HUMAN MEMORY AND COGNITIVE CAPABILITIES
Mechanisms and Performances
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INFORMATION PROCESSING BEFORE AND AFTER THE FORMATION OF AN INTENT

Heinz Heckhausen and Peter Gollwitzer
Max-Planck-Institut für psychologische Forschung
Munich
FRG

We postulate different modes of information processing before and after the formation of an intent or decision, i.e., before and after crossing the Rubicon that separates motivation from volition. Motivation requires an accurate view of reality in order to evaluate incentives and probabilities of success and failure. But volition needs to focus only upon how to act to bring an outcome into existence. Thus, in a state of motivation we should be open to a broad range of information which we probe impartially, whereas in a state of volition we should turn into narros - minded partisans of our action plans and become correspondingly preoccupied.

To test these assumptions we designed an experimental paradigm that allowed to call forth information processing in either a predicisional (i.e., motivation) state or a postdecisional (i.e., volition) state. In four experiments we have investigated (1) flow of thought content (2), memory span (3), cued recall of state-relevant and state-irrelevant information, and (4) performance in an arithmetic task. The findings encourage to further explore the Rubicon conception of motivation and volition as different modes of processing information.

When we trace the tradition of motivation psychology back in time, we do not run into Hermann Ebbinghaus, but rather into Marziss Ach, who is one generation younger than Ebbinghaus. Ach (1910) constructed his motivation theories on the basis of memory phenomena. Ever since then, motivation and memory have had a good, but distant relationship. Researchers of motivation showed an early interest in memory, remember the Zeigarnik-effect, for instance (Zeigarnik (1927), Atkinson (1953)). Nowadays, however, memory has begun to borrow from motivation with investigations of, for example, the effect of mood (Bower (1981)) or decision on memory (Dellarosa and Bourne (1984)). In the near future we will, no doubt, witness a still closer exchange, if not integration of research traditions initiated by Ebbinghaus (1885) and Ach (1910).

Ach had much to say about volition. He discussed how volition begins with the act of will and how it prompts and leads action. However, he had nothing to say about motivation proper, i.e., about such things as deliberating about values and expectancies before an eventual commitment to one of the many options for action. Ach began his analysis with the mysterious transition point between motivation and volition, the transition we call "decision" or "intent". When Boring, the historian of our discipline, first ran into the now familiar abbreviation of "nAch" for need achievement, he asked himself what it could have to do with N(arziss). Ach. We owe a delayed but enlightened answer to that question to Julius Kuhl (1983) who distinguished between "selection motivation" and "realization motivation", two successive segments of the behavior stream which correspond to motivation and volition. In contrast to Ach, achievement motivation research has over the last decades concentrated on the first segment "selection motivation" and has neglected or misunderstood the problems of "realization motivation", or volition, as we prefer to label the second segment.

In a joint paper with Kuhl, we have recast the whole of motivation simply as the processes of elaborating incentives and expextancies in order to select among options for later action (Heckhausen and Kuhl (1985)). These motivation processes eventually end when an intent or some other, but less conspicuous process launches the individual into a volitional period. During the volitional period, the focus is on when and how to act to accomplish what one is determined to do. Processes of this volitional period are not simply a continuation of motivation tendencies into action tendencies but are processes of another nature. We think of the transition from motivation to volition as similar to crossing the Rubicon - one cannot return.

We postulate different modes of information processing before and after crossing the Rubicon, i.e., before and after the formation of an intent. In this, we subscribe to a straightforward functionalism. Motivation requires an accurate view of reality in order to evaluate incentives and probabilities of success or failure. But volition needs to focus only upon how to act to bring an outcome into existence. Thus, the modes of processing information should differ between these two states accordingly. In a state of motivation we should be open to a broad range of information which we probe impartially, whereas in a state of volition we should turn into narrow-minded partisans of our action plans and become correspondingly preoccupied.

Here we want to describe a set of studies which tested our assumption. We designed an experimental paradigm that allowed us to control when subjects "crossed the Rubicon", so that we could assess information processing in either a predecisional (i.e., a motivational) state or a postdecisional (i.e., a volitional) state. In four experiments we have contrasted the two states with regard to (1) the flow of thought content, (2) memory span, (3) recall of decisional information versus procedural information, and (4) performance in an arithmetic task.

The decisional problem we gave subjects consisted in picking which one of two types of pictures - either black-and-white or colored - would best allow their creative potential to achieve its fullest expression. Subjects were led to believe that their task was to write a story that connected a set of six pictures. Experimental subjects were told that the two types of picture sets, colored or black-and-white, differentially stimulate people's creativity and that only subjects themselves are in a position to evaluate which type of pictures would best reveal their genuine creative potential. Control sucjects were not given a choice, but were assigned a type of test material; assignment were yoked to experimental subjects' choices. After a warm-up with a similar choice problem that sensitized subjects to the need of careful deliberation, each subject was ushered into a separate experimental cubicle equipped with a TV-monitor and intercom system. Subjects saw six sample pictures of each type of the monitor. This was followed by an interval of 90 sec for deliberation over which picture set to choose. At the end of this interval, a decision was requested from some subjects, and was postponed for a while for others. In each of the four experiments a special intervention for assessing the dependent variables of information processing was made either before or briefly after the decision, thus creating a predecisional condition and a postdecisional condition. Shortly after subjects finished working on the respective information processing task the experiment was ended and subjects were debriefed.

STUDY 1: FLOW OF SPONTANEOUS THOUGHT CONTENT

Our first aim was to test the contention that thought differs in content and orientation on each side of the Rubicon. When in a motivational state, we expect the person to be occupied with thoughts about the value of possible outcomes as well as about the expectancies that possible actions lead to certain outcomes and that these, in turn, have consequences aimed at. These elaborations of values and expectancies should be reality-oriented. In contrast, after an intention has been formed, thought should be more restricted to procedural problems of how to act in order to achieve one's intention.

To gather information about such thoughts, our subjects (female university students) were instructed to write down the thoughts that had crossed their minds during a 90 second interval just before or just after a decision. They were to first report the thought experienced immediately prior to our interruption; next, what they had been thinking just prior to this very thought, third, the first thought they had at the beginning of the waiting period, and, finally, what they had thought in between.

In the predecisional condition, memory probes of spontaneous thought covered a 90-second interval just after presentation of the sample pictures. In the postdecisional condition, the subjects first chose one type of pictures. The experimenter then said she would present the chosen set of pictures of the subject's TV-monitor as soon as possible, but after 90 seconds she reported back that another subject was still working on the test material. She then asked subjects to fill the waiting time, by writing down their thoughts they had had during the waiting time after their choice of test material. In the two control conditions, preassignment subjects had to report their thoughts prior to the assignment of one of the two types of test material; postassignment subjects reported their thoughts after they had been assigned one type of test material.

A content analysis, with good inter-rate reliability classified the contents of our four memory probe questions. Three types of content were significantly more frequent for predecisional subjects, as compared to postdecisional subjects: These thoughts concerned: (1) the incentive values of the two options, (2) action-outcome expectancies, and (3) what we call metamotivational control directives. These were things such as critically evaluating whether one's first preference was being possibly biased (i.e., stressing reality orientation) or trying to avoid a bottom-line tendency while deliberating. Interestingly, control subjects, even those in the preassignment condition, rarely had such motivational contents in their thought flow. Indeed, they had as little as postdecisional subjects (Figure 1).

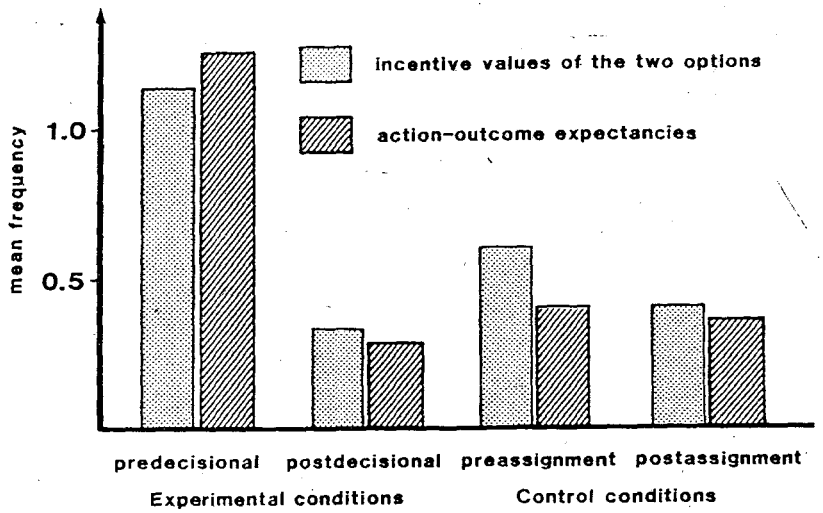

Figure 1
Frequency of deliberative thoughts; representing incentive values of the two options and action-outcome expectancies, in the various conditions

In addition, predecisional subjects had virtually no thoughts about the procedural steps that would be taken to begin an action. This lack of action planning thoughts in motivational state contrasted, as expected, with the frequent occurence of such thoughts in volitional state. Action-planning thoughts predominated both for the experimental, postdecisional subjects as well as for the control, postassignment subjects (Figure 2a).

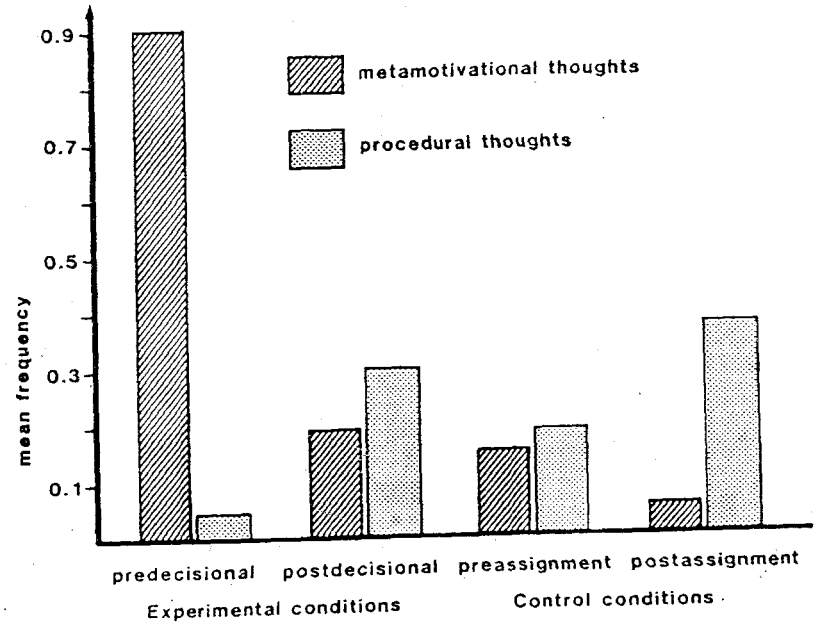

Figure 2
Frequency (a) of metamotivational thoughts and (b) of procedural thoughts in the various conditions.

There were two other categories of thoughts that varied between conditions in our experiment. Whereas predecisional subjects were engaged in deliberative thought and rarely wondered about the purpose of the experiment, postdecisional subjects and both control groups did the latter quite often. Since it was not given much information on how to do the task, postdecisional thinking was not much occupied.

Secondly, the control (assignment) groups, in contrast to either experimental (decision) group, showed a much higher incidence of distraction by outward aspects of the experimental situation at recalled biographical episodes which were irrelevant for the task and hand (Figure 3).

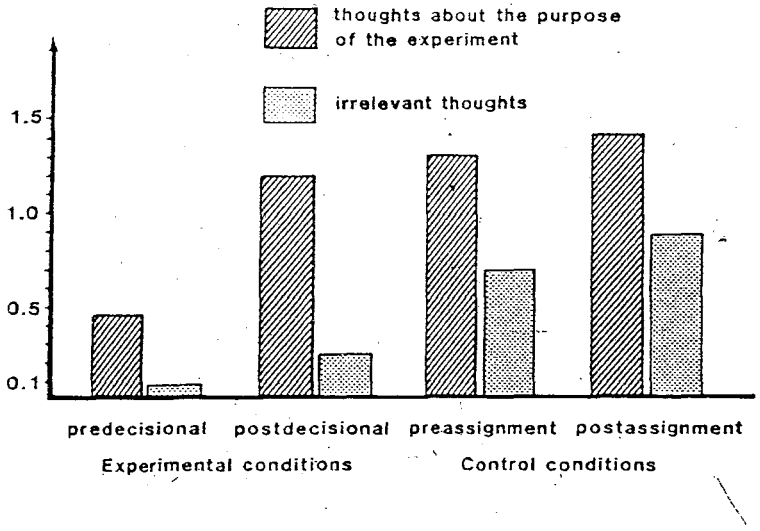

Figure 3

Frequencies (a) of thoughts about the purpose of the experiment and (b) of irrelevant thoughts (outward aspects of the experimental situation or recalled irrelevant biographic episodes), in the various conditions.

This last result should provide a lesson to every psychologist who wants devoted subjects whose minds will not wander from the task: The secret is to refrain from assigning subjects to a treatment or a task, but to let them choose their task. In other words, first put them into a motivational state that then launches them into a genuine volitional state (cp. Heckhausen, Boteram and Fisch (1970)).

To summarize, the results from this first study confirmed our assumption that there are functional differences in the contents of conscious thought flow in motivational states versus volitional states. Note, that this was true even though our experimental paradigm was not optimal. The decision problem did not concern goal options but only referring to means (i.e., type of picture material).

STUDY II: MEMORY SPAN

In addition to thought content, we have assumed that mental processing in a motivational state is oriented toward wider gathering of information than in volitional state processing. Memory span is a straightforward measure to test this prediction.

Subjects were again female university students. Within our experimental paradigm, the design of the present study had three experimental conditions and one control condition. At the beginning of the experiment we gathered baseline measures of subjects' memory span and presented the same creativity procedure I described for the first study. Then we assigned subjects to different conditions. In the predecisional condition subjects did further memory span tasks just prior to choosing between the two types of picture materials designed to measure creative potential. In the postdecisional condition, subjects' memory span was tested briefly after they had made a choice. In a third, so-called activated-intent condition, postdecisional subjects were allowed to stop doing memory span tasks whenever they wanted to move on to the creativity test. We explained to subjects in this condition that there was, for each individual, an optimal level of mental activation that furthers creative performance. In the control condition, subjects were simply asked to do memory span tasks.

We tested memory span by presenting six lists of words. The first two lists contained five, one-syllable nouns, the two middle lists contained six nouns, and the last two lists had seven nouns. About two-thirds of the words had a concrete meaning, one third of them had an abstract meaning. For each list, the experimenter slowly read the words, and then signalled subjects to write down all the words in the order presented. The number of lists presented in predecisional, postdecisional, and control conditions was yoked to the number of lists subjects in the activated-intent condition chose to work on. We measured memory span, assessed according to the "Woodworth & Schlosberg Index" (Woodworth and Schlosberg (1954), p. 696f.).

In the predicisional, motivation state short-term (immediately) memory span comprised more words than in the postdecisional, volition state, the activated-intent condition as well as in the control condition (see Figure 4). Using base-line data as a covariate, a significant difference was found between

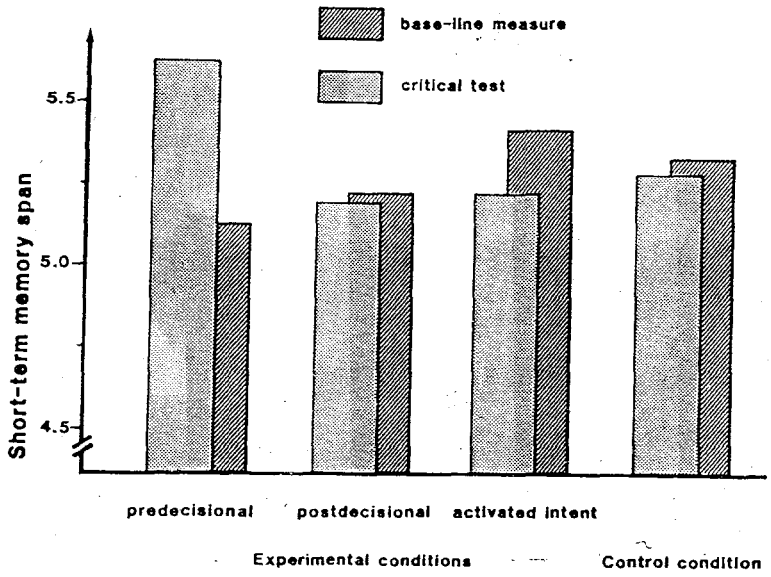

Figure 4
Short-term memory span (Woodworth-Schlosberg Index) for the various conditions.

memory span in the predecisional and all of the other three conditions. Moreover, the predecisional subjects were the only ones who significantly improved their memory span from baseline to later measurement within the experimentally created state. Our only unexpected finding was that performance in the activated-intent condition did not turn out to be worse than performance in the control condition.

In sum, we have preliminary evidence that information processing in a motivational state is broader than in volitional

states. Of course, such a general statement still must be confirmed by other types of variables.

STUDY III: CUED RECALL OF STATE-RELEVANT AND STATE-IRRELEVANT INFORMATION

Our straightforward functional view suggests that information relevant to the state one is in should be processed at a deeper, more semantic level than information that is not relevant. Following Craik and Lockhart's (1972) level-of-processing paradigm, state-relevant material should be more easily retrieved by cued recall within the same, motivational or volitional, state than material that is not state-relevant. This difference should be more pronounced in a volitional than in a motivational state for two reasons. First, a volitional state is more restricted in attentional focus; and second, although procedural performance information is not directly state-relevant in a motivational state, it may be used to generate action-outcome expectancies.

The conditions of the present study were the same as that of Study II, and included a predecisional condition, postdecisional condition, activated-intent condition and one control condition. Subjects, this time male university students, were asked to transform sentences from an active into a passive voice. Twenty-six sentences were presented. Of these, two contained information favoring the choice of the black-and-white set of pictures, two spoke against such a choice; four other sentences were concerned with analogous information about the colored material. Four sentences provided metamotivational information, for example on how to make decisions (e.g., taking one's time improves decisions). Eight sentences discussed how to write creative stories, that is they gave procedural information. Finally, there were six irrelevant sentences. Immediately after subjects finished transforming all the sentences, they were provided with written incomplete texts that matched the originally presented sentences in order to cue recall of those sentences. The order of presentation of the incomplete sentences followed the original sequence of the complete sequence (with the exception of the irrelevant sentences that were placed in front of the relevant ones).

The data did not reveal any of the expected results. State-relevant information - for instance, for postdecisional subjects, sentences with procedural performance - were not better recalled than state-irrelevant information. However, the failure to confirm our hypotheses is not surprising because the recall material was too hard. On the average only two to three sentences (from twenty-six!) could be recalled. Obviously, that is too low a rate to see any effects of differences among sentence types. However, there was an unexpected but suggestive finding. When we looked at the sentence transformation task predecisional subjects had the lowest success rate.

One might interprete this performance deficit as the outcome of a dual task performance; that is the predecisional, motivational subjects may have devoted too much attention to picking up state-relevant information, which interfered with the task of transforming. This ex-post-facto explanation deserves further test.

STUDY IV: PERFORMANCE IN AN ARITHMETIC TASK

Another derivation from our functional view concerns mental operations that demand some effort. Again, we suspected that performance in a motivational state might be superior. The conditions of the present study are the same as in Study II and III. Instead of memorizing strings of words or transforming sentences, subjects now had to solve arithmetic tasks.

Male and female highschool students (16 to 19 years of age) were first familiarized with an arithmetic task by Düker (1949). To take baseline measures, subjects were asked to solve as many problems as they could within eight minutes. Each problem in the task has two lines with three single digits. One line is placed on top of the other; if the sum of the top line is larger than the sum of the lower line, the subject must subtract them, if the reverse is true, the subject must add the two sums. At the end of the 90 second intervals before or after a decision, predecisional and postdecisional condition subjects worked on the arithmetic task. The subjects in the activated-intent condition were asked to stop working on the problems (150 problems were presented on a single sheet of paper) when they felt ready to go on to the creativity test. The exact time when activated-intent subjects stopped working was recorded. For the subjects of the other three conditions, the time spent working on the tasks was yoked to that of the activated-intent subjects. The time spent varied between two and eleven minutes.

The results did not reveal any significant differences in performance between conditions. Partialling out the time spent working on the task, or arithmetic proficiency failed to change our null result. We concluded therefore that our prediction was simply wrong. However, on second thoughts this appears quite plausible for two reasons. First, solving arithmetic problems is an overlearned automatic routine for highschool students. Automatization is, of course, one way in which mental operations become independent from conscious thoughts and from states of mind such as motivation or volition. Second, the arithmetic task may form a segment of its own within the stream of behavior so that it is relatively independent from the framing states of motivation or volition. These interpretations warrant furhter explorations that vary task demands, the extent to which mental operations are automatized and the extent to which the task is related to the preceding motivational or volitional state.

In sum, the evidence so far for the effects of our Rubicon concept on mental operations is mixed, but suggestive. Admittedly, our forays into information processing have been rather crude for testing the more subtle cognitive processes such as processing state-relevant and state-irrelevant information. What we have established is an effect of motivational or volitional states on the content of conscious thought, as well as a related difference in informational receptivity. The formation of an intent or making some such transition from deliberating options to enacting one of them appears to be a psychological Rubicon, the boundary line between different states of mind.

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