Cognitive Performance After Preexposure to Uncontrollability and in a Depressive State

Going with a Simpler “Plan B”

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What is a helpless mind to do? Extending previous work noting parallels between cognitive impairments in depression and after preexposure to uncontrollability (Cox, Enns, Borger, & Parker, 1999; Flett, Vredenburg, & Krames, 1997; Hartlage, Alloy, Vazquez, & Dykman, 1993; Healy & Williams, 1988; Seligman, 1978), we present in this chapter new evidence that the mind switches to a simpler, less effortful “Plan B.” In examining the pattern of performance of complex cognitive tasks observed among helpless or depressed participants, we observe that this lowered level of performance is still clearly above the threshold of random or chaotic behavior. In our presentation of previous and new experimental evidence, we are guided by the view that the switch to the less efficient, but still not chaotic, performance (i.e., a switch to a cognitive exhaustion state, see Kołta & Sedek, 1998; von Hecker, Sedek, & McIntosh, 2000; von Hecker & Sedek, 1999) might represent an adaptive way of adjusting to prolonged uncontrollability and might also describe characteristic aspects of cognitive functioning in depression. In these states, there are not merely decrements across all measures, but instead there are impairments specifically in higher-order processes.

After we recall the origins of uncontrollability research, we unpack our perspective first by noting the similar pattern of cognitive deficits after exposure to uncontrollability among two very smart, although completely different, populations: laboratory rats and high school students. We then describe the cognitive exhaustion model of uncontrollability and depression and briefly summarize existing research evidence. Next, we describe our research examining cognitive functioning in complex task situations applying different experimental paradigms: syllogistic reasoning, dual-task performance, a modified Oberauer task, and a cognitive psychophysical approach to neurological tests (PASAT). The common denominator of these complex cognitive tasks is that they can be solved at various levels
of efficiency, and different patterns of inefficiency can be attributed to specific dysfunctions. Our particular interest is to shed more light on the specificity of the “pathomechanism” of the inefficient performance of helpless or depressed participants across different cognitive tasks: What are the characteristic aspects of task demands that are preserved, which aspects are seriously impaired, and how might these behavioral patterns be explained by existing models of cognitive performance? In brief, we find that individuals who are in depressed or helpless states fall back from using the most effective strategies and instead use a simpler “Plan B” – they do the one thing that is clear and do it well.

BACKGROUND

Origins of Uncontrollability Research

Since Seligman and colleagues (Seligman & Maier, 1967; Overmier & Seligman, 1967) described learning deficits in dogs exposed to uncontrollable shocks, psychologists have sought to understand the effects of uncontrollability on humans. Sustained exposure to uncontrollability leads to a syndrome of psychological disturbances (Wortman & Brehm, 1975). Three deficits are classically associated with such helplessness states: failure to initiate responses (motivational), emotional disturbances (affective), and failure to learn (cognitive; Maier & Seligman, 1976).

Motivating investigation into learned helplessness has been the observation that it may present a laboratory model of some mental dysfunctions associated with reactive depression (Miller & Seligman, 1975; Seligman, 1978). In 1975, Miller and Seligman suggested that the similar effects of helplessness training and depression appear primarily cognitive in nature. Despite this view of cognitive deficits as a key link between helplessness and depression, since the late 1970s, the most influential theoretical approaches in human uncontrollability research have highlighted the role of beliefs and negative emotions as the primary motivational aspects of performance deficits. One approach follows the attributions individuals make in uncontrollable circumstances (Abramson, Seligman, & Teasdale, 1978; Sweeney, Anderson, & Bailey, 1986). A second view focuses on the negative emotional concomitants of failure (e.g., Benson & Kennelly, 1976; Frankel & Snyder, 1978), holding motivation as the primary deficit. Linking to the early proposal that the cognitive deficit in helplessness is crucial in understanding performance deficits associated with depression, our work has instead focused on understanding the nature of the relatively neglected cognitive dysfunctions caused by exposure to uncontrollable circumstances.

Animal and Human Studies on Complex Learning After Preexposure to Uncontrollability

To illustrate the similarities among cognitive deficits in animals and humans, we succinctly present studies on cognitive deficits among rats after inescapable shocks (Jackson, Alexander, & Maier, 1980; Minor, Jackson, & Maier, 1984; Maier & Minor, 1993) and compare the results with our previous research on uncontrollability deficits among students (Kofta & Sedek, 1990; Sedek & Kofta, 1990).

Jackson et al. (1980) used a Y-maze response choice task in which the rat must choose between two response alternatives (turning left or turning right). Because of the Y shape of the maze, the rat could be in any of the arms at the start of a given block of trials, and the correct avoidance response was defined as the systematic turning in relation to the rat’s actual position (e.g., go to the right). Rats previously exposed to inescapable shocks learned this rule more poorly than did rats from the control group. In fact, the performance of rats from the uncontrollability exposed group did not improve above chance (50% errors) during half of the experimental session, and the difference in accuracy between the two groups remained substantial through the end of the experimental session. Of particular interest is that the accuracy index was not correlated with response latency. This pattern of dissociation of simple response performance and loss of complex functions is one we will see also in later research.

The researchers replicated these results with the extended triadic design. Rats from the first control group were merely restrained in their wheel-turn boxes and did not receive any shocks in the first phase of the study. The second control group (escape) was first trained to escape shocks by turning a wheel. The third (yoked) group had experimentally induced uncontrollability; rats in this condition received inescapable shocks yoked to the shocks received by the second control group. Therefore, rats from both the escape control group and the yoked experimental group received the same number and durations of shocks; however, only the rats from the yoked group had no control over the shocks. All groups were examined on the Y-maze avoidance learning task 24 hours later. Rats from the yoked group were significantly slower to learn the escape rule than the rats from the both control groups.

Minor et al. (1984) replicated these findings and demonstrated that the uncontrollability-related impairment was especially pronounced when irrelevant external cues were presented (a light appeared randomly in one of the three arms). Therefore, the poor learning was attributed to the deficits in selective attention.

An alternative explanation is that the results are due to the inescapable shocks producing excessive fear (perhaps inescapable shocks produce...
more fear than the same, but escapeable shocks), which is activated in the next escape tasks. In fact, the model assuming intensive overactivation of critical neurons in frontal cortex resulting from pretreatment fear, leading to sensitization and neural exhaustion, is intensively examined in the animal helplessness and escape performance literature (Hunter, Balleine, & Minor, 2003; Minor, Chang, & Winslow, 1994; Minor & Hunter, 2002). However, Maier and Minor (1993) demonstrated that the deficits in the Y-maze choice learning could not be attributed to induced fear. Selected rats from each condition received fear-reducing drugs (e.g., diazepam) before the pretreatment sessions. The drugs eliminated the standard motivational deficit between the groups in simple escape response speed (implying that the motivational deficit is emotion-related), but they had no effect on the interference in escape learning observable in the group preexposed to uncontrollability. These findings strongly suggest that uncontrollability in rats interferes with complex choice learning through a mechanism not involving fear/anxiety processes.

In our studies with high school students (Kofa & Sedek, 1989b) examining the relative role of uncontrollability and repeated failure on complex avoidance learning and response latency (response speed), we obtained a similar pattern of findings. The uncontrollability manipulation we applied was an unsolvable versus a solvable concept-formation task, frequently used in studies on learned helplessness in humans (e.g., Hiroto & Seligman, 1975). During the test phase, participants were presented with a series of trials with unpleasant noises. They had the opportunity to avoid the unpleasant noise by discovering a hidden rule (pressing the appropriate button when a green lamp was lit on a panel). If participants failed to avoid the noise, they could escape it by pressing another button (the escape response was simpler). Across two studies, we found interaction effects between experimental condition and block of trials. Specifically, for participants in the control group, the number of correct avoidance responses increased over time, whereas for participants in the uncontrollable condition they did not. However, helpless participants were not completely incapable of learning. As with the rats, reaction time and accuracy were not coupled. Data for the latency measure (primarily measuring speed of escape responding) showed that both control and helpless participants got faster over trials. This is the first demonstration in humans of the characteristic pattern that we scrutinize with subsequent experimental paradigms.

To summarize, for both animals and humans, preexposure to uncontrollability seems to impair more refined ways of solving complex tasks but preserves a capability to manage the tasks using simpler fallback strategies. As specified in the next section, our research is guided by the general idea of the evolutionary adaptive ability of higher organisms to switch to a cognitive exhaustion state after prolonged and futile mental activity. In this temporary Plan B state cognitive performance is less efficient but requires less mental effort. The ability to avoid a complete loss of problem-solving capabilities and to preserve even nonoptimal performance is an adaptive strategy in strained situations.

Cognitive Exhaustion Background

The research described in this chapter is based on the cognitive exhaustion model of helplessness and depression. This model assumes that people are likely to engage in systematic mental activity when dealing with problem-solving situations. In controllable situations, these mental activities stimulate people to engage in more generative modes of thinking like the construction of integrative memory representations, such as mental models or elaborating complex cognitive strategies with a hierarchy of subgoals. However, in uncontrollable surroundings, such activity is futile because it cannot lead to real progress in problem solving. It is hypothesized that prolonged cognitive effort without "cognitive gain" results in an altered psychological state, which we term cognitive exhaustion.

The essential quality of this transitory state is a generalized impairment of constructive and integrative mental processing. In terms of general adaptive functions, cognitive exhaustion states seem especially disruptive to more complex problem solutions requiring multiple nonroutine, flexible steps of processing in either achievement or interpersonal realms.

There are a number of close parallels between some aspects of cognitive functioning in depression and the state resulting from preexposure to uncontrollability. We believe that some of the cognitive impairments observed in depression can be explained in terms of experienced uncontrollability. This experience may stem from past, irreversible life events, from subsequent ruminating, or from counterfactual thinking. We theorize that uncontrollability and, in particular, ruminating thoughts about uncontrollable conditions, lead to a depletion of those cognitive resources that support generative and flexible thinking. On the other hand, depressed persons' performance is seldom impaired in tasks dealing with more elementary cognitive strategies.

In another chapter (von Hecker, Sedek, Piber-Dabrowska & Bedynska, this volume), findings are reviewed that examine specifically how the cognitive deficits in depression and helplessness states might be characterized as dysfunctions in deploying higher-order strategies requiring coordinative processing of incoming piecemeal information into mental models (von Hecker & Sedek, 1999; Sedek & von Hecker, 2004). In the present chapter, we tested the predictions that in those states there are also decrements in other complex cognitive tasks.

In a number of studies over the past decade, we have used a laboratory paradigm that, as we argue later, is analogous to a crucial aspect of a
depressive style of rumination, to investigate cognitive deficits associated with cognitive effort without cognitive gain (Kohta & Sedek, 1998; Sedek & Kohta, 1990). This Informational Helplessness Training (IHT) paradigm differs from behavioral learned helplessness approaches to depression in that it does not require ineffective behavior for the deficits to appear. In IHT, participants in each of four problems attempt to learn a rule based on five dimensions, each with two features: (a) size (large, small); (b) shape (circle, triangle); (c) pattern (dotted, plain); (d) line position (top, bottom); and (e) letter size (R, F). One figure at a time appears on a monitor with “yes” or “no,” indicating the presence or absence of the target feature. In the control condition, “yes” and “no” each appear 50% of the time and are consistent across trials with a given feature. In the helplessness condition, “yes” and “no” each appear 50% of the time, but each feature appears twice with “yes” and twice with “no,” so that no hypothesis for the identity of the target feature is correct. Each participant indicates his or her final hypothesis at the end of the trial from a list that includes all the features. At no time is the participant given feedback on his or her performance.

In our first set of experiments (Sedek & Kohta, 1990), we confirmed the hypothesis that after preexposure to informational uncontrollability, performance in a more complex task (avoidance of unpleasant noise) is grossly impaired but performance in a simpler task (escape learning) remains intact. The more recent research indicates that among helpless participants and also among subclinically depressed students, subsequent constructive and integrative mental processing is impeded (von Hecker & Sedek, 1999). Participants in the helplessness condition show cognitive demobilization, lack of task involvement, inhibited generation of ideas, and difficulties with attentional focus (Sedek & Kohta, 1990; Sedek, Kohta, & Tyszka, 1993). This phenomenon may account for deficits such as impaired cognitive functioning in depression and intellectual helplessness in school settings (Kohta, 1993; Kohta & Sedek, 1998; Sedek & Kohta, 1990; Sedek & McIntosh, 1998). The primacy of the cognitive underpinnings of the phenomenon is supported by data showing that these deficits emerge in conditions that minimize the likelihood of effort withdrawal as an ego-protective tactic, in the absence of social performance feedback, when negative mood is statistically controlled, and for accuracy but not effort outcomes (Kohta & Sedek, 1998; Ric & Scharnitzky, 2003; Sedek & Kohta, 1990; Sedek & McIntosh, 1998; for discussion, see Snyder & Frankel, 1989 and Kohta & Sedek, 1989).

It is important to note that during IHT participants from both control and uncontrollable groups are not overtly responding and consequently there is no evaluative feedback concerning their responses. The essence of this procedure is exposure to inconsistent task information that does not enable formulation and support for any reasonable task solution, even when a considerable amount of cognitive effort is invested. As we discuss later, some persistent mental activities among depressed individuals, such as ruminations or counterfactual thinking, might be conceptualized as self-generated forms of informational helplessness training.

Ruminations and Counterfactuals as Forms of Helplessness Training in Depression

Rumination may link helplessness and depression, as it may serve as a form of helplessness training after an aversive event and thus cause the cognitive deficit we have explored in the laboratory. Moreover, nonproductive rumination associated with depression may be part of the cause of cognitive deficits seen in depressed individuals.

After a negative event, individuals often experienced intrusive, recurrent thoughts about it; this rumination is considered part of the process of psychologically integrating the information of the experience (Horowitz, 1976; Janoff-Bulman, 1989). Although repeated thoughts of negative events may be necessary for assimilating such experiences, they are dysfunctional if they do not cause progress in understanding such events (Epstein, 1998). One type of reflection that differs from more general rumination is counterfactual thinking, which focuses not on the events as they actually occurred but rather on consideration of what did not happen – how the event may have been avoided (Davis, Lehman, Wortman, Silver, & Thompson, 1995). Counterfactuals may be constructive when they enable enhanced control over future events; however, in situations in which future control is not possible (e.g., a singular traumatic event), counterfactual thinking is probably not adaptive (Davis et al., 1995; Markman & Weary, 1998). Consideration of alternative realities that are better than one’s true situation is associated with less satisfaction in laboratory paradigms (Markman, Gavanski, Sherman, & McMullen, 1993) and higher levels of distress after traumatic life events (Bulman & Wortman, 1977; Davis et al., 1995). As we elaborated in more detail elsewhere (Kohta & Sedek, 1998), repeated engagement in mental undoing of a negative event means long-lasting cognitive investment in a futile problem-solving attempt, just as IHT provides exposure to long-lasting cognitive effort without any gain.

As Joormann (this volume) notes, there is an important difference between rumination that facilitates digestion of an event (see McIntosh, Silver, & Wortman, 1993) and rumination that is simply cognitive churning. We believe this distinction between effective and ineffective cognitive processing is crucial and provides a window into understanding both the effects of counterfactual ruminations after aversive events and some cognitive deficits of depression. Ruminations are a key cognitive characteristic of dysphoria and depression (Hertel, 2004; Papageorgiou & Sible, 2003; see also Joormann, this volume); individuals who are depressed experience sustained cognitive load in the seconds following exposure to emotional information (Siegler, Steinhauer, Carter, Ramel, & Thase, 2003). Ruminations
in the presence of dysphoria is associated with reduced ability to solve problems (Nolen-Hoeksema, 1996). Indeed, it is rumination combined with dysphoria that appears detrimental, not mere rumination (Lyubomirsky, Kasri, & Zehm, 2003). Depressive rumination appears different from typical rumination in that it involves brooding about problems without taking action to solve those problems (Nolen-Hoeksema, 1996). This thinking without solution is reminiscent of counterfactual thinking and the cognitive effort combined with no cognitive gain that leads to cognitive exhaustion. Note that rumination after a stressful event seems particularly predictive of depressive episodes and their duration (Robinson & Alloy, 2003). In this sense “bad habits” (Hertel, 2004) of being involved in ineffective cognitive activities such as a depressive way of ruminating and counterfactual thinking might be understood as cognitive entrapments producing prolonged effects similar to a situation of endless informational helplessness training.

NEW RESEARCH

In the following sections, we review studies based on the helplessness and cognitive exhaustion theories discussed above. The goal of this set of studies is to identify the nature of cognitive deficits in uncontrolability and depression. We start with a demonstration of how uncontrolability causes individuals to think more simply on syllogism tasks and then move to demonstrations of parallel deficits seen in clinical depression and helplessness on dual tasks. In both groups, the deficit in complex thinking is evident, yet there is a preservation of performance on simple, straightforward tasks. We next present work that conceptually replicates the dual-task findings and examines specifically the role of negatively valenced information. In the final paradigm, we use time–accuracy functions to more closely determine the mechanisms of cognitive inefficiency we see in helplessness and depression.

IHT and Syllogisms

To examine complex thinking in helplessness, we had undergraduate participants solve a series of syllogistic reasoning tasks. They were randomly assigned in a yoked design to helpless and control conditions. IHT, as described previously, was used to manipulate helplessness. Participants completed a syllogism task used by Channon and Baker (1994), which was adapted from Gilhooly, Logie, Wetherick, and Wynn (1993).

Each participant was presented serially with 20 syllogisms, each consisting of two premises from which a solution had to be deduced. There are three strategies of varying sophistication that participants could use to solve syllogisms. The most sophisticated strategy is logic, which leads to correct conclusions in every case. A less sophisticated strategy follows two atmosphere rules as summarized by Begg and Denny (1969). The rule of quality states that if at least one premise is negative, then the conclusion is negative; if neither premise is negative, then the conclusion is positive. The rule of quantity states that if at least one premise is particular, then the conclusion is particular; if neither premise is particular, then the conclusion is universal. A still simpler strategy is matching, in which the rule is to match the form of the solution to the most conservative form of the premises, where the forms from most to least conservative are “No,” “Some not,” “Some,” and “All.” Note that the less sophisticated strategies do not require keeping both premises in mind when determining the answer. A simple, but not completely ineffective, rule can be used.

Responses were compared to those produced by the three strategies. In cases in which more than one strategy could have been used to produce the answer given, participants received credit for using both (or all) strategies. The number of responses fitting each strategy category was totaled, and participants were categorized by the strategy type employed in at least 55% of their responses. If participants used multiple strategies equally and at least 55% of the time, they were categorized as using a mixed strategy (e.g., atmosphere/matching). If no strategy was used consistently, the participant was categorized as such. A score was created in which the strategies used consistently were ranked by level of sophistication (logic = 5, atmosphere = 4, atmosphere/matching = 3, matching = 2, and no consistent strategy = 1). Higher scores on this measure reflect the use of more sophisticated strategies.

Consistent with expectations, there was a significant difference between control and helplessness trained groups in the level of sophistication of the strategies used in solving syllogisms, with controls consistently using more sophisticated strategies than the helpless group. Helplessness appears to reduce complex thinking, but did not result in completely random performance. In the studies that follow, we use a variety of paradigms to determine what aspects of performance are reduced in helplessness and depression and what aspects are spared.

Clinical Depression, IHT, and Dual-Task Performance

We adopted an analytical approach to understanding the mechanisms of lowered efficiency of depressed and helpless participants in cognitively demanding tasks. We begin from an analysis of similarities in the impairments in dual-task processing between clinically depressed patients and students who underwent IHT. An informative introduction to the history and goals of dual-task methodology is offered by Li, Krampe, & Bodnar (this volume). We share their perspective and the view of other authors in the present volume that it is important not only to look at general composite
mean levels of performance of given task, but also to conduct more fine-grained analyses of the behavioral patterns responsible for the observable group difference in task performance (see the analytical approach of West and Bowry, this volume, to understand the pattern of Stroop test performance of older adults). In doing so, we first describe the dual-task problems applied in these studies and then present analytical predictions examined in a series of experiments.

In the first experiment on dual-task processing (McIntosh & Sedek, 2005), 24 clinically depressed patients participated; they were tested in the beginning of their stay in a psychiatric hospital and 1 month later after intensive pharmacotherapy. A control group was matched to the clinical group on age and education. The findings of this study are compared to results of a second experimental study in which 24 high school students underwent IHT and another 24 students were in the control group.

We examined participants' cognitive functioning using a modified version of the dual-task procedure developed by Necka (1996, 1997). In this task, participants first completed a series of a primary task, and then they engaged in a series of trials while also performing a secondary task. The single, primary task involved letter recognition. A computer program presented an uppercase letter in a central frame on screen. The program then presented a lowercase letter in different surrounding frames. Participants were to press the left key of the computer mouse whenever the lowercase letter matching the uppercase target was presented. The matched letter was presented for 1 second. During the primary task two or four distracting letters were simultaneously visible. We recorded hits (the number of times the key was pressed when a letter matching the target was present), false alarms (the number of times the key was pressed when the matching lowercase letter was not on screen), and the response time (RT) for the correct responses, that is, RT of hits (how long after the matching letter appeared does the participant press the key).

During the dual-task segment, participants simultaneously completed both the primary task and a secondary task. For the secondary task, the computer program displayed a horizontal line in one of the rectangles next to the letter matrix used for the primary task. The line automatically drifted downward, and the participant used the right mouse key to raise the line. The task was to press the right mouse key to prevent the moving line from crossing two boundaries indicated by small spots. If the line fell too far or was raised too high, the computer made an unpleasant noise. As a measure of secondary task performance, we recorded the mean deviation from the middle points. These data addressed the question of whether performance on the primary task is sacrificed to enhance secondary task performance.

From the analytical, procedural perspective adopted here, the cognitive demands of this dual task can be understood as the flexible and orchestrated implementation of several (sub)goals. The first, relatively simple goal was to quickly press the appropriate key if the participant notices the correct letter. If we calculated the mean correct RT, we can assess the efficiency of this procedure, independent of whether the number of correct responses (hits) was relatively low or high. We expected that this goal would be executed relatively well by depressed or helpless participants because it is simple and clearly explicated in the instructions. However, there were three other goals that needed to be implemented to perform the dual-task requirements most effectively. To implement the second goal, participants needed to notice all matched elements (maximize number of hits over omissions). To implement the third goal, participants needed to inhibit the tendency of pressing the mouse key on not matched (distracting) letters, to avoid making false alarms. The fourth goal was to keep the performance of the secondary task at the demanded level.

From the cognitive exhaustion perspective that assumes worsening of cognitive efficiency during task performance, we predicted deeper impairments for the number of hits and false alarms (these procedures are more complex to implement, as they require contingent responses) than for correct RT measure (this goal is the easiest to implement, as it requires only attention to one stimulus state and motivation to perform a simple task).

For the clinical study, the methodological problem discussed in detail by Li, Krampe, and Bondar (this volume) in their chapter about dual-task approach in studying aging was immediately apparent. The clinically depressed participants differed from control participants not only on dual-task performance, but also on single-task performance. Therefore, to evaluate the specific demands created by adding the secondary task, we calculated dual-task costs [see detailed discussion of Li et al., this volume, about relative and proportional dual-task costs (DTC)]. For hits and correct RT, dual-task costs were calculated by computing the difference in single versus dual-task performance, then dividing by single-task performance.

The predicted pattern emerged (see Figure 9.1) concerning DTC for correct RT and hits. There were no significant differences for correct RT among clinically depressed patients, those patients after 1 month of pharmacotherapy, and control participants. However, a different pattern was revealed for the hits; there was a proportionally similar number of hits made by depressed participants before pharmacotherapy in comparison to the test after pharmacotherapy, and both pre- and post-pharmacotherapy depressed groups differed from control participants. This deficit was especially evident in the dual-task conditions. For the false alarms measure, there was an interesting pattern (see Figure 9.2), indicating that the number of false alarms did not change significantly after 1 month of pharmacotherapy and did differ significantly from the control group. In contrast to hits and correct RT measures, the number of false alarms was similar in single- and dual-task conditions.
Regarding the students in which IHT was used to induce helplessness, the pattern for DTC concerning correct RT and hits is quite similar to the depression data when comparing participants in the uncontrollable condition to control students (see Figure 9.3).

Again, there was no difference in correct RT, but there was a difference in number of hits. As with the depressed patients, the helpless students pressed the key button as quickly as the control participants if they noticed the correct element. However, similar to clinically depressed patients, helpless students made proportionally fewer correct responses in the more demanding dual-task condition. For the number of false alarms (see Figure 9.4), the pattern is slightly different than it was in the clinical study; the number of false alarms is significantly higher in the uncontrollable situation, but this difference is especially visible in the dual-task situation.

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**Figure 9.1.** Dual-task related decline in performance in Correct RT and Hits on Necka task for depressed participants pre- and post-pharmacotherapy and for control participants. There are no group differences for correct RT. Regarding Hits, control participants showed significantly less dual-task costs than pre- and post-pharmacotherapy depressed groups.

**Figure 9.2.** Number of false alarms during single and dual conditions on the Necka task for depressed participants pre- and post-pharmacotherapy and for control participants. False alarms did not change after 1 month of pharmacotherapy, and the control group showed fewer false alarms than did the other groups. The number of false alarms was similar in single- and dual-task conditions.

**Figure 9.3.** Dual-task related decline in performance in Correct RT and Hits on Necka task for participants in control and induced uncontrollability conditions. There are no group differences for correct RT. Control participants showed significantly less dual-task costs than did those in the uncontrollability group.

**Figure 9.4.** Number of false alarms during single and dual conditions on the Necka task for participants in control and induced uncontrollability conditions. Number of false alarms is significantly higher in the uncontrollable condition; this difference is especially visible in dual-task situation.
In both studies, performance on the secondary task (deviations from midpoint) was used to determine whether poorer performance on hits and false alarms was caused by compensatory improvement of secondary task performance. It was not. Secondary task performance of the depressed group was better after pharmacotherapy but still worse than for the control participants. For students, the uncontrollable group level of performance of the secondary task was similar to the control group.

To summarize, we found a similar pattern of results for the clinical and uncontrollability studies, indicating the predicted pattern of findings. The performance of the simplest goal was intact — when you notice the target element, press the key. However, more implicit and complex procedures that needed to be implemented in this task to solve it most effectively were substantially impaired both among depressed and helpless participants.

Depression and Performance on Modified Oberauer Task

The next experiment sought to conceptually replicate, using a new paradigm, the above dual-task findings regarding preservation of performance on the simple rule but decrements in execution of a complex set of rules. In addition, we addressed the question of the specific role of negative self-relevant information in processing an executive task that demands coordination of several goals. We compared performance of subclinically depressed participants with control participants. Outcome predictions differ depending on whether one believes that negative self-information has attentional priority for depressed individuals. One prediction might be that the execution of a task demanding the processing of negative information would be especially impaired because the attention of depressed participants would be especially distracted in this condition. Alternatively, another stance might be that there is a more general deficit in execution of multi-goal tasks (such as the previously studied dual-task problems) and thus the influence of negative information on processing might not be crucial here, and similar impairments would be observed for neutral and positive conditions. In either case, we are looking for the overall pattern seen in the dual task described earlier.

As existing literature shows (see review in Joormann, this volume), depression impairs performance of emotionally neutral memory and inhibitory tasks; however, sometimes deficits are more evident when there is negative emotional content. In this project, we examined the nature of cognitive deficits in depression using a modified Oberauer (2001) task, because neutral or highly emotional material can easily be implemented and produce strong interference in so-called intrusion probes.

Our modification of the Oberauer task (Oberauer, 2001; Oberauer, this volume) focuses on the intrusive character of the probes with the same word or phrases but different colors and thus removes the active forgetting aspect (we omit presentation of a color frame). Participants were instructed that after a short presentation of two words or two phrases with different colors, they would be presented with a single word or single phrase. They were instructed to press the YES key only if the second, single stimulus was an already presented word (or phrase) with the same color; this was the positive probe. They were instructed to press the NO key if the second stimulus was a new word (or phrase); this was the negative probe. They were also told to press the NO key if the second stimulus was an already presented word (or phrase) with a different color; this was the intrusion probe, as it includes an already presented stimulus, but with a negating characteristic. In addition, the stimuli varied on whether they were negative or positive in self-reference and emotional content. The participants were presented with four kinds of material in random order:

1. two nouns of different colors (e.g., pencil, house)
2. two self-referred phrases of positive meaning
3. two self-referred phrases of negative meaning
4. two self-referred phrases of nonsense meaning

To illustrate this procedure a bit more, in condition (2) participants were presented with two sentences such as: “I’m wonderful” in green and “I’m excellent” in red. In the test phase only one sentence was presented. If it was, for example, “I’m excellent” in green (already presented phrase, but differing color – an intrusion probe), the participant should press NO.

In this study, the simple rule is to press NO when the second stimulus is a new word or phrase. The complication is that the participant also has to keep in mind that one must press NO when it is the same word or phrase presented in a different color. For this kind of task, we propose a general hypothesis for cognitive impairment of depressed persons similar to what we found for dual-task performance: larger differences in accuracy than in correct RT, especially for intrusive trials. That is, we do not expect a difference in how quickly individuals will perform the primary, simple goal – reaction time for correct NOs should be the same across conditions. However, we expect accuracy will be compromised because we theorize that the depressed group will have trouble maintaining the rule to press NO when the second stimulus is an old word (cuing YES) but a different color. The rationale is that it is more difficult to implement the goal to notice and carefully differentiate the cases in which the words were already presented but are dissimilar in colors. As already mentioned, another interesting question was whether these impairments would be especially evident for negatively valenced material.

There were highly significant main effects of probe type: The worst performance was for intrusion probes, the best was for negative probes, and performance on positive probes was in between. The results
Correct RT for all materials

Figure 9.5. Correct RT on modified Oberauer task for each probe type for control and depressed participants. There was a significant main effect, with the worst performance for intrusion probes, the best for negative probes, and performance on positive probes was in between. There is no significant probe by group interaction.

were significant both for proportion correct (hits) and correct RT (see Figure 9.5).

As predicted, the significant interactions with depression emerged only for accuracy data, not response time. There was a general significant interaction effect of depression x probe type across all kinds of presented material (see Figure 9.6) and no interaction with the emotional content of material. However, subsequent analyses showed that this interaction is most significant for negative self-referred material. It seems then that similar to the findings for dual-task processing, there is a general impairment in performing more complex processing goals but the simpler goal is relatively intact. The negative valence aspect of the task increased the strength of observed interference, but it was not the necessary condition for the emerging of the depression-related impairment. Emotion appears neither necessary for the observed deficits, nor irrelevant to their presence.

Subclinical Depression and Time Accuracy Functions: Studies With Modified PASAT

In this final section, we describe studies applying a new methodology – cognitive psychophysics – to capture more precisely the mechanisms of cognitive inefficiency in subclinical depression. We start with the recognition that previous results in dual tasks and modified Oberauer tasks may be described by two distinctive mechanisms.

One mechanism of the observed cognitive inefficiency can be described in terms of fluctuation of cognitive efficacy caused by individuals with depression being easily attentionally distracted. This account predicts that if those with depression were able to focus fully on the complex problems such as dual tasks for a long time, there would be no observable impairments. In line with this explanation, depressed individuals are constantly distracted by negative thoughts or task-irrelevant stimuli. Consequently, they might be able to carry out the simple processing goal but are too distracted to orchestrate implementing other important task goals included in the instructions.

An alternative mechanism can be described in terms of a persistently lowered cognitive efficiency in depressed individuals. Instead of the sudden and unpredictable “ups and downs” as described previously, they exhibit a continuously stable level of lowered efficiency in more cognitively demanding task situations. The important caveat is that we are not attempting here to describe the dynamic of mental activity on a longer period of time, but we are simply focused on the dynamics of mental efficiency during the limited time spent on performance of cognitively demanding tasks.

To compare the above two explanations of lowered cognitive efficiency in subclinical depression, we needed an experimental paradigm that both enabled reliable diagnosis of each individual’s level of cognitive performance and enabled making intergroup comparisons.

In this section, we will describe the main results of two studies using time accuracy functions (TAF; for the detailed description of the paradigm, see Kliegl, Mayr, & Oberauer, 2000; Verhaeghen, 2000). The originsators of this relatively new method describe it as a cognitive psychophysics, because
Estimated formula:  \[ p = d + (c - d)(1 - \frac{1}{e^{t/a}}) \]

FIGURE 9.7. Description of estimating parameters of time accuracy function (TAF) from the accuracy points for different time intervals. In this paradigm, presentation time (t) is converted into accuracy (p) according to a delayed exponential function. As a consequence of this procedure, for each individual, the precise parameters of the function might be calculated instead of one average index of performance. Parameter a (location, chance level crossing) – time needed for processing information above chance level. Parameter b (slope or rate) – how fast performance is rising to the maximum (asymptotic) level. Parameter c (asymptote) – maximum level of performance under infinite amount of time.

They determine psychometric functions at the individual task-specific level using presentation time in the same way that stimulus as energy was used in psychophysics (e.g., manipulations of tone intensity to determine the ear sensitivity). The main assumption to apply TAF to a given cognitive task is that task accuracy is a monotonic function of presentation time. The data for each participant is based on an experimental procedure in which presentation-time demands are specified for some levels of target accuracy by decreasing or increasing presentation time (see Figure 9.7 for explanation of the approach). As a consequence of this procedure for each individual, the precise parameters of exponential functions can be calculated covering the range between chance and perfect performance for given individual. To our knowledge, this approach has never been used on studies concerning depression or other emotional disorders. Based on the findings from similar data on research concerning cognitive aging (Mayr, Kliegl, & Krampe, 1996; Oberauer & Kliegl, 2001; Verhaeghen, Kliegl, & Mayr, 1997), we applied the following formula, where presentation time (t) is related to accuracy (p) according to a negatively accelerated exponential function:

\[ p = d + (c - d)(1 - e^{(t - e^{a/b})}) \]

where d is a parameter for chance performance, parameter c represents the asymptotic accuracy reached when processing time is not externally limited, parameter b is the slope of the function – the rate of approaching asymptote, and parameter a the point in time (t) where accuracy rises above chance (see Figure 9.7). In our estimations of parameters, we fixed d (parameter of chance performance) to 0.25 because, during task performance, the participants answered by selecting one of four keys. The maximum value of parameter c is 1 (100% accuracy), for the other parameters, the larger the value, the worse the performance. That is, as illustrated at Figure 9.7, the participant with larger a needed more time to respond above chance level, and the participant with larger b achieved asymptotic level at slower rate.

As explained in detail by Verhaeghen (2000) the exact meaning of the parameters depends on the specificity of cognitive task; it is different when the TAF methodology is applied to a simple attentional task or, as in our case, to the complex working memory task known as Paced Auditory Serial Addition Test (PASAT; Gronwall, 1977). In general, parameters a and b describe the dynamic aspects of performance (speed and effectiveness), parameter c refers more to the absolute limit of performance; it estimates the potential upper limit of accuracy in task performance when the task is solved without time restrictions.

We adapted time-accuracy functions to the PASAT (Gronwall, 1977). This popular neuropsychological test was devised by Gronwall and colleagues to provide an estimate of a participant’s rate of processing (or the amount of information that can be handled at one time). The PASAT is thought to measure some central information processing capacity similar to that seen on divided attention tasks. According to many neuropsychological findings, PASAT is very sensitive to even very subtle deficits in information processing ability among postconcussion patients, those with mild and severe head injuries, and brain-injured patients with attention disorders.

PASAT requires that a participant continuously add pairs of heard randomized digits so that each digit is added to the digit immediately preceding it. For example, if the spoken digits were 5, 3, 7, 5, the appropriate answers should be: 8(5 + 3), 10(3 + 7), 12(7 + 5).

In our computerized procedure, the participant is required to comprehend the auditory input from the computer program and respond by pressing the correct key (selected from four options). It is important to note that
this procedure contained the aspects of different executive functions of working memory, such as coordination, memory preserving of needed information, inhibition, and updating. To produce the correct answers 10 and 12 in the previous example, the participants first have to inhibit the previously selected answer 8, update from memory digit 3, add it to just heard digit 7, select 10 among four options and press the appropriate key, then inhibit this sum, update 7, and add to just heard digit 5, select 12 among four options, and so on.

As is clear from the previous example, the participants had to develop a system of internal commands to be able to perform this task correctly. In particular, they had to inhibit encoding their own response while attending to the next stimulus in a series, update instead the previous digit, and then perform selection of the correct response at an externally determined pace. In line with previous findings, we expected that this procedure would reveal some details of working memory limits among subclinically depressed students.

Participants were subclinically depressed participants and controls. We tested in two sessions. The first day was preliminary training with various time intervals. The next day, after a short training, there were two 25–35 minute sessions of continuous adding with eight time intervals, changing to a shorter or faster pace after a series of 12 presentations. One benefit of this procedure is that the precise parameters of the function can be calculated for each individual separately, instead of one overall group average index of performance. The first step in analyzing these data was examining if the accuracy data fit well the postulated exponential formula and then examining whether there were significant differences between groups. If the fit were poor or there were significant differences resulting from a more chaotic way of responding among depressed participants, the results of TAF might not be valid. It appeared, however, that the fit was perfect, and the mean the R-square in curvilinear regression analyzes was .96 in the control group and a similarly high .95 in the depressed group. The extremely good fit to the exponential function of the depressed participants is inconsistent with the first presented explanation provided earlier of subclinically depressed individuals having lowered cognitive performance because of fluctuations in performance. If the depressed participants had made a lot of unpredictable attentional lapses during performance of this task, then the fit to the function would be poor and significantly lower than among the nondepressed participants.

The pattern for the three estimated parameters is depicted in Figure 9.8. The analyses revealed no differences in the asymptotic level of performance (parameter c in both groups was about .90). However, there were significant differences between subclinically depressed and control participants for both parameters a and b (recall that larger scores reflect worse performance). Interestingly, Channon, Baker, and Robertson (1993) in their research on working memory impairments in clinical depression also included the classical version of PASAT, and they obtained marginally significant differences. It seems that the more sophisticated TAF methodology with the modified PASAT is able to identify some subtle differences in working memory functions, even among subclinically depressed participants. In the next study, we examined whether the complexity of the required set of internal commands is the key component of the observed deficit, or if the crucial component is the necessity to inhibit encoding the sum. If the latter explanation is correct, then we should observe a similar difference between depressed and control participants when the list of internal commands of this task is shortened, but the need to avoid encoding and adding next digit to the just calculated sum is retained. Again in two sessions, participants were first trained and then tested the next day on the two kinds of tasks. The first one was the same as before; participants had to add two randomly generated digits. The second task was to add 5 to continuously spoken digits and select the appropriate answer among four. In this version, the participants needed to encode the digit, add 5, select appropriate answer among four, then inhibit the sum, listen the next digit and again add 5, and so on. As is clear, the list of commands here is much shorter, but the inhibitory aspect of the task remains. Therefore, the question was whether this inhibitory aspect was sufficient to produce the significant differences between groups. It was not. As depicted in Figure 9.9, in the random digit task, requiring execution of the coordinated list of commands, there was a replication of the previous findings: significant differences in parameters a and b, no differences in parameter c. However, when participants performed the version of task with the constant adding to 5, there were no significant differences between depressed
is that helpless and depressed minds do. We approach this question from a cognitive exhaustion perspective. That is, we believe that sustained cognitive effort (e.g., in our laboratory tasks or from unproductive ruminations common in reactive depression or dysphoria) can lead to a changed cognitive state in which complex thinking is abandoned in favor of more simple, less effortful thinking. We believe it is striking that the pattern of results is consistent across paradigms. The deficit does not seem tied to a particular method of assessment, and thus we believe it has good ecological validity. Indeed, underscoring the applicability of this approach is that it has been used successfully to account for difficulties in school performance (Sedek & McIntosh, 1998). Common to each study was a decrement in higher-order thinking involving coordination of premises (as in the syllogism task), subgoals (as the PASAT), or task requirements (as in dual-task paradigm and Oberauer tasks), with the simultaneous preservation of simple tasks, such as using simple reasoning rules in syllogisms and responding quickly when the proper target is perceived (dual tasks and Oberauer).

We also believe that the performance parallels between the induced helpless participants and the depressed participants (combined with the data indicating separable emotional and cognitive deficits in helpless rats; Maier & Minor, 1993) suggest that explanations of the deficits in depression (and dysphoria) should consider factors beyond the emotional. It is important to note that we are not arguing that cognitive exhaustion related to sustained cognitive effort with no gain explains depression. Our goal is not to propose a new model for depression, but instead to note that a fundamental aspect of depression, ruminations, can lead to some of the cognitive deficits evident in depression. Moreover, given that these deficits are present in subclinical populations, it would be imprudent to consider these deficits or the rumination as the cause of depression.

The next steps in this research program will include specifying the nature of the deficit; the final study using time accuracy functions in PASAT is a step in this direction. Further, additional work exploring the connections with depression and rumination (e.g., in processing a traumatic life event) are important in the application in this research. Determining if similar processes occur in other populations will help detect the parameters of this phenomenon (e.g., could ruminations regarding an activated stereotype explain cognitive deficits under conditions of stereotype threat, Steele & Aronson, 1995?).

Most broadly, we think it is worthwhile to note that the mind is adaptive. Humans and other animals inevitably face situations in which sustained cognitive effort does not lead to success. Although we see clear evidence for subsequent deficits in these situations, we also see evidence that thinking does not turn off or become chaotic. Any consideration of deficits (in depression and other psychopathologies, helplessness, aging, and the like) should simultaneously consider what functions are preserved. Generally

**Summary and Conclusion**

Building on the foundation of early learned helplessness work that pointed to the importance of similarities in the cognitive deficits in helplessness and depression, we here presented several studies aimed at identifying what it
Speaking, our minds appear to move to a backup “Plan B” in which simple, but sustainable, strategies are employed to allow at least some level of performance in even quite difficult cognitive circumstances. Understanding what is lost and what is retained will enhance both basic understanding of the mind and behavior, and will also suggest compensatory strategies and interventions that may be helpful to individuals in these conditions.

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References


SECTION III
ATTENTION, INHIBITION, AND REASONING PROCESSES