corresponding sign (i.e., the graphical sign that appears in the original display). Coding of the graphical sign under each digit will be done by pressing use of the appropriate key on the keyboard. Once you have pressed the appropriate key, the cursor will move automatically to the next item, and you cannot go back and correct. Try to work quickly, and not to make mistakes -- the computer registers both the speed and accuracy of your performance. You don't have to remember which sign is related to which digit, since the original display will appear during the whole session on the upper part of the screen.

Do you have any questions?

If you don't have any questions, press a key for the rest of the instructions and for practice."

These instructions were followed by a brief practice session and then the coding task proper. Subjects in the counter condition read an additional sentence: "At the bottom of the screen you will see a counter indicating the number of signs you have already coded.

1	2	3	4	5	6	7	8	9
—	⊥	J	L	U	O	^	X	=

2	1	3	7	2	4	8	1	5	4	2	1	3	2	1	4	2	3	5

100

The average time for the coding task performance was about 8 minutes. Following an additional thirty-second rest period, the second recall trial began. With the exception of the information about list length that varied according to groups, the procedure was similar to that of the first recall trial. After the end of the second recognition test subjects were given a specific questionnaire concerning the various stages of the experiment. Particular emphasis was given to subjective estimates of performance, and experienced task difficulty (see Appendix A). Finally, subjects signed a commitment to keep discretion about the experiment, were paid, and released.

RESULTS

Performance Measures. Free recall was analyzed using the following indices:

a. Total correct - the total number of correct words recalled during the allotted time.

b. Primacy items - the number of correct words recalled from the first 6 positions of the input list.

c. Recency items - the number of correct words recalled from the last 6 positions of the input list.

d. The number of extralist intrusions from two sources: new words that have not appeared in the input, and words that belonged to the training list. For the second list, extralist intrusions from the first recall or recognition list were also analyzed.

e. The number of repetitions of list words during recall (the number of repetitions of errors was less than 0.10 over all groups, and therefore would not be analyzed).

It should be noted that the choice of 5-6 positions for estimations of recency in lists of 8-20 words is the usual procedure used in other investigations (e.g., Bernbach, 1975; Hanley & Thomas, 1984; Shallice, 1975; Watkins & Watkins, 1974). We have also analyzed the above results deleting the first and last item from the list and found similar trends.

Table 2 presents the mean recall indices for the first and second trial according to groups. In each case the actual number of words presented was 20.

Starting with the first trial, we see that **Discouraging Information reduces all recall measures.** One-way Analyses of Variance (ANOVA) were applied to each of the above indices, using the three information conditions [Exact information (20), No information, and Discouraging information (40)], as the independent variable. These analyses showed that the effects were significant for the Primacy Items index [$F(2,117) = 5.53$, $p < .01$], with means of 4.10, 3.98 and 3.00 for Exact information, No information, and Discouraging information, respectively. A pairwise Scheffe test showed significant differences ($p < .05$) between Discouraging information and either the No information or the Exact information conditions. The results were not statistically significant for the Extralist Intrusions (new) [$F(2,117) = 2.71$, $p < .08$], although the trend was similar as in recall, i.e., most intrusions appeared in the Discouraging condition. No effect was found for the number of repetitions ($F < 1$).

Table 2: Mean recall according to trials and groups.

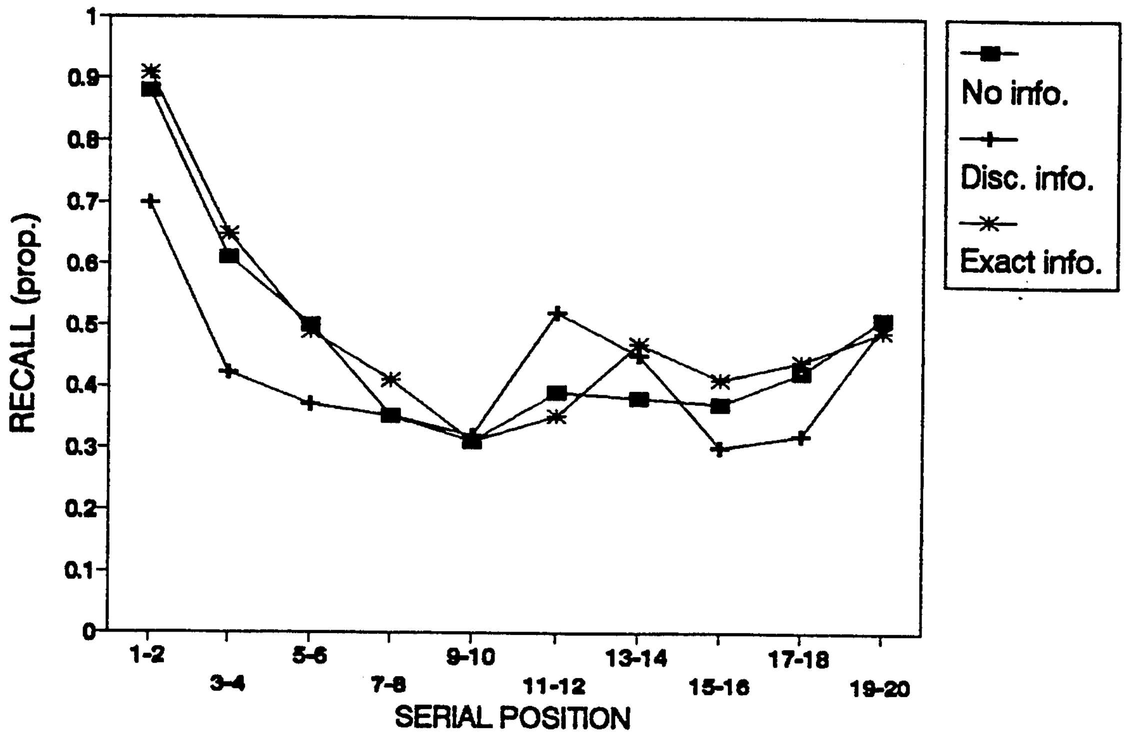
Group	No Info. A	No Info. B	Trial 1 20 C	40 D	No Info. E	20 F
Total Recall	9.75	9.95	9.55	8.55	8.65	10.20
Primacy Items	4.30	3.80	4.20	3.00	3.85	4.00
Recency Items	2.20	3.15	2.60	2.25	2.40	2.75
Extralist Intrusions (new)	0.35	0.35	0.60	0.90	0.55	0.40
Extralist Intrusions (training)	0.50	0.25	0.35	0.30	0.30	0.40
Repetitions	0.90	0.80	1.00	1.15	0.80	0.65

Group	20 A	40 B	Trial 2 C	No Info. D	No Info. E	20 F
Total Recall	11.55	10.25	10.35	10.05	10.00	11.55
Primacy Items	4.40	3.50	3.75	3.65	3.60	4.45
Recency Items	3.40	2.85	3.60	2.55	3.40	3.45
Extralist Intrusions (new)	0.50	0.40	0.45	0.45	0.30	0.40
Extralist Intrusions (training)	0.10	0.00	0.00	0.00	0.05	0.05
Extralist Intrusions (1st recall)	0.20	0.35	0.45	0.40	0.40	0.15
Extralist Intrusions (1st recog.)	0.00	0.05	0.20	0.10	0.35	0.00
Repetitions	1.15	0.80	0.90	0.90	0.85	0.90

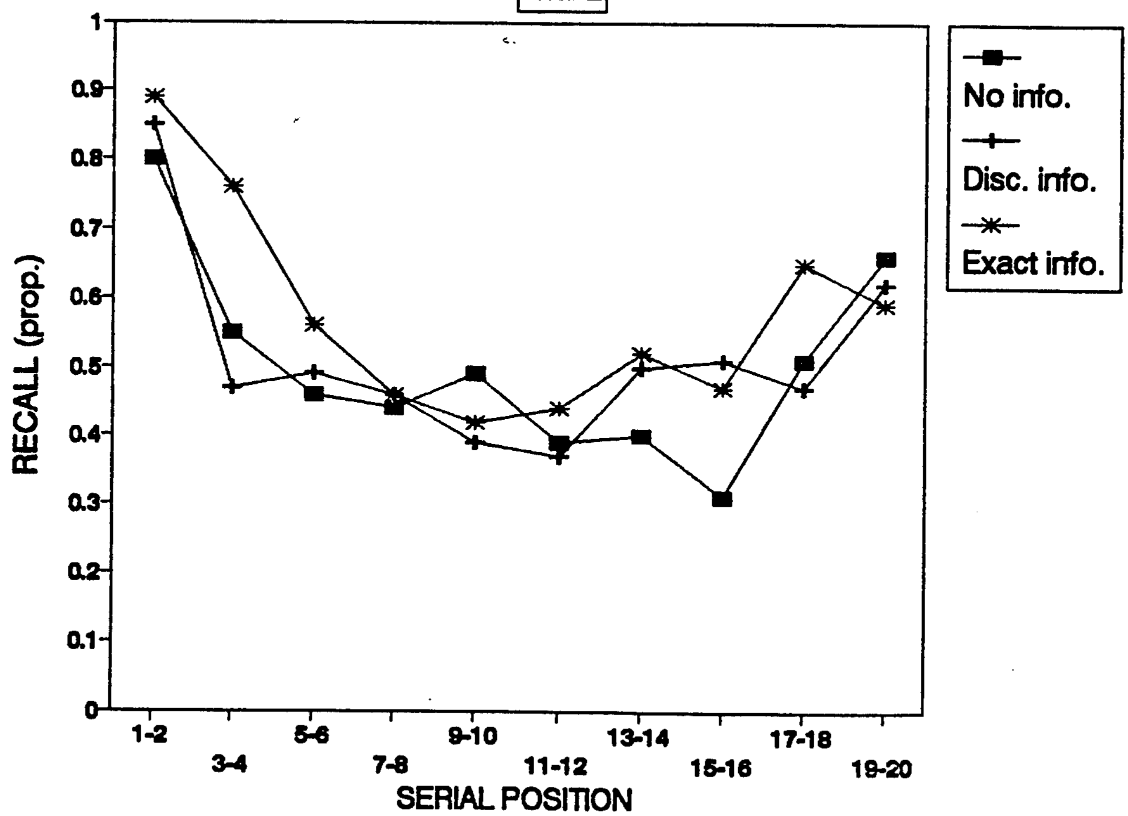
The data from the second trial essentially confirms the above finding, namely, the Discouragement condition lowered the number of items recalled, but in addition, performance was also low in the No information condition. This can be seen on all recall measures, with marginal significance for total recall [$F(2,117) = 2.31$, $p = .10$], and with high significance for the primacy items [$F(2,117) = 5.08$, $p < .01$], with means of 4.43, 3.63 and 3.63 for Exact information, No information, and Discouraging information, respectively. A pairwise Scheffe test indicated significant differences between the Exact information and either the No information or the Discouragement information conditions. All Extralist Intrusions indices showed similar trends, but the effect was significant only for the intrusions from the first recognition test. No effect was found for the number of repetitions ($F < 1$). We also analyzed the effects of information on the second trial for Groups A B and E, in which all subjects performed the first trial under a No information condition. As for the general analysis, the effect was significant for the primacy items [$F(2,57) = 3.00$, $p = .057$], but not for total recall.

Figure 1 presents the serial position curves of each information condition on the first and second trials. As can be seen in the figure, the effects of the information manipulation are prominent particularly on the first positions in each trial. Furthermore, the primacy effect is much stronger than the recency effect for both the first [$t(119) = 7.57$, $p < .0001$] and the second trial [$t(119) = 4.33$, $p < .0001$]. Thus, unlike previous

Fig. 1- The effects of information on recall - Trial 1



Trial 2



data which show marked recency effects in free recall (e.g., Baddeley, 1986, 1990), in the present research the first items on the list were the best remembered. This is probably due to the fact that in the present experiments the words were presented visually, while the recency effect is usually observed with auditory presentation. Indeed, Engle et al. (1980) found a modality effect in free recall with visual presentation leading to lower recency than auditory presentation.

Recognition Data. There were three separate recognition measures:

a. Hit Rate (HR) - the proportion of words that appeared in the input list (old words) and were recognized as such.

b. False Alarm Rate (FAR) - the proportion of words that did not appear on the input list (new words), and were mistakenly recognized as old words.

c. Recognition Index (RI) - Recognition corrected for guessing, by subtracting the FAR from the HR.

Table 3 presents the results for both trials according to groups.

Table 3. The complete recognition data

Trial 1

Group / Index	No Info. A	No Info. B	20 C	40 D	No Info. E	20 F
RI	.74	.78	.74	.66	.61	.72
HR	.82	.88	.84	.82	.79	.85
FAR	.08	.10	.10	.16	.18	.13

Trial 2

Group / Index	20 A	40 B	C	No Info. D	No Info. E	20 F
RI	.76	.76	.73	.64	.65	.78
HR	.86	.86	.85	.81	.80	.90
FAR	.10	.10	.12	.17	.14	.12

An ANOVA applied to the recognition data of the first trial, showed no effects for information, although the results in Table 3 suggest a decrease in RI for the Discouraging information condition (0.66) when compared with the No information (0.71) or the Exact information condition (0.73). The second trial showed significant effects for both HR [$F(2,117) = 3.52$, $p < .05$], and RI [$F(2,117) = 4.66$, $p = .01$]. As predicted, **best performance**

was obtained in the Exact information condition on both RI (0.77) and HR (0.88), the Discouraging information showed a somewhat lower performance (0.74 and 0.85 for RI and HR respectively), and the worst performance was observed in the No information condition (0.65 and 0.80, respectively).

<u>Training effects.</u> Our overall design made it possible to test for training effects directly, by looking at Groups E and F, both of which were given the same information on both trials. A two-way information X trial ANOVAs, with trial treated as a within-subject factor, were carried out. The effect of trial was significant for both total recall [$F(1,38) = 7.01$, $p < .01$], and recency [$F(1,38) = 11.42$, $p < .01$], with no interactions between information and trial. In each case performance was better on the second trial (see Table 2). No training effects were found for the primacy items.

<u>Subjective estimates</u>. The post experimental questionnaire included items that give us some clues as to the subjective estimates of performance, and perceived difficulty of the various stages of the task. The types of estimates are of specific interest:

1. Estimated number of words appearing in the list (Estimated Length).
2. Estimated number of words announced at start (Estimated Information), testing for awareness of the experimental instructions.
3. Estimated number of words the subject expected to recall (Anticipated Recall).
4. Estimated number of words the subject actually recalled (Estimated Actual Recall).
5. Estimated difficulty of recall for the Primacy, Middle and Recency items in each list (1=easy 7=difficult).

<u>Table 4</u> presents the mean estimates for each trial according to groups. One-way ANOVAs were carried out for the data of the first trial. These analyses showed that **subjects in the Discouraging information condition thought that more words appeared on the list** (25.65) than subjects in the other conditions (18.51 and 18.45 for the Exact and No information conditions respectively, $F(2,116) = 9.78$, $p < .001$). Experimental instructions were well remembered [$F(1,55) = 287.42$, $p < .0001$, $M = 20.50$, $n = 40$ for the Exact condition, and $M = 38.82$, $n = 17$ for the Discouragement condition, respectively]. Although subjects in the Discouraging information group expected to remember more words [$F(2,105) = 21.72$, $p < .0001$], they correctly estimated that their actual recall was lower than expected, and consequently the groups did not differ on the estimated number of words actually recalled ($F < 1$). As for recall difficulty, all subjects thought that primacy items were easier to recall than the middle [$t(119) = 20.44$, $p < .0001$] or recency items [$t(119) = 11.83$, $p < .0001$], and that recency items were easier than the middle ones [$t(119) = 3.66$, $p < .001$]. In the Discouraging condition Recency items were rated as more difficult than in the other conditions [$F(2,117) = 3.56$, $p <$

.05]. An average difficulty index (summing over the three ratings), showed a significant difference between information conditions [$F(2,117) = 3.36$, $p < .05$], with averages of 3.79, 4.00 and 4.30 for the No, Exact, and Discouragement conditions, respectively.

Moving now to trial 2, all subjects remembered the experimental instructions perfectly (M=20.00, n=37 for the Exact condition, and M=40.00, n=40 for the Discouragement condition, respectively). Subjects in both No information (M=24.30) and Discouraging information (M=23.15) thought that more items were presented than subjects in the Exact information condition (M=20.43) [$F(2,117) = 4.16$, $p < .02$]. Once again, although those in the Discouragement group expected to remember more words [$F(2,109) = 9.50$, $p < .001$], they estimated the recall to be similar ($F = 1.69$). Insofar as subjective difficulty is concerned, on this trial there were no significant differences between groups. As found for trial 1, all subjects thought that primacy items were easier to recall than the middle [$t(119) = 16.99$, $p < .0001$] or recency items [$t(119) = 12.29$, $p < .0001$],

<u>Table 4</u>: Mean estimates by trials by groups.

			Trial 1			
Group / Measure	No Info. A	No Info. B	20 C	40 D	No Info. E	20 F
Estimated Length	17.80	18.85	17.63	25.65	18.70	19.35
Estimated Information	N/A	N/A	21.00	38.82	N/A	20.00
Anticipated Recall	8.83	9.53	10.28	16.60	10.69	10.53
Estimated Actual Recall	8.25	8.50	8.80	9.35	8.00	8.45
Difficulty Primacy	1.90	2.05	2.30	2.25	1.90	2.25
Difficulty Middle	5.10	4.90	5.40	5.20	5.45	5.50
Difficulty Recency	4.40	3.55	4.60	5.45	4.85	4.00

Group Measure	20 A	40 B	Trial 2 C	No Info. D	No Info. E	20 F
Estimated Length	20.00	23.75	22.55	26.65	21.95	20.85
Estimated Information	20.00	40.00	40.00	N/A	N/A	20.00
Anticipated Recall	10.26	14.68	13.61	11.06	9.56	10.25
Estimated Actual Recall	9.50	10.84	11.05	10.80	8.60	9.65
Difficulty Primacy	1.95	2.80	2.55	2.70	2.30	2.35
Difficulty Middle	5.00	4.90	5.35	5.15	5.40	5.25
Difficulty Recency	4.60	4.20	4.85	5.50	4.80	4.10

information conditions used as the independent variable. Whereas no significant effects were found for the first trial, on the second trial rehearsal was significantly more frequent in the No information condition (Chi-square = 6.87, $p < .05$). Analysis of the first strategy reported by each subject led to the same result (Chi-square = 14.91, $p < .01$).

Subjects were also asked to compare the difficulty of the three tasks (i.e., first memory task, coding task, and second memory task). The only significant finding was obtained on trial 2, and it sheds important light on the main theme of this study. Thus, on the second trial, **subjects in the Discouraging information condition rated the first memory task as easier than the rest of the subjects** (the averages were 4.30, 4.88, and 5.03, for the Discouraging information, Exact information, and No information respectively, $F(2, 117) = 3.09$, $p < .05$). Thus, subjects presented with discouraging information after either no information or exact information, find it to be more difficult. This is in line with Breznitz' (1990) finding that relative, rather than absolute information, affects performance.

Person and background variables. The data collected on our subjects included sex and age as person variables. All groups contained an equal number of males and females, and all subjects were of similar age, with age means of 23.73, 24.35 and 25.00 for the No information, Exact information, and Discouraging information respectively. In order to assess the generality of our results over these variables, we have computed two-way ANOVAs including sex as a second factor. No effects for sex were found for any of the recall or recognition measures, and no interactions were observed with the information manipulation. In contrast, age showed a correlation of -.20 with total recall on trial 1, over all subjects ($n = 120$, $p < .05$), and with FAR on trial 2 [$r(118) = .25$, $p < .01$]. An analysis of covariance (ANCOVA) was applied to the recall and recognition indices, with age used as covariate. The same significant effects reported above were found.

To sum up, the effects of information on recall and recognition indices were not confounded by any of the person variables.

Intercorrelations between measures. In addition to the various analyses carried out already, it appeared to be useful to look at the broader picture, by calculating observing the relationships between the various performance measures themselves. Table 6 presents the correlations between the various performance indices, on each trial.

Table 6: Correlations between performance indices.

Trial 1

	Primacy Items	Recency	RI	HR	FAR
Total Recall	.58	.69	.71	.59	-.49
Primacy Items		.13	.33	.27	-.25
Recency Items			.47	.41	-.31
RI				.80	-.73
HR					-.18

Trial 2

	Primacy Items	Recency Items	RI	HR	FAR
Total Recall	.66	.66	.72	.60	-.51
Primacy Items		.26	.49	.43	-.31
Recency Items			.53	.44	-.37
RI				.79	-.75
HR					-.19

note: $n = 120$; for $r > .18$, $p < .05$

As can be seen in Table 6, all correlations are positive and significant in most cases, except for the expected negative correlations between FAR and the other indices. The correlations between the first and the second trial memory measures were in the range of .35 and .59 ($p < .001$).

Total recall was negatively related to estimated subjective difficulty, for both first and second trial [the correlations of total recall with average difficulty, over the three estimates of primacy, middle and recency, were -.42 and -.40 ($p < .0001$), respectively]. Similar trends were observed by all memory indices. Thus, on the individual level, as actual performance worsen, estimated difficulty is greater. It should be emphasized that these are correlated data; thus, while difficulty may determine performance, the level of performance itself may affect estimates of difficulty in a posthoc evaluation.

INFORMATION EN ROUTE.

Design and rationale. The Core Experiment utilized two recall tasks with basically three different information conditions: No information, Exact information (20 items), and Discouraging information (40 items). All subjects were presented with 20 items on both trials, irrespective of the initial information condition. Results showed that the effects of information about list length on free recall performance were mainly indicated for the primacy items: Exact information elevated performance on these items, and discouraging information degraded it.

The Core Experiment results were obtained under conditions that were less than optimal for information effects: Subjects in the Exact information condition were told about the exact number of items to be presented, but since no counter was present to indicate how many items were already processed, and how many were still ahead of them, they could use this information only on a general level. It could be argued that **information effects may be enhanced by the presence of a counter indicating the number of items still to be processed.** Although, by its very nature, it could have only a very limited impact on the primacy items, its effects on recency could be more pronounced. This, would be in line with previous research (e.g., Shallice, 1975; Watkins & Watkins, 1974).

The procedure of the following experiment was identical to the one employed in the Core Experiment, using two recall tasks with a coding task in between. Group G received exact information (20 items) on the first trial and discouraging information (40 items) on the second trial, and Group H received these conditions in the reverse order (Discouraging information on the first trial and Exact information on the second). The coding task was performed with Exact or Discouraging information, as in the Core experiment, but the Discouraging information was more extreme (500 signs instead of 300). The main feature of the present experiment was that a backwards running counter was present on all the tasks. Thus, subjects knew at each point how many items were left for processing.

Another, important reason for the Information En Route Experiment was **to replicate the results that have been obtained so far.**

Subjects. Forty subjects participated in the Information En Route experiment, 20 subjects in each group. All were students at the University of Haifa or the Technion, responding to a call for subjects offering IS30.00 (approximately $12.50) for taking part in the experiment. The university guidelines concerning human subjects were followed. The sample consisted of 20 men and 20 women, with an average age of 23.30 (SD = 1.75, range = 20-27). All subjects had normal or corrected vision and their mother tongue was Hebrew.

Stimuli. All stimuli, as well as all procedures were identical to those used in the Core Experiment. Thus, the same lists were used for the recall tasks and the recognition tests. The words in each list were randomly mixed so that 20 different orders were used in each group of subjects, and order of lists was counterbalanced. Each recognition test included the words used in the recall task and 20 distractors all printed on paper in random order.

The coding task was also identical to the one used in the Core Experiment. All stimuli were presented on the PC AT computer, and the data recorded included subject demographics, experimental conditions, lists presentation orders during recall tasks, and reaction times (Rts), as well as the actual responses during the coding tasks. In addition, a taperecorder was used for recording subject recall and a stopwatch for recognition and coding performance times.

Subjects were told about the counter, and it appeared on the training list as well. The numbers appeared about 1 cm under the words, each number centered under the specific word. Thus, following the training instructions, subjects were told: "Pay attention! A counter will appear under the words presented and it will show the number of words left for presentation (including the word presented at the moment). Counting will be done backwards, for example -- in the 5-word training list, the number 5 will appear under the first word presented, the number 4 under the second word, and so on, until the last word under which the number 1 will appear. Is everything clear? please do not hesitate to ask any question."

The instructions about the counter were also verbally repeated by the experimenter.

Subjects in group G were told that they would be presented with a list of 20 words. The counter started with the number 20, counting backwards until 1 for the last item. Subjects in group H were told that they would be presented with a list of 40 words. The counter started with the number 40 for this group, counting backwards to 21. Following item 1 for group G or item 21 for group H all subjects were told to start recalling the items, and then performed on the recognition test which lasted for about 80 sec on average. Then the coding task was performed, i.e., subjects were presented with a list of 100 signs to be coded, or 500 signs to be coded, in the Exact and Discouraging information respectively, counting backwards from 100 or 500. All subjects coded 100 items. This was followed by the second recall task, reversing the conditions of the two groups (i.e., for group G subjects were told that a list of 40 items would be presented and for group H -- a list of 20 words). After the recall session, a recognition test followed, lasting for 78 sec on average. Finally, subjects were given the same questionnaire as in the Core Experiment.

<u>RESULTS</u>.

Memory performance was analyzed as in the Core Experiment, using the same recall indices. These data were compared with the equivalent groups of the Core Experiment. For the first trial, these were groups C, D and F. For the second trial, these were groups A, B, C and F. The data of the various indices appear in Table 7. Since the number of intrusions and repetitions was extremely small, they will not be presented.

Table 7: Mean recall and recognition indices according to trials, experiments, and groups.

Trial 1

Index	En Route Experiment 20 G	En Route Experiment 40 H	Core Experiment 20 C+F	Core Experiment 40 D
Total Recall	10.10	9.70	9.88	8.55
Primacy Items	4.25	3.70	4.10	3.00
Recency Items	2.30	2.50	2.68	2.25

Trial 2

Index	En Route Experiment 20 H	En Route Experiment 40 G	Core Experiment 20 A+F	Core Experiment 40 B+C
Total Recall	11.30	12.10	11.55	10.30
Primacy Items	4.30	4.25	4.43	3.63
Recency Items	3.15	3.35	3.43	3.23

One-way ANOVAs performed on the two groups of the present experiment did not produce any significant differences between these groups on any of the performance measures, although the averages for total recall and primacy items were in the same trend as the ones obtained in the Core Experiment (see Table 7). On the other hand, two-way ANOVAs, Information (20 vs 40) X Counter (yes vs no), which were applied to each of the above indices, showed significant main effects for the Primacy Items index, for both the first and the second trial [$F(1,96) = 10.88$, $p < .001$, and $F(1,116) = 5.81$, $p < .05$], respectively]. No effects were found for total recall, or for the recency portion of the list, and no effects were found for the counter manipulation or for the Information X Counter interaction. **The present study could be viewed as a successful replication of our results from the Core Experiment.**

The recognition measures were analyzed as in the Core Experiment, and the averages appear in Table 8, according to experiments and information, as in Table 7.

Table 8 : The complete recognition data

	Trial 1			
	En Route		Core	
	20	40	20	40
Group	G	H	C+F	D
Index				
RI	.74	.71	.73	.66
HR	.86	.87	.85	.82
FAR	.12	.16	.12	.16

	Trial 2			
	En Route		Core	
	20	40	20	40
Group	H	G	A+F	B+C
Index				
RI	.73	.76	.77	.74
HR	.86	.87	.88	.85
FAR	.13	.11	.11	.11

Two-way ANOVAs applied to the recognition indices of the first and second trial showed significant effects for information only for the FAR of the first trial [$F(1,96) = 3.77$, $p = .055$]. No effects were found for the counter manipulation or for the information X counter interaction.

Subjective estimates. The post experimental questionnaire was analyzed as in the Core Experiment, and Table 9 presents the mean estimates for each trial according to experiments, information and groups.

Table 9: Mean estimates in each experiment by trials by groups.

Trial 1

Group	En Route 20 G	En Route 40 H	Core 20 C+F	Core 40 D
Estimated Length	17.65	24.30	18.51	25.65
Estimated Information	20.00	40.55	20.50	38.82
Anticipated Recall	11.05	15.80	10.41	16.60
Estimated Actual Recall	8.90	11.00	8.63	9.35
Difficulty Primacy	1.95	2.50	2.28	2.25
Difficulty Middle	5.05	5.45	5.45	5.20
Difficulty Recency	3.60	4.30	4.30	5.45

Trial 2

Group	En Route 20 H	En Route 40 G	Core 20 A+F	Core 40 B+C
Estimated Length	20.00	25.10	20.43	23.15
Estimated Information	20.00	40.00	20.00	40.00
Anticipated Recall	11.20	13.60	10.26	14.16
Estimated Actual Recall	10.10	10.90	9.58	10.95
Difficulty Primacy	2.65	2.45	2.15	2.68
Difficulty Middle	4.80	4.75	5.13	5.13
Difficulty Recency	4.05	4.10	4.35	4.53

Two-way ANOVAs were applied to the data of the first trial. These analyses showed that subjects in the Discouraging information condition indeed thought that more words appeared in the list than subjects in the Exact information condition [$F(1,95) = 25.02$, $p < .0001$], with no effect for the counter. Experimental instructions were well remembered for trial 1 [$F(1,91) = 877.66$, $p < .0001$], and the counter affected this variable [$F(1,91) = 34.29$, $p < .0001$], so that subjects in the Information En Route experiment remembered that more words were presented to them than subjects in the Core Experiment. Subjects in the Discouraging information groups expected to remember more words [$F(1,93) = 41.08$, $p < .0001$], and they also estimated that their actual recall was higher [$F(1,96) = 4.84$, $p < .05$]. As for recall difficulty, effects were found only for the recency items. In the Discouraging condition Recency items were rated as more difficult than in the Exact condition [$F(1,96) = 5.11$, $p < .05$], and the effect of the counter was to lower the subjective difficulty of recency [$F(1,96) = 4.21$, $p < .05$].

Moving now to trial 2, most of the above effects were repeated: subjects in the Discouraging information condition estimated that more words appeared in the list than those in the Exact information condition [$F(1,116) = 11.80$, $p < .001$], and they perfectly remembered the experimental instructions. Those in the Discouraging information group expected to remember more words [$F(1,113) = 18.17$, $p < .0001$], and they estimated their recall to be somewhat higher [$F(1,115) = 3.59$, $p < .06$].

Similar trends were observed for overall difficulty, with the primacy items rated as easier to recall than the middle or the recency items (see Table 9).

As in the Core Experiment data, actual performance was lower than expected in the Discouraging information group compared with the Exact information condition on both trials. For trial 1 the actual-expected recall means were -1.05 and 1.23, respectively, $F(1,96) = 13.26$, $p < .001$, and for trial 2 the means were 0.05 and 1.72, respectively, $F(1,115) = 9.82$, $p < .01$. Thus, the previous results were replicated in this respect as well.

Finally subjects were again asked to report about the specific strategies they employed while memorizing the items. The data appear in Table 10 -- each subject could contribute to more than one type of strategy.

Table 10: Reported strategies (in percentages) according to trials.

Trial 1

Strategy \ Group	20 G	40 H
Rehearsal	60	30
Associative	25	35
Elaborative /Imagery	35	35

Trial 2

Strategy \ Group	20 H	40 G
Rehearsal	55	45
Associative	30	35
Elaborative and Imagery	30	55

Chi-square tests were computed for each strategy, with information conditions as the independent variables, but none of the results were significant. The above strategies were also compared with the Core Experiment groups, first using the counter as the independent variables and then using the information as the independent variable. For the first comparison, the effects were significant for the first trial, indicating that **the rehearsal strategy was reported more frequently in the absence of the counter** ($p < .05$).

Finally, subjects were asked several questions in regard to the various tasks performed. **The no counter groups tended to report all of the tasks as more difficult than the counter groups**, and the effects were significant for the coding task and the second memory trial ($p < .05$). The same trend, but much weaker, was found for rated success on the tasks, with only marginal significance for the second memory trial ($p = .055$).

Person and background variables. The data collected on our subjects included sex and age as person variables. All groups contained an equal number of males and females, and all subjects were relatively young persons and average age was similar between information conditions [the F's < 1 for both trials 1 and 2]. There were some minimal differences between the counter conditions on age for trials 1 and 2 [$F(1,96) = 7.72$, $p < .01$ and $F(1,116) = 3.76$, $p < .05$, respectively, in both cases the counter groups being somewhat younger (23.30) than the no counter groups.

To assess the generality of results over these variables, we computed two-way ANOVAs including sex as a second factor. The effects of information remained unaltered, with no interactions with sex for the main indices. An ANCOVA applied to the memory indices with time of day and age treated as covariates, and sex entered as a third independent factor, revealed the same effects for primacy items of the first trial. In addition, in these analyses, the effect of the counter was found to be significant for correct recognition in cases of incorrect recall [$F(1,90) = 4.81$, $p < .05$], with corrected means of .71 and .80 for no counter vs. counter, respectively. Thus, **the counter affected processing in a way which led to better recognition performance when recall failed.**

DISCONFIRMATION EXPERIMENT.

The next experiment investigated the effects of changing information in the middle of the task. This manipulation was found to have major impact on performance in our stress endurance studies (Breznitz, 1990), and its potential impact on a cognitive was, therefore, a potentially interesting question. Two groups of subjects were used: On the first trial, one group was instructed to anticipate 10 items only. However, following the presentation of the 10 items, subjects were told that additional 10 items will be presented before testing for recall. Thus, subjects in this group (Group 10+10) started with initially encouraging information, with subsequent discouragement. The other group consisted of a mirror image of the first one. At start subjects were instructed to anticipate 40 items, but following the presentation of the first 10 items, this was reduced to 20. (Group 40-20).

The two groups in the Disconfirmation Experiment, like those in the Information En Route experiment, were presented with a counter indicating the number of items outstanding. We hypothesized that the first batch of 10 items would be processed more effectively in Group 10+10 than in Group 40-20, with the opposite effects following the disconfirming information. Group 10+10 could be expected to be encouraged by the fact that the task is short, and that the chances of remembering most of the items are high. At the point when they learn that 10 more items would be presented, discouragement may set in. Group 40-20, on the other hand, should process the first 10 items exactly as Group 40 in the Information En Route experiment, but the subsequent encouragement may provide an advantage.

Both groups received Exact information (20 items) on the second trial. The coding task was performed with parallel manipulations. A counter was present on all tasks performed, and counting for all tasks was done backwards. Thus, subjects knew at each point how many items were left for processing.

Subjects. Forty subjects participated in the Disconfirmation experiment, 20 subjects in each group. All were students at the University of Haifa or the Technion, responding to a call for subjects offering IS30.00 (approximately $12.50) for taking part in the experiment. The university guidelines concerning human subjects were followed. The sample consisted of 20 men and 20 women, with an average age of 24.23 (SD = 2.81, range = 20-32). All subjects had normal or corrected vision and their mother tongue was Hebrew.

Procedure. The experimental procedure, as well as all stimuli, were identical to those used in the Information En route experiment. The instructions were also identical, with the exception of the additional information in the middle of the task. This information was given in a format aiming to reduce the ensuing interruption to a bare minimum (15 seconds). Thus, subjects in Group I (10+10) were interrupted after 10 items, when the counter reached 1, and were told:

"We decided to lengthen the list, and instead of finishing now, you will be presented with additional ten words before being asked to remember all twenty words. Wait for the screen to change." Following these instructions, the counter started counting again from 10 backwards to 1. In Group J (40-20) subjects were interrupted after 10 items, when the counter reached 31, and were told:

"We decided to shorten the list, and instead of additional thirty words, you will be presented with only ten words before being asked to remember all twenty words. Wait for the screen to change."

Following these instructions, the counter started counting from 10 backwards to 1, as in Group I.

Subjects were told about the counter and it appeared on the training list as well. The interruption in the middle of the list was present on trial 1 only, and took place without any prior indication or warning.

Following the last item (reaching the number 1 for the two groups) all subjects were told to start recalling the items, and then performed on the recognition test which lasted for 80 sec on average. Next they engaged in the coding task. In Group I, subjects were instructed to anticipate a list of 50 signs to be coded, with additional 50 added upon completion. Group J expected to code 500 signs, but following the first 50 this was reduced to just 50 more. The counters were adjusted correspondingly.

All subjects encoded 100 signs, with the average time for coding of about 8 minutes. Next came the second recall task, which in this experiment consisted of the Exact information condition for the both groups. After testing for recall and recognition, subjects were given the post experimental questionnaire.

RESULTS.

In addition usual indices, several new ones, assessing performance for each of the four 5-item parts of the list, for the first trial were calculated. This was deemed necessary, since the particular design used in this study made the first 10 items psychologically different from the last 10. Consequently, in addition to the previous definition of Primacy and Recency, i.e., the first and last 6 items, we obtained information on the basis of 5 item segments as well. On the first trial, Groups I and J of the present experiment were compared with Groups G and H, and then with Groups C+F and D. For the second trial, in which Groups I and J were tested under an Exact information condition, the parallel groups were Group H and then Group A+F. Table 11 presents the data.

Table 11: Mean recall by groups, experiments, and trails.

Trial 1

	Disconfirmation		En Route		Core	
	10+10	40-20	20	40	20	40
Group Index	I	J	G	H	C+F	D
Total Recall	9.95	9.80	10.10	9.70	9.88	8.55
Primacy Items	3.50	3.60	4.25	3.70	4.10	3.00
Recency Items	2.70	2.80	2.30	2.50	2.68	2.25
Items1-5	3.10	3.20	3.65	3.25	3.58	2.65
Items6-10	2.10	2.30	2.35	2.30	1.98	1.70
Items11-15	2.50	1.85	2.15	2.05	2.03	2.20
Items16-20	2.25	2.45	1.90	2.10	2.30	2.00

Trial 2

Group Index	Disconfirmation 20 I+J	En Route 20 H	Core 20 A+F
Total Recall	11.45	11.30	11.55
Primacy Items	4.10	4.30	4.43
Recency Items	3.63	3.15	3.43

Comparisons of Groups I and J on the first trial did not indicate any significant differences. However, when these groups were compared with the other 4 groups, in a two-way ANOVA, Experiment (Disconfirmation vs En route vs Core) X Information (20 vs 40), significant effects were found for information [$F(1,134) = 7.53$, $p < .01$], and the Information X Experiment interaction [$F(2,134) = 3.12$, $p = .05$], for the primacy items. Similar effects were found for the Item1-5 index. As can be seen in Table 11, the effect of disconfirmation or counter en route was to elevate performance on the first items in Groups J and H (40-20 or 40) in comparison with Group D (40; no counter).

Figure 2 presents the serial position curves of Groups I and J compared to Groups G and H. As can be seen in the figure, the relative performance of the latter is elevated for the last items as compared with the first items. These groups were compared on a difference score which indicated relative recency performance (by subtracting the last two items from the first two). The effect of disconfirmation in was significant [($F(1,76) = 5.36$, $p < .05$]. Thus, **disconfirmation elevated the recall of the last items.**

Comparing performance of the six groups that got Exact information conditions on the second trial showed no differences between the groups on any of the recall or the recognition measures presented below. This suggests that at **the effects of information on recall are highly robust, and reproducible even if the conditions on the first trial differ.** It is conceivable that the coding task, which serves to separate the two recall tasks is quite effective in minimizing whatever impact the differential conditions on the first trial might have had.

The recognition measures were analyzed as in the Core Experiment, and the averages appear in Table 12.

Fig. 2-trial 1: The effects of change in info. en route (upper) Vs. counter en route (lower)

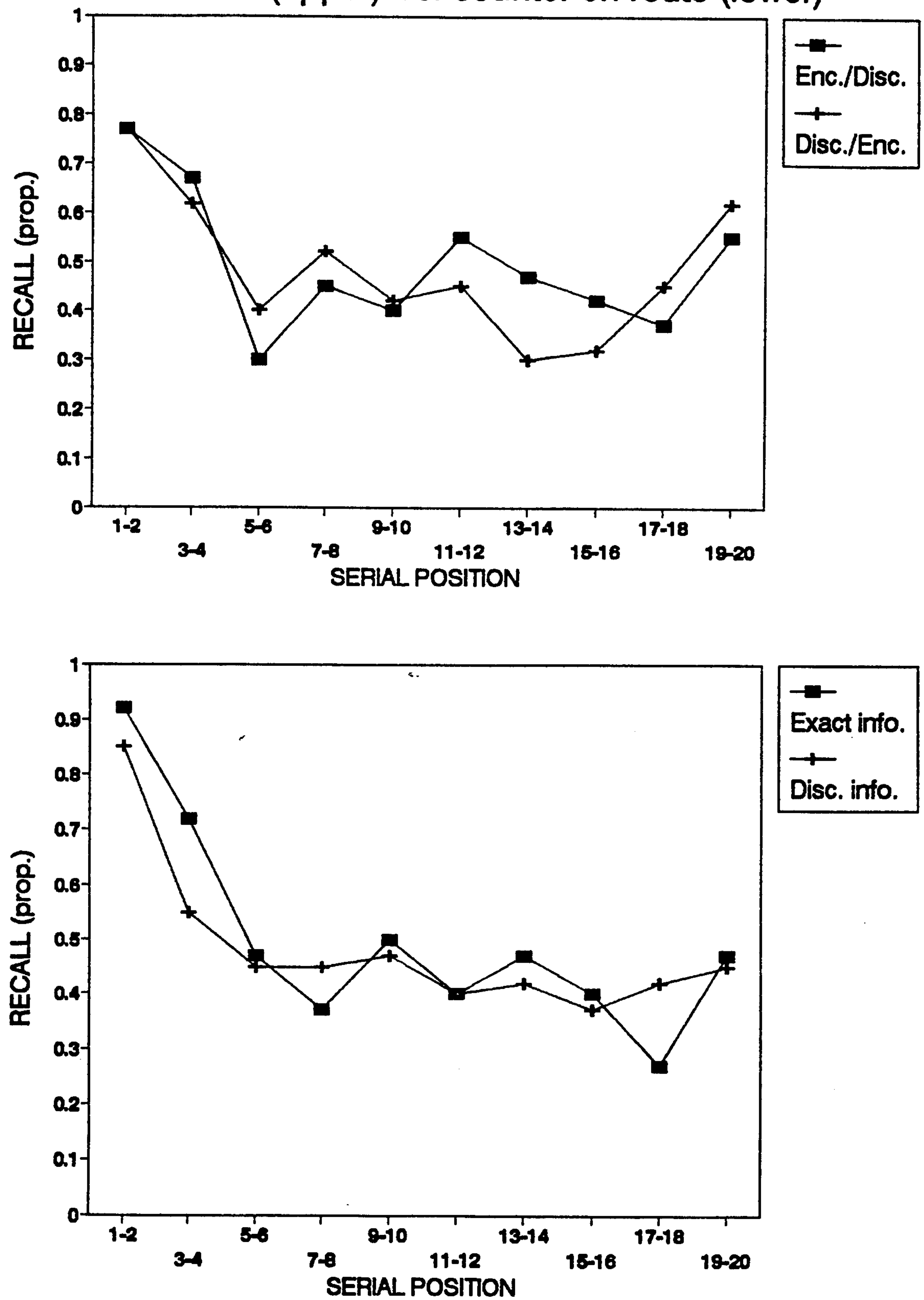


Table 12: The complete recognition data

Trial 1

Group	Disconfirmation 10+10 I	40-20 J	En Route 20 G	40 H	Core 20 C+F	40 D
Index						
RI	.76	.71	.74	.71	.73	.66
HR	.85	.86	.86	.87	.85	.82
FAR	.09	.15	.12	.16	.12	.16

Trial 2

Group	Disconf. 20 I+J	En Route 20 H	Core 20 A+F
Index			
RI	.75	.73	.77
HR	.88	.86	.88
FAR	.14	.13	.11

Subjective estimates. The mean estimates for each trial according to experiments, information, and groups, appear in Table 13. Comparisons of Groups I and J showed significant effects forthe first three estimation indices of trial 1 [$F(1,38) = 15.14$, 94.51, and 21.25, all $p < .001$]. Thus, subjects in Group I thought that fewer words were presented to them than in Group J, and they also reported that they were told about fewer words, and anticipated to recall fewer words. Estimated actual recall was similar in the two groups ($F < 1$).

The assessments of difficulty also differed in the two groups: Group I estimated primacy items to be less difficult to remember than Group J [$F(1,38) = 5.21$, $p < .05$], while they estimated the recency items to be more difficult [$F(1,38) = 4.65$, $p < .05$]. Thus, **disconfirmation clearly impacts the subjective domain** -- difficulty in remembering the last items depends on whether these items were unexpectedly being added to the list, or they are the only ones left after the encouraging subtraction of 20 items.

Table 13: Mean estimates in each experiment by trials by groups.

Trial 1

	Disconfirmation 10+10	40-20	En Route 20	40	Core 20	40
Group	I	J	G	H	C+F	D
Estimated Length	17.35	25.25	17.65	24.30	18.51	25.65
Estimated Information	14.00	40.70	20.00	40.55	20.50	38.82
Anticipated Recall	10.75	18.65	11.05	15.80	10.41	16.60
Estimated Actual Recall	9.95	10.75	8.90	11.00	8.63	9.35
Difficulty Primacy	1.85	3.00	1.95	2.50	2.28	2.25
Difficulty Middle	5.00	5.10	5.05	5.45	5.45	5.20
Difficulty Recency	4.50	3.20	3.60	4.30	4.30	5.45

Trial 2

Group	Disconf. 20 I+J	En Route 20 H	Core 20 A+F
Estimated Length	20.55	20.00	20.43
Estimated Information	20.75	20.00	20.00
Anticipated Recall	11.60	11.20	10.26
Estimated Actual Recall	10.30	10.10	9.58
Difficulty Primacy	2.48	2.65	2.15
Difficulty Middle	5.00	4.80	5.13
Difficulty Recency	3.78	4.05	4.35

Two-way ANOVAs showed significant effects for information on difficulty of primacy items [$F(1,134) = 5.32$, $p < .05$], and significant Experiment, and Experiment X Information interaction effects [$F(2,134) = 3.29$, $p < .05$ and $F(2,134) = 6.00$, $p < .01$]. Thus, the effect of the Disconfirmation experiment was to reverse the effect on subjective estimates of recency -- while subjects in the usual discouraging information conditions thought that the last items on the list were difficult, **when the initially discouraging information was disconfirmed, (i.e. Group J), the same items were perceived to be easier to remember!** No differences were found between the six groups on the second trial.

Actual performance was similar to that expected in Groups I and J ($F < 1$). A two-way ANOVA showed the usual effect of Exact vs Discouraging information conditions [the actual-expected recall means were 0.93 and -1.02, respectively, $F(1,134) = 8.57$, $p < .01$].

Subjects in the two disconfirmation groups did not differ on the main questionnaire measures for trials 1 and 2, and did not differ in strategies reported for the first trial.

Person and background variables. Groups I and J had equal proportions of men and women, and the average age did not differ between the two groups (the means were 24.30 and 24.15, $F < 1$).

THE CODING TASK.

The main purpose of the coding task in this study was to engage subjects between the two main recall tasks. It was always performed under the same information conditions as the first recall. At the same time, since coding requires a type of cognitive processing far removed from that involved in recall, it could be of interest in its own right. Are there any information effects on performance of what appears to be a relatively simple cognitive activity?

The coding task consists of translating the digits 1-9 into their corresponding graphical symbols, as fast as possible. There are no memory demands beyond the iconic or the very short term visual memory, since a display of the coding chart is always available to the subject. It requires exact and quick reactions, and therefore, the main measure of performance is reaction time.

In the following section we shall describe the results pertaining to coding performance for the 10 experimental groups used in this project. The experimental design of the coding task consisted of the following information conditions: No information, Exact information (100 items), and Discouraging information of two levels -- 300 or 500 items. The reason for adding a more extreme discouragement condition was that subjects in the first groups evaluated the coding task as easy and underestimated the number of codes carried out. A forward or a backward counter was used in most of the groups. The two variations of "Disconfirmation en route" were also applied to the coding task.

The full experiment consists of 10 groups of subjects. Table 14 presents the design, indicating the information subjects received at the start of each session (n=20 in each information group). All subjects were presented with 100 items irrespective of their initial information condition.

Table 14: Design of the coding task.

Group	Information		Counter
A	No information		forward - 10 sub
B	No information		forward - 10 sub
C	Exact information - 100		forward
D	Discouraging info - 300		forward
E	No information		forward
F	Exact information - 100		forward
G	Exact information - 100		backward
H	Discouraging info - 500		backward
I	Encouraging-Discouraging	50+50	backward
J	Discouraging-Encouraging	500-400	backward

Two-hundred subjects participated in the full project, 20 subjects in each group. All were students at the University of Haifa or the Technion, responding to a call for subjects offering IS30.00 (approximately $12.50) for taking part in the experiment. The university guidelines concerning human subjects were followed. The sample consisted of 100 men and 100 women, with an average age of 24 (SD = 2.35, range = 20-34).

The experimental procedure was described in the Core Experiment section. Following the performance of the first memory task, the subject read the coding task instructions. The instructions always mimicked the memory instructions for the first recall task in terms of the information conditions. The subjects were given a detailed explanation about coding performance and also carried out a short training session.

The post-experimental questionnaire included several questions related to the coding task, thus providing some information about some of its subjective aspects.

RESULTS.

The results will be analyzed according to the following sections:

1. Core Experiment: Comparing the effects of information conditions -- No information, Exact information and Discouraging information -- on performance, where a forward counter was always present, and levels of information were 100 and 300 for the Exact and Discouraging conditions, respectively.
2. Information En Route: Comparing the effects of a counter on performance, in the absence of information.
3. Extreme discouragement data: Comparing Exact information to particularly discouraging information by elevating the number of coding trials to 500.
4. Disconfirmation en route: Changing the number of coding trials in the middle of the task from 50 to 100 total, or from

500 to 100 total.

Dependent variables. Since the number of coding errors was too small (the range was 1-4.8% for the 10 experimental groups), to consist a meaningful index of performance, our main dependent variable is reaction time (RT). Consequently, all indices are reaction time (RT) indices. Two subjects had more than 30% missing responses due to apparatus failures or lack of understanding of task requirements and their data are not included in the following analyses. The average performance time over the 100 trials, and over the 198 subjects was 2.17 sec (SD = 0.38). However, there were several dozens of particularly long responses (over 10 sec) and therefore all RT data were log transformed and then averaged over trials. The entire session was divided into 10 blocks of 10 coding signals each. The following are the main performance measures:

a. RT100 - Average RT of correct responses based on all 100 trials.
b. RT50a - Average RT of correct responses based on the first 50 trials.
c. RT50b - Average RT of correct responses based on the last 50 trials.
d. Ten-blocks division - Average RT of correct responses for successive blocks of 10 trials each.

Core Experiment.

Table 15 presents the mean RT according to the information conditions.

Table 15: Coding indices according to No information, Exact information, and Discouragement information conditions.

Group Index	No Information A+B+E* (n=40)	100 C+F (n=40)	300 D (n=20)
RT100	2.23	2.09	2.18
RT50a	2.44	2.31	2.40
RT50b	2.03	1.89	1.97

*Note: Not including 20 subjects in the no counter subgroups.

Table 15 shows that for all three main indices, **Exact Information (100) leads to better performance than Discouraging information (300), which in turn is better than No Information.** One-way ANOVAs resulted in significant effects for RT50b [$F(2,96) = 3.16$, $p < .05$]. When comparing performance of the Exact and No information conditions pooled together vs the Discouragement condition on these measures, no significant effects were observed, but the comparison of Exact and Discouragement information vs No information resulted in significant effects for RT100 [$F(1,97) = 5.11$, $p < .05$], and RT50b [$F(1,97) = 5.94$, $p < .05$].

Figure 3 presents the serial position curves of each information condition, the 10 positions being the 10 blocks of trials. As can be seen in the figure, for most cases the same effects obtain: The No information condition leads to lower performance than the other two conditions. These effects were significant in the two-group comparison for blocks 4, 6, 8 and 10, indicating that information effects are stronger on later rather than earlier trials.

The results reported above were found even when gender was added as an additional factor, and age and time of day treated as covariates.

Subjective estimates. The post experimental questionnaire included items that give us some clues as to the subjective estimates of both performance and differential difficulty of the various stages of the task. These were:

1. Estimated number of codes appearing in the task (Estimated Length),
2. Estimated number of codes announced at start (Estimated Information), testing for awareness of the experimental instructions,
3. Estimated number of codes the subject expected to encode (Anticipated performance),
4. Estimated number of codes the subject actually encoded (Estimated Actual performance),
5. Estimated difficulty of early (primacy), middle, and later (recency) items (1=easy 7=difficult).

Table 16 presents the mean estimates for each condition. One-way ANOVAs were applied to the data, showing significant effects for estimated information [$F(2,60) = 56.00$, $p < .0001$], and anticipated performance [$F(2,67) = 22.69$, $p < .0001$], but not actual performance ($F < 1$). As can be seen in Table 16, **all subjects underestimated the number of codes actually encoded,** which may explain the relatively high performance on the task. As for difficulty, only the primacy items showed significance [$F(2,96) = 4.74$, $p < .05$]. Subjects in the No information estimated the beginning of the task to be less difficult than subjects in the other conditions. This points out the complex effects of the No Information condition. Embarking on a task in the absence of information about its expected duration, or length, may encourage overly optimistic subjective estimates of duration or length.

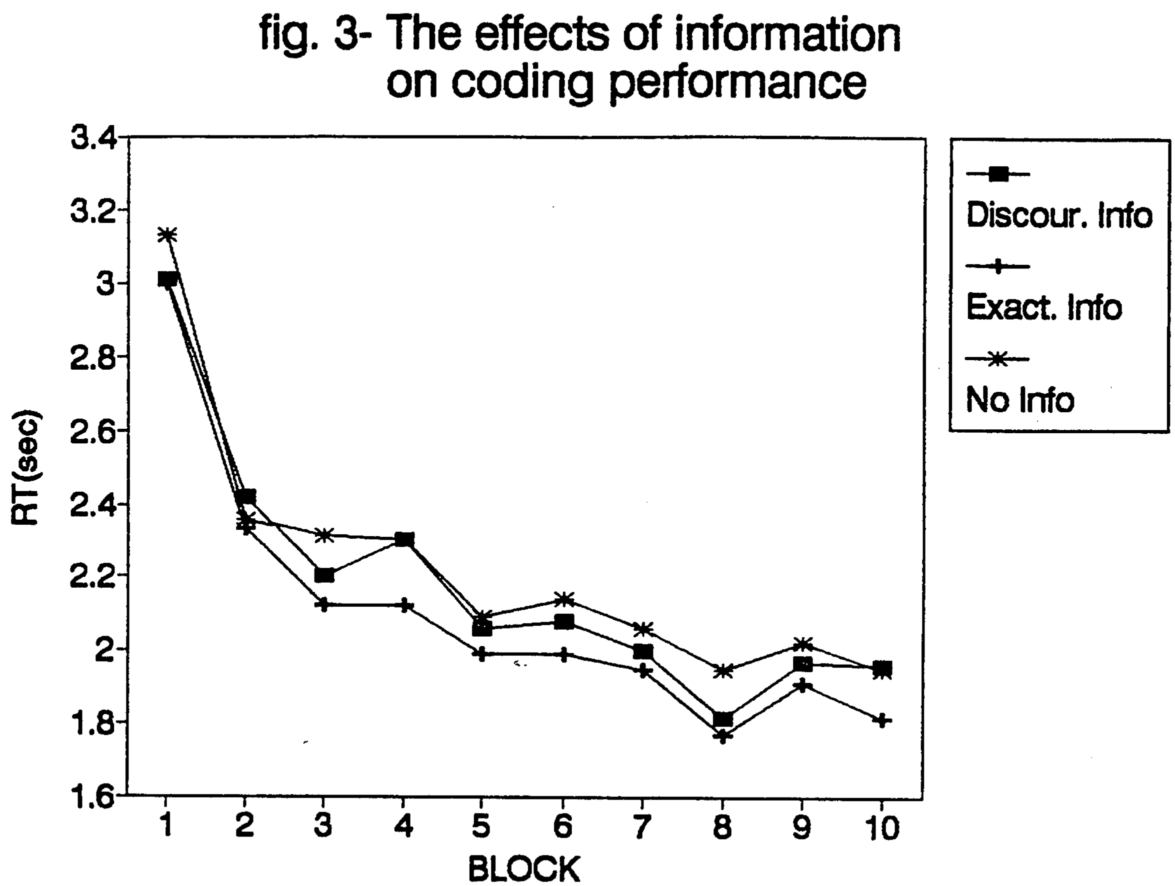


fig. 3- The effects of information
on coding performance
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
RT(sec)
1
2
3
4
5
6
7
8
9
10
BLOCK
Discour. Info
Exact. Info
No Info

Table 16: Mean estimates by conditions.

	No Information	100	300
Group	A+B+E* (n=40)**	C+F (n=40)	D (n=20)
Measure			
Estimated Length	64.60	63.42	82.21
Estimated Information	----	107.69	284.71
Anticipated Performance	66.77	81.21	185.33
Estimated Actual Performance	69.63	67.15	76.00
Difficulty Primacy	3.10	4.18	4.10
Difficulty Middle	2.98	3.10	3.50
Difficulty Recency	2.71	2.58	2.70

*Not including 20 subjects in the no counter subgroups.
**Number of subjects may be less than N due to subjects not remembering the number required

Subjects were also asked to compare the various tasks. Information conditions had no significant effects the relative difficulty of recall and coding, nor did they affect the perceived relative success on these tasks. On the whole, subjects reported coding as significantly less difficult than recall ($p < .0001$; the means were 4.92 for mean memory difficulty and 2.38 for coding difficulty) and felt they were significantly more successful on this task ($p < .0001$; the means were 3.22 and 5.36, respectively). Most subjects (90%) reported as having no prior experience with similar tasks.

The groups did differ in reporting that the first memory task may have had an effect on their coding performance. Specifically, more subjects in the Discouraging information condition reported such an inter task effect (60%) than in the other groups (Exact information = 22.5%; No information = 25.64%, Chi square = 9.68, $p < .01$).

Information En Route Experiment.

Table 17 presents the mean Rts according to experimental condition.

Table 17: Coding indices in the counter and no counter conditions.

Index	Counter (n=40)	No Counter (n=20)
RT100	2.23	2.19
RT50a	2.44	2.36
RT50b	2.03	2.04

The results indicate that the counter had practically no effect on performance.

Subjective estimates. Table 18 presents the mean estimates for each subgroup.

Table 18: Subjective estimates in the counter and no counter conditions.

Measure	Counter (n=40)	No Counter (n=20)
Estimated Length	64.60	43.42
Estimated Information	N/A	N/A
Anticipated Performance	66.77	62.08
Estimated Actual Performance	69.63	41.10
Difficulty Primacy	3.10	2.95
Difficulty Middle	2.98	2.90
Difficulty Recency	2.71	2.85

As expected, subjects in the counter condition estimated the length of the task more accurately [$F(1,55) = 6.17$, $p < .05$]. Estimates of actual performance were also more accurate [$F(1,56) = 12.46$, $p < .01$]. It is interesting that **even in the presence of the counter, subjects seriously underestimate the number of items actually coded.**

Increasing the levels of Discouraging information.

Table 19: Exact vs. Highly Discouraging information.

Group	100 G	500 H
RT100	2.20	2.10
RT50a	2.48	2.29
RT50b	2.03	1.93

Table 19 shows that the more extreme information (as well as changing the forward into a backward counter) had very little effect on performance, and indeed neither of the above measures, nor the RT means for the 10 blocks, proved to be significant. There was a slight tendency for Group H to perform a bit faster, and this unexpected trend would be analyzed in the discussion section of this report.

Subjective estimates. Table 20 presents the mean estimates for each condition.

Group	100 G	500 H
Estimated Length	56.55	118.35
Estimated Information	97.00	500.00
Anticipated Performance	80.00	331.13
Estimated Actual Performance	61.35	126.85
Difficulty Primacy	3.95	3.10
Difficulty Middle	2.90	2.60
Difficulty Recency	2.30	2.50

All four estimations of performance were significantly higher in the Highly Discouraging information condition. No differences were found between the two conditions on the other questionnaire indices pertaining to the coding performance.

Disconfirmation Experiment.

Table 21 presents the mean RTs according to groups.

Table 21: Disconfirmation data.

Group	50+50 I	500-400 J
RT100	2.38	2.03
RT50a	2.72	2.27
RT50b	2.14	1.80

Contrary to our initial expectations, disconfirmation half way through the task did not produce differential effect in the two groups. In addition, there is a clear main effect, namely, **Group 500-400 was faster than Group 50+50 on all measures.** (significant at $p < .05$). This is in line with the previous finding concerning highly discouraging information. It too enhanced performance speed compared with the exact information condition.

Table 22 presents the **subjective estimates** by group.

Group	50+50 I	500-400 J
Estimated Length	51.11	60.55
Estimated Information	55.55	447.55
Anticipated Performance	55.00	348.95
Estimated Actual Performance	60.48	100.45
Difficulty Primacy	2.84	3.45
Difficulty Middle	2.26	2.90
Difficulty Recency	2.00	2.20

The only significant differences between the two conditions were the obvious ones based on differential instructions.

Since the analyses of Groups G H I J suggested an unexpected effect of information on RT, we pooled together the data of these groups, and analyzed them in a two-way ANOVA. The results indicate that the effect of information was significant for RT100 [$F(1,75) = 4.31$, $p < .05$] as well as for RT50a and RT50b, with no interactions with the experiment. The same results were obtained for most of the 10 trial blocks. Figure 4 illustrates that **Highly Discouraging information indeed pushed subjects to perform faster.**

DISCUSSION.

Cognitive resources.

The present study was a direct offspring of our earlier research on enhancement of endurance by information about the duration of stressful tasks (Breznitz, 1990). The cost effectiveness of information management techniques is so high that their potential generalizability to other (non-stress) domains becomes a major goal. Although the a priori chances of success would have been greater if the tasks of choice shared some common elements with those previously tested (i.e.: physical exertion and pain tolerance), we opted for the more risky strategy of venturing into the more distant cognitive area. If successful, **our approach could pave the way to a significantly broader view of the underlying principles involved in information management enhancement of human functioning.**

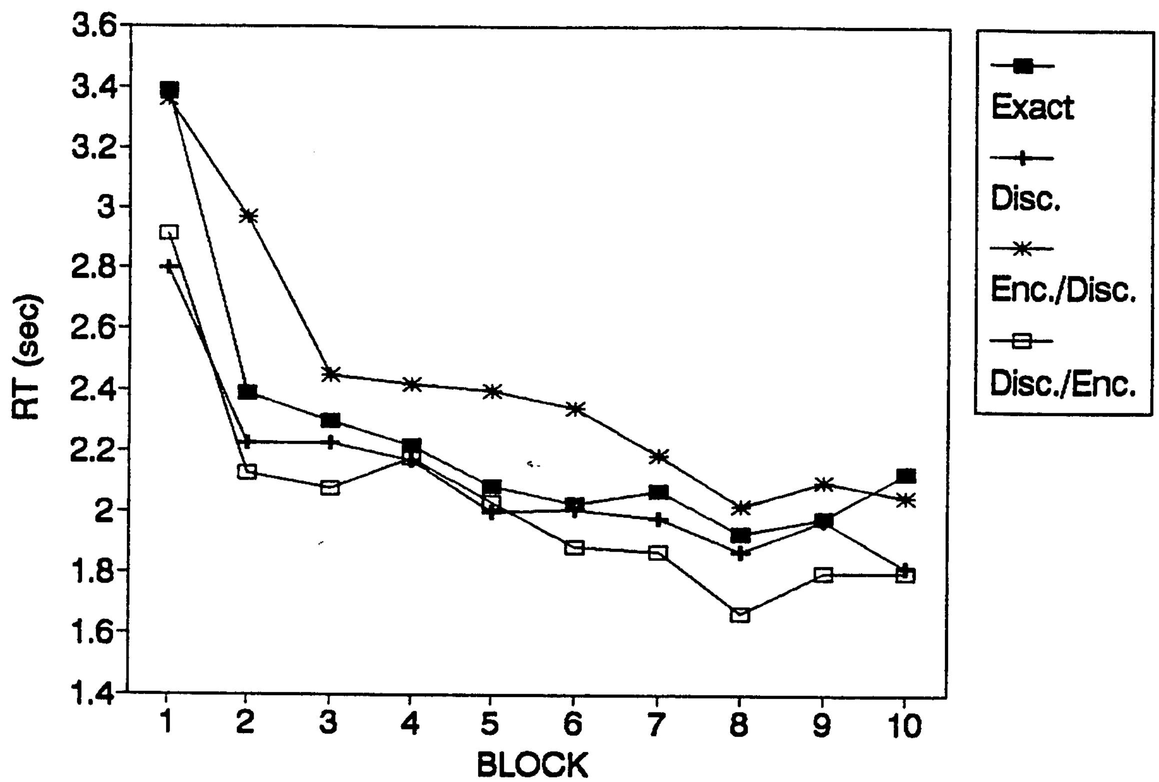
At the same time, the suggested testing of earlier discovered principles in the context of free recall was not motivated solely by practical considerations of generalization. On the contrary, our previous findings indicated that the usefulness of a theoretical framework that could be potentially relevant to cognition in general, and memory in particular. Thus, in trying to explicate the result of both our laboratory and field experiments, issues related to "**mobilization of effort**" appeared to be of central importance. The manipulations of encouragement and discouragement, which were the focus of those studies, illustrate this quite effectively:

Soldiers embarking on what they expected to be a very long and arduous march were sometime found to "give up" and fail the task after walking a relatively short distance, well within their capacity. It was argued that if information on start is too discouraging, this may lead to ineffective and insufficient mobilization of resources, and turn into a self-fulfilling prophecy. If the initially discouraging information is subsequently altered into a more encouraging one, the soldiers are allowed access to spare resources, and effectively finish the march.

Full information about task duration was found to **facilitate the distribution of effort.** Not unlike the marathon runners, the soldiers on a long march, and the subjects participating in a pain tolerance experiment, must **effectively husband their resources** for the entire duration of their respective tasks. The **capacity to mobilize major effort at points of crisis** was yet another issue analyzed in the context of the above type of conceptualization. So was the finding about the effectiveness of delivering "promising signals" at various points during a stressful task.

The notion of resources is not new, and has often been used as a hypothetical construct in a broad spectrum of cognitive

Fig. 4- The effects of change in information en route vs. type of information



research. In a critical analysis of the concept Navon (1984) defined resource as: "any internal input essential for processing (e.g., locations in storage, communication channels) that is available in quantities that are limited at any point in time." (p. 217). Although resource theory was initially applied in the context of research on attention (Kahneman, 1973), in recent years it penetrated other areas of cognitive research, including the one most relevant to this study, i.e., memory.

In a theoretical paper devoted to the role of "cognitive resources" and "cognitive effort" in memory, Mitchell and Hunt (1989) try to explicate this family of concepts in a detailed manner. They define cognitive effort as: "the percentage of the available capacity or resources allocated to a given task. Under this paradigm, performance of any task will be influenced by resource requirements of the task only if resource demand exceeds resource supply." (p. 338). Thus, performance deficit, i.e., failure to remember something may be due to insufficient resources, inadequate allocation of available resources, or insufficient effort in resource utilization. Whereas decline in memory function in old age is often attributable to overall reduction of the pool of resources (Craik & McDowd, 1987; Salthouse, 1988), developmental increase in performance on memory tasks in children is usually explained in terms of growingly efficient resource utilization (Case, 1984; Kail, 1984).

Resource theory in the context of the present study.

Although some scholars argue that mental effort should always be tested directly within the context of any particular experiment (Mitchell, & Hunt, 1989), others view the potential interference of these two tasks (memory and tapping, or any dual task design) as problematic (Bjorklund, & Harnishfeger, 1989). Hence, in there was no attempt in the present study to measure effort directly, but rather manipulate the expectations about effort via information.

The main task in our experiments consists of recall of a twenty-item list of unconnected words, following a single presentation. As such, it is clearly beyond the capacity of our subjects, even under the best of circumstances. Stated differently, even if all available resources were allocated to the task, they would still be insufficient for perfect recall. The actual **performance would thus depend on the amount of resources allocated to the task, and their utilization (effort).** Furthermore, the same amount of resources may be differentially distributed within the various segments of the task proper. Such an inter-item allocation would be the basis for serial position effects.

In the absence of information concerning the expected task duration (either in terms of time, or number of items), resource allocation and effort would be determined "on line" by the actual requirements of the task. However, when specific information about task duration is available, it provides the basis for **EXPECTED EFFORT. Expected effort is viewed as influencing both the total amount of resources allocated to the task, and the within task resource allocation** (e.g.: resources per item).

According to the above mentioned definition of effort as the percentage of resources allocated to a task, the amount of actual effort spent would depend on the adequacy of resources. The concepts of resources and effort are both **hypothetical constructs**, and cannot be measured directly. Nevertheless, they have systematic impact on performance. This is well illustrated by a brief summary of our main research findings.

Discouraging information on start reduces recall.

Our results indicate that **Exact information leads to higher performance on recall, and Discouraging information leads to lower performance**, especially when primacy effects are tested. This suggests that information may affect the encoding and rehearsal of items in long-term or secondary memory.

The above findings differ from previous research that showed information on list length to affect the recency portion of the list (e.g., Shallice, 1975; Watkins & Watkins, 1974). These differences may be reconciled if we take into account the fact that all other experiments utilized auditory presentation, and subjects were specifically asked to start recalling the last items first.

Although all groups of subjects were tested after exposure to 20 items, their initial information differed. Thus, subjects in the Discouraging information condition were told that the list would be 40 items long. Results indicate that **discouraging information on start significantly reduces recall.** Within our theoretical framework this can be explained by two different mechanisms which are not mutually exclusive:

(a). We postulate that when a task is seen as unmanageable, this reduces the motivation to allocate all available resources. **Anticipated failure protects the waste of resources.**

(b). Whatever the initial resource allocation, if the expected list is twice as long (40 instead of 20), the **resources per item** are much smaller. This will inevitably reduce performance.

Both of these possible explanations are in line with our previous findings with soldiers on long marches, and experiments on pain tolerance. Anticipated failure operated as a "self fulfilling prophecy", often leading to "giving up" early in the task. It is important to note that in the present study as well, **the main impact of discouraging information was on the early, "primacy" items.**

Experience enhances resource allocation.

All subjects in our experiments indicated that they did not have prior experience with similar tasks. Consequently, on the first trial they could not effectively evaluate the implications of the information about list length. Thus, those in the Exact information condition, had probably only a vague notion as to how much resources have to be allocated, and how many items of the 20 indicated they could be expected to recall. It is conceivable that when presented with the information of 40 items, while obviously discouraged, the extent of the difficulty became clear only as the task progressed.

By the same token, having no information about the expected list length on the first trial, does not necessarily imply a more difficult task. The totally ambiguous situation may, at least at the start of the experiment, be perceived as potentially shorter than 20 items. After all, 20 items are more than subjects can reasonably expect to recall. At the same time, **absence of information precludes any rational allocation of resources, as any item may well be the last one.** However, as the task progresses, the optimistic appraisals are gradually replaced by a more discouraging evaluation of its difficulty.

The situation is quite different on the second trial. Having experienced the actual length of the item list, as well as the recall performance itself, subjects are better able to evaluate the **expected effort**. This is particularly so when given an exact number of items in the start of the second trial. They are now better able to allocate the necessary resources, **as indicated by significantly higher recall on the second trial.**

In the No information condition, the benefit of experience is minimal, which accounts for the finding that the advantage in both recall and recognition of the Exact information over the No information condition reaches statistical significance only on the second trial. Stated differently, just like in the case of endurance of a stressful task, **exact information promotes effective resource allocation**, particularly after some prior experience.

Information en route reduces effort.

Even in the Exact information condition, subjects can maximize their within task resource allocation only to the degree that they can monitor the number of items passed, and those anticipated in the future. Such monitoring adds extra demands, unless it is provided on line, externally. In several of the experiments reported above we introduced a specific counter that indicated the number of items outstanding.

Although this condition did not affect the amount of recall, it nevertheless reduced the subjective experience of difficulty. Thus, **subjects receiving continuous information about list length** (Groups G and H) **reported the task to be easier than those without such information.** Furthermore, the reduced difficulty pertains primarily to the last segment (recency) of the list. It stands to reason that during the initial phase of the experiment subjects are still able to follow the serial position of each item, a task that grows more difficult with each new item presented.

The above finding suggests that subjective difficulty may be a useful, albeit post facto, indicator of effort. For the entire sample of 200 subjects, the correlations between subjective difficulty and performance on the recall tasks are, as expected, negative, although not very high. Once again, **the highest correlations are between subjective difficulty and performance on the recency items** ($r=-.31$ $p<.0001$) and $r=-.30$ $p<.0001$ for the two trials respectively). This finding supports the notion that part of the effort is to keep some record of the progression of the task, as it unfolds.

If subjective difficulty reflects effort, and effort is strongly related to amount of resources allocated to a task, it is possible to obtain at least a distal indication of the resources themselves. The presumed relationships between these variables received interesting support in Groups I and J, when the initial information was altered half-way through the task. After exposure to ten items, subjects in Group I (10+10) learned that there will be ten additional items, whereas Group J subjects (40-20) learned that the task is 20 items shorter. In line with the above reasoning, **Group J judged the primacy items to be significantly more difficult than Group I,** [$F(1,38) = 5.21$, $p<.05$] (the expected effort to recall 40 vs 10 items) **and Group I judged the recency items to be significantly more difficult than Group J** [$F(1,38) = 4.65$, $p<.05$] (increase of 10 items vs. decrease of 20).

The effects of disconfirmation on resource mobilization and allocation remain at this point of our research basically unknown, although additional experiments along the lines pursued here may shed important light on this complex issue. A particularly fascinating question pertains to manipulations such as that in Group J, namely, **reduction of expected effort.** What are the implications of a sudden release of previously committed resources? Are they reallocated among the remaining fewer items, or quickly removed back to the general "pool" as suggested by the visible drop in recall of items 11-15 in Group J (see Table 11)?

<u>Within-task competition for resources</u>.

Assuming an initial allocation of resources to a task on the basis of expected effort, and further assuming only a limited amount of correction of that initial allocation during the task proper, **within-task competition for resources will follow whenever they are insufficient.** The above conditions define a zero-sum situation, so that if more resources are used at a particular stage of the task, fewer are left for the remaining portion of the task.

The most obvious case of such within-task competition is when time is the necessary resource, and it is not long enough for successful performance of the entire task. The limited time available for rehearsal of items, combined with the constraints of working memory, make the present study a particularly relevant case in point. In addition to the theoretical interest of this conceptualization, its practical implications are potentially far reaching. Thus, it might be useful to search for clues of such a modus operandi. The following analyses all support the above formulations:

(a) <u>Primacy vs. recency</u>. Subjects differ in their memory capabilities, and consequently, on the bais of indications of performance on any segment of the task we should be able to predict performance on other segments. In order to obtain as reliable estimates of this factor as possible, the data of all the subjects from the ten experimental groups were pooled together. <u>Table 23</u> presents the intercorrelations between recall of primacy and recency items on both tasks for the entire sample of 200 subjects.

Table 23: Correlations between primacy and recency, both trials.

	Primacy 1	Recency 1	Primacy 2	Recency 2
Primacy 1	1.00	.06	.26	.19
Recency 1		1.00	.17	.32
Primacy 2			1.00	.18
Recency 2				1.00

As hypothesized, all correlations, with the exception of Primacy 1 with Recency 1 are significant below the $p<.01$ level. Thus, for instance, those who recall more items on the primacy segment of trial 1, will also recall more items on the primacy segment of trial 2. The same holds for recency. This is largely due to individual differences in our subjects' capacity for recall, and overcomes the specific differences between the various conditions of the two trials.

Since the conditions within the same trial are the same, we should expect the correlation between Primacy 1 and Recency 1 to be the highest, whereas in fact it is the lowest, indicating that **within the same trial, there is competition for resources!** It is interesting to note that even the correlations between Primacy 1 with Recency 2 and vice versa are higher, thus removing several alternative explanations to our finding. Stated differently, on the first trial, subjects who allocated more resources to primacy items, had fewer left for the recency portion. It is suggested that if we could remove the positive component due to stable individual differences, the theoretical correlation between these segments would actually be a negative one. (This correlation is the lowest one in all information conditions. In the Exact information condition it is $r=.07$, in the Discouraging information condition it is $r=-.02$, and in the No information condition it is $r=.07$).

Lastly, it appears that the within-task competition for resources is smaller on the second trial. It is conceivable that prior experience with the task leads to greater resource allocation, and/or helps our subjects to distribute the limited resources available more efficiently.

It should be mentioned that the correlations between the appraisals of subjective difficulty of the various segments of the two trials indicate the same phenomenon. Thus, whereas the correlations between subjective difficulty of Primacy 1 with Primacy 2 and Recency 1 with Recency 2 are very high ($r=.66$ and $r=.77$ correspondingly), the correlations within each trial are low and non-significant. This finding lends additional support to the notion that subjective difficulty may provide a useful index of effort, and resource allocation.

(b) Between-segments variability. In order to obtain yet another measure of the way subjects in our experiments invested their resources during the various stages of the task, we divided the 20 item list into four segments of 5 consecutive items each. Next we computed the number of items recalled in each such segment, and finally the variance between these numbers. **The smaller this variance, the smoother and more consistent the performance.** High variance, on the other hand, indicates inconsistent effort, and hence inconsistent item to item resource allocation.

For all groups pooled together, the correlation between total recall on trial 1 and between-segments variability was $r=-.16$ ($p<.05$), suggesting a significant, though minor, detrimental impact of variability on performance. The corresponding correlation for trial 2 was $r=-.20$ ($p<.01$). The correlations of this index with recall of primacy items were both positive ($r=.30$ and $r=.28$ respectively), and with recall of recency items they were negative ($r=-.18$ and $r=-.14$). This suggests that **subjects overinvest in primacy, with subsequent shortage of resources.** There is, of course, some affinity between this index and the one discussed in the preceding section.

We tested whether on the first trial the detrimental impact of between-segments variability differs across information conditions. The correlations for Exact information, Dicouraging information and No information were $r=-.14$, $r=-.01$, and $r=-.30$ respectively. Only the impact in the No information condition was significant ($p<.05$), suggesting that **one of the benefits of information about task duration/length is that it facillitates the within-task resource allocation.**

The above conclusion received additional support from the finding that between-segments variability dropped significantly from the first to the second trial. (Mean 1=1.84, Mean 2=1.60, $t=1.95$, $n=200$, $p<.05$). Once again we witness the increased efficiency of resource allocation due to prior experience.

(c) Non-recalled recognition (NRR). Research on memory is unambiguous about the positive relationship between recall and recognition, and the empirical correlations between them are usually very high. Since the second is typically the easier of the two, subjects that are able to spontaneously recall an item, are also able to recognize it on the recognition task. On the other hand, some items may fail to be recalled, and yet correctly recognized.

From the vantage point of our conceptualization, if the stated goal is to recall and not recognition, **non-recalled items that are recognized indicate waste of resources.** Since correct recognition cannot take place without investing some resource, the failure to recall the item makes it a wasteful investment. Stated differently, in a situation of limited resources, any investment that is not sufficient to ensure success in the task is wasted. Thus, if instead of several subthreshold investments subjects could concentrate their efforts on fewer items, their performance would increase.

For each subject, we calculated the proportion of recognized non-recalled items out of all non-recalled items. Mathematically this is represented by the equation:
NRR = (Recognition - Recall)/(1 - Recall). In the case of a ideallly performing subjects, NRR should be small, and the correlation between NRR and Recall itself should be negative, indicating minimal waste of resources. The forces leading to positive relationships between recall and recognition indexes are, however, too powerful to actually observe a negative correlation, which must be inferred from more complex data.

As anticipated, the observed correlations between NRR and Recall are all high and positive, due to individual differences, and the inherent overlap between the two tasks. At the same time, as we move from the first to the second trial, the correlations drop markedly, particularly in the Exact information condition. Table 24 presents the data.

Table 24: Correlations between NRR and Recall by information condition and trial.

	Trial 1	Trial 2
Exact information	.37	.18*
Discouraging info.	.48	.43
No information	.53	.36

* Not significant

The data suggest that experience with the task enhances the relationship between performance and absence of wasteful investment. The effect is most pronounced in the Exact information condition, which is the optimal case for resource allocation.

The coding task.

The simple task of coding does not initially pose a problem of insufficient resources. Information about task length (100 vs. 300 vs. 500 stimuli) affects performance only during the second half of the task itself. This indicates that **with the onset of fatigue, even very easy tasks are influenced by expected effort.** Specifically, performance in the Exact information condition is better (i.e. faster) than in the Discouraging condition, with the worst performance in the No information condition.

Subjects judged coding to be very easy, and systematically underestimated the number of stimuli presented. The introduction of an on-line counter led to more accurate estimates, although still well below the actual numbers.

Finally, when told to expect 500 stimuli, that were eventually reduced by 400, subjects performed faster than if they expected 50, and subsequently told of 50 more. This may be the outcome of greater resource allocation at start in Group 500, leading to corresponding shorter reaction times. Once the response pattern was established, the subsequent disconfirmation had little impact.

Yet another explanation of the above finding would stress the within-task allocation. When expecting 500 stimuli, the psychological importance of each stimulus is much smaller than if only a small number of stimuli are expected. The reduced reaction times may actually indicate reduced effort. Were it not that the coding task was very easy, this might have led to a greater number of mistakes. More research needs to be carried out to sort out some of these issues.

Optimal expected effort.

The results of our experiments suggest that the relationship between expected effort and initial resource allocation is a complex one. Thus, Group I (10+10) and all the groups in the Discouraging information condition, appear to function below the level of the Exact information condition. This would imply that the function is not linear, but a curvilinear one. Stated differently, **the relationship between expected effort and initial resource allocation may well replicate the classical inverted U curve of Yerkes Dodson fame.** Thus, if the task is expected to be too easy or too difficult, resource mobilization would be sub-optimal. It is conceivable that the prevalent explanatory power of the inverted U curve may, at least partially, be accounted for by the above argument.

SUMMARY.

Information management principles that were found effective in enhancing endurance of stressful tasks were successfully applied to the area of free recall. Considering the conceptual distance between the domain of physical exertion or pain tolerance, and that of memory, the potential applicability of the specific information management techniques to a broad spectrum of cognitive tasks is a distinct possibility.

The theoretical framework focusing on available resources, their effective mobilization, and within task allocation, was found useful in bridging the gaps between the various domains tested. It offers a variety of potentially effective interventions aiming at maximizing performance. The present authors are now engaged in pretesting these principles in the context of decision making.

REFERENCES

Ashcraft, M.H. (1989). Human memory and cognition. Glenview, Ill.: Scott, Foresman and co.

Appley, M.H., & Trumbull, R. (1967). Psychological stress: Issues in research. New York: Appleton-Century-Crofts.

Baddeley, A. (1986). Working memory. Oxford: Oxford Science Publications.

Baddeley, A. (1990). Human memory: Theory and practice. Hove: Lawrence Erlbaum Associates.

Baddeley, A.D., & Hitch, G.J. (1977). Recency reexamined. In S. Dornic (Ed.) Attention and Performance VI. Hillsdale, N.J.: Erlbaum.

Badia, P., Harsh, J., & Abbott, B. (1979). Choosing between predictable and unpredictable shock conditions: Data and theory. Psychological Bulletin, 86, 1107-1131.

Becker, L.J. (1978). Joint effect of feedback and goal setting on performance: A field study of residential energy conservation. Journal of Applied Psychology, 63, 428-433.

Ben-Zur, H., & Breznitz, S. (1981). The effect of time pressure on risky choice behavior. Acta Psychologica, 47, 89-104.

Bernbach, H.A. (1975). Rate presentation in free recall: A problem for two-stage memory theories. Journal of Experimental Psychology: Human Learning and Memory, 104, 18-22.

Bjorklund, D.F., & Harnishfeger, K. K. (1987). Developmental differences in the mental effort requirements for the use of an organizational strategy in free recall. Journal of Experimental Child Psychology, 44, 109-125.

Breznitz, S. (1967). Incubation of threat: Duration of anticipation and false alarm as determinants of fear reaction to an unavoidable frightening event. Journal of Experimental Research in Personality, 2, 173-180.

Breznitz, S. (1968). Incubation of threat in a situation of conflicting expectations. Psychological Reports, 22, 755-756.

Breznitz, S. (1971). A study of worrying. British Journal of Social and Clinical Psychology, 10, 271-279.

Breznitz, S. (1972). The effect of frequency and pacing of warning signals upon fear reaction to threat. Scientific Report, Ford Foundation.

Breznitz, S. (1984). Cry wolf: The psychology of false alarms. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Breznitz, S. (1988). Enhancing performance under stress by information about its expected duration. First Annual Report to U.S. Army Research Institute for the Behavioral and Social Sciences.

Breznitz, S. (1989). Information induced stress in humans. In S. Breznitz, & O. Żinder (Eds.) Molecular biology of stress. New York: Alan R. Liss.

Breznitz, S. (1990). Theory-based stress measurement? Not

yet. Psychological Inquiry, 1.
Breznitz, S., & Goldberger, L. (1982). Stress at crossroads. In L. Goldberger, & S. Breznitz (Eds.) Handbook of stress. New York: Free Press.
Brown, J. (Ed.). (1976). Recall and Recognition. New York: Wiley.
Case, R. (1984). The process of stage transition: A neo-Piagetian view. In R.J. Sternberg (Ed.), Mechanisms of cognitive development (pp. 19-44). New York: W.H. Freeman.
Craik, F.I.M., & McDowd, J.M. (1987). Age differences in recall and recognition. Journal of Experimental Psychology: Learning, Memory, & Cognition, 13,474-479.
Crowder, R.G. (1969). Behavioral strategies in immediate memory. Journal of Verbal Learning and Verbal Behavior, 8, 524-528.
Druch, A. (1988). Contextualization of input and output events in memory. M.A. Thesis, Haifa University, Haifa Israel (Hebrew).
Engle, R.W., Clark, D.D., & Cathcart, J.S. (1980). The modality effect: Is it a result of different strategies? Journal of Verbal Learning and Verbal Behavior, 19, 226-239.
Erez, M. (1977). Feedback: A necessary condition for the goal setting-performance relationship. Journal of Applied Psychology, 62, 624-627.
Eysenck, M.W. (1982). Attention and arousal: Cognition and performance. Heidelberg, Germany: Springer-Verlag.
Folkins, C.H. (1970). Temporal factors and the cognitive mediators of stress reaction. Journal of Personality and Social Psychology. 14, 173-184.
Glanzer, M. (1972). Storage nechanisms in recall. In G.H. Bower & J.T. Spence (Eds.), The psychology of learning and motivation. Vol.5, pp. 129-193, New York: Academic Press.
Goldberger, L. & Breznitz, S. (1982). Handbook of stress. New York: Free Press.
Hannafin, M.J. (1981). Effects of teacher and student goal setting and evaluations on mathematics achievement and student attitudes. Journal of Educational Research, 74, 321-326.
Hanley, J.R., & Thomas, A. (1984). Maintenance rehearsal and the articulatory loop. British Journal of Psychology, 75, 521-527.
Haslam, D.R. (1985). Sleep deprivation and naps. Behavior Research Methods, Instruments, & Computers, 17, 46-54.
Janis, I.L. (1949). In: Stouffer, S.A., et.al.: The American soldier; Combat and its aftermath. Vol. 2. Manhattan, KS., MA-AH PUB.
Janis, I.L., & Mann, L. (1977). Decision making. New York: Free Press.
Kahneman, D. (1973). Attention and effort. Englewood Cliffs, N.J.: Prentice-Hall.
Kail, R. (1984). The development of memory in children (2nd

ed.). New York: Holt.
Latham, G.P., Mitchell, T.R., & Dossett, D.L. (1978). Importance of participative goal setting and anticipated rewards on goal difficulty and job performance. Journal of Applied Psychology, 63, 163-171.
Lazarus R.S. (1966). Psychological stress and the coping process. New York: McGraw-Hill.
Lazarus, R.S., & Folkman, S. (1984). Stress, appraisal, and coping. New York: Springer.
Lazarus, R.S., & Launier, R. (1978). Stress-related transactions between person and environment. In L.A. Pervin, & M. Lewis (Eds.) Perspective in interactional psychology. New York: Plenum.
Locke, E.A., & Shaw, K.N. (1981). Goal setting and task performance: 1969-1980. Psychological Bulletin, 90, 125 152.
Maher, C.A. (1981). Effects of involving conduct problem adolescents in goal setting: An exploratory investigation. Psychology in the Schools. 18, 471-474.
Mansueto, C.S., & Desiderato, O. (1971). External vs. self produced determinants of fear reaction after shock threat. Journal of Experimental Research in Personality, 5, 30-36.
McGrath, J.E. (1970). Social and psychological factors in stress. New York: Holt, Rinehart & Winston.
Mitchell, D.B., & Hunt, R.R. (1989). How much "effort" should be devoted to memory? Memory and Cognition, 17 (3), 337-348.
Murdock, B.B. (1962). The serial position effect of free recall. Journal of Experimental Psychology, 64, 482-488.
Navon, D. (1984). Resources - A theoretical soupstone? Psychological Review, 91, 216-234.
Nomikos, M.S., Opton, E.M. Jr., Averill, J.R., & Lazarus, R.S. (1968). Surprise versus suspense in the production of stress reaction. Journal of Personality and Social Psychology, 8, 204-208.
Penney, C.G. (1985). Elimination of the suffix effect on preterminal list items with unpredictable list length: Evidence for a dual model of suffix effects. Journal of Experimental Psychology: Learning, Memory, and Cognition, 11, 229-247.
Shallice, T. (1975). On the contents of primary memory. In P.M.A. Rabbitt & C. Dornic (Eds.), Attention and performance, vol. 5, London: Academic Press.
Selye, H. (1950). The physiology and pathology of exposure to stress. Montreal: Acta.
Selye, H. (1956). The stress of life. New York: McGraw-Hill.
Stevenson, M.K., Kanfer, F.H., & Higgins, J.M. (1984). Effects of goal specificity and time cues on pain tolerance. Cognitive Therapy & Research, 8, 415-426.
Watkins, M.J., & Watkins, O.C. (1974). Processing of recency items for free recall. Journal of Experimental Psychology, 102, 488-493.
Weinberg, J. & Levine, S. (1980). Psychobiology of coping animals: The effects of predictability. In S. Levine, &

H. Ursin (Eds.) Coping and health. (NATO Conference Series III: Human factors). New York: Plenum.
Willer, B. & Miller, G.H. (1976). Client involvement in goal setting and its relationship to therapeutic outcome. Journal of Clinical Psychology, 32, 687-690.

Appendix A : Post experimental questionnaire.

We need your sincere reactions to the following questions relating to the tasks you have performed. The sequence in which you have performed the tasks is identical to the sequence of the sets of questions. Some of the questions have multiple choice answers. Choose the answer which in your view is the most appropriate.

1. On the first list of words that has been presented on the computer:

   a) How many words, in your opinion, how many words appeared on the list?
   (Even when the number of words on the list was indicated in the instructions, sometimes the subject might sense that the number of words presented is not identical to the number indicated.)
   (write a numerical estimation.)______________

   b) How many words were you told would appear on the list?
   (write a numerical estimation)____________

   c) How many words did you expect to remember from the word list, before beginning the task?
   (write a numerical estimation.) ____________

   d) How many words do you think you have remembered? (write a numerical estimation.)__________

   e) While the words have been presented on the screen, did you make use of any method in order to remember them? Specify

   ____
   ____
   ____
   ____
   ____

   f) Did you, at any stage during word presentation, come to the conclusion that you will not be able to remember the words, and stoped memorizing? yes / no
   If yes, circle the position in the list of these words (You may circle more than one position):
   Beginning of list----Middle of list----Towards the end of list

   g) Please rate the degree of difficulty in recalling words that appeared at different positions of the word list.

	very easy						very difficult
	1	2	3	4	5	6	7
Beginning of list	1	2	3	4	5	6	7
Middle of list	1	2	3	4	5	6	7
End of list	1	2	3	4	5	6	7

h) Have you, in the past, participated in performing tasks which are similar to the memory tasks you were asked to perform in our research, and did it have any effect on your performance?
Specify____

2. Regarding the coding task you have performed on the computer:
a) In your opinion, how many graphical signs appeared in the task? (Even when indicated in the instructions, sometimes the subject may sense that the number of signs presented is different from what was indicated.)
(write a numerical estimation)____________
b) How many signs were you told would be presented?
(Please write a numerical estimation.)____________
c) What was the number of signs that you expected to complete coding, before beginning the task?
(write a numérical estimation)__________
d) How many signs do you believe you have coded? (write a numerical estimation.)_________
e) Did you use any method to facilitate or improve your performance of the coding task? Specify____________________

f) Did you, at any stage in the signs presentation, come to the conclusion that you cannot continue coding, and coded randomly or stopped coding? yes / no
If yes, circle the stage in which it had occurred. (You may circle more than one position):
Beginning---Towards the Middle---Towards the end---
g) Rate the degree of difficulty of the coding performance at the different stages of the coding task:

	very easy					very difficult
	1	2	3	4	5	6	7
Beginning	1	2	3	4	5	6	7
Towards the Middle	1	2	3	4	5	6	7
Towards the End	1	2	3	4	5	6	7

h) Have you participated in the past in performing a task similar to the coding task done here? yes / no
If yes, did it have any effect on your present performance ? yes / no
If it had any effect, explain briefly______________________
____

i) Did the recall task presented before the coding task have any effect on performance on the coding task? yes / no
If it had, explain briefly how?____________________________
____
____

3. Regarding the second word list that has been presented on the computer:
a) How many words appeared on the list?
(Even when the number of words on the list was indicated in the instructions, sometimes the subject might sense that the number of words presented to him is not identical to the number indicated.)
(write a numerical estimation.)______________
b) How many words were you told would appear on the list?
(write a numerical estimation)____________
c) How many words did you expect to remember from the word list, before beginning the task, if you had any expectations
(write a numerical estimation.) ____________
d) How many words do you think you have remembered? (write a numerical estimation.)__________
e) While the words have been presented to you, did you make use of any method in order to remember them? Specify
____
____
____
____
____

f) Did you, at any stage during word presentation, come to the conclusion that you will not be able to remember the words presented, and, therefore stopped memorizing? yes / no
If yes, circle the position in the list of these words (You may circle more than one position):
Beginning of list----Middle of list----Towards the end of list
g) Please rate the degree of difficulty in recalling words

that appeared at different positions of the word list.

	very easy						very difficult
	1	2	3	4	5	6	7
Beginning of list	1	2	3	4	5	6	7
Middle of list	1	2	3	4	5	6	7
End of list	1	2	3	4	5	6	7

h) Did the fact that you have already performed a similar recall task affect your expectations regarding the number of words to be presented to you? yes / no
If yes, in what way (if you had any expectations)__________

____

____

i) Did the fact that you have already performed a similar recall task affect the memory method you used? yes / no
If yes, in what way ______________________________

____

j) Did the coding task have any effect on the performance of the recall task which followed? yes / no
If yes, in what way? ______________________________

____

____

4. Questions regarding tasks comparison:
   a) Please rate the tasks according to their relative degree of difficulty for you:

	very easy						very difficult
	1	2	3	4	5	6	7
first recall task	1	2	3	4	5	6	7
coding task	1	2	3	4	5	6	7
second recall task	1	2	3	4	5	6	7

b) Please grade the tasks according to your (relative) success in performing them.

	poor performance				excellent performance		
	1	2	3	4	5	6	7
first recall task	1	2	3	4	5	6	7
coding task	1	2	3	4	5	6	7
second recall task	1	2	3	4	5	6	7

c) The presentation time of the words in the memory tasks was:

too short / sufficient / too long

5. During the presentation of words on the computer (as opposed to the oral recall period), what methods have you used (if any):
I. Associations, images, rote memorization... specify exactly which type?
II. Did this method involve a few words connected together, or each word separately?
III. Did you use different methods in different parts of the lists?

a) During the first recall task: ______________________________

____

____

____

b) During the second recall task (were there any changes in comparison with the method in the first task): ______________

____

____

____

6. Regarding the oral recall period, what recall method did you use (if any)?
a) Regarding the first recall task ______________________________

____

____

____

b) Regarding the second recall task: (were there any changes from the method used in the first task)______________________________
____
____

7. How many words have been actually presented to you in the two oral recall tasks? (experimenter! Check whether subjects knows that he/she has been deceived in the appropriate experiment conditions, and how did that affect him/her.)
First recall task:____
Second recall task:____

8. Did the presence of the counter in the coding task have any effect on performance:
a) Did it: disrupt/aid.
b) How much did you pay attention to the counter?_________
Did you look at it at: (please circle)
the beginning of task/middle of task/towards end of task

9. How did the information about the number of words to be presented on the word lists affect your expectations regarding the number of words you will remember, and the memory method you have used?
Regarding the first list:_____________________________________
____
____
Regarding the second list:____________________________________
____
____

10. General comments:____
____
____