The Influence of Effort on Impairments of Attention Associated with Major Affective Disorders

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Ilan Lohr

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ILAN LOHR, M.Ed., M.A.

For my parents, Simcha (of blessed memory) & Tova Lohr, who gave me their unconditional support from miles away, and patiently anticipated my successful completion of this project.

ABSTRACT

That neuropsychological performance is impaired in patients with affective disorders is now widely accepted, and there is growing evidence that attentional dysfunction (effortful attention in particular) is one of the major impairments normally observed. The present study aimed at defining the nature of attentional dysfunction in depression by means of tests designed to measure specific aspects of attention, such as sustained, selective, focused, divided attention, etc. We also tested the effect of increasing effortful attentional demands on subjects' performance. To that end, effort level was increased on the task variable that was considered to be the defining characteristic of each task. For example, the Stroop Color-Word is a test of perceptual interference, so that on the high effort condition we presented two types of interference - visual as well as auditory (recorded messages). Fourteen unipolar and thirteen bipolar patients were recruited from the inpatient psychiatry unit at the University of Massachusetts Medical Center, based on DSM-III criteria and score on the Inventory to Diagnose Depression (IDD). An age and education matched control group (N=20) was recruited from hospital workers. Subjects were administered a battery of twenty neuropsychological tests, including: Computerized Stroop Test, Continuous Performance Test, Trail Making, Symbol-Digit Modalities Test, Finger Tapping & Controlled Word Generation, Visual Letter Search, Digit Span, and a Levels of Processing Memory task. For each of these tasks, a low and high effort levels were employed. Subjects filled out two self-report scales, Fatigue Assessment Inventory and Profile of Mood States, before and after testing.

Both unipolar and bipolar patients exhibited severe depression as measured by the IDD. ANOVA procedures indicated that on most measures patients performed significantly poorly when compared to normal controls ($p<.0001$), except for the Visual Letter Search. With respect to the dimension of effort, all subjects performed more poorly on high effort task demands ($p<. 001$). Interaction of effort by diagnosis was statistically significant for the following tasks: Stroop error rate, Trail Making, Symbol Coding, and Concurrent Response Production, indicating greater decrements in patients' performance relative to controls. While various attentional processes were affected, greatest impairments occurred on tasks requiring sustained and focused attention, under conditions of high effortful task demand. A discriminant function analysis showed that subjects were correctly classified to their respective groups with high accuracy level (85%).

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INTRODUCTION

Preface

Affective disorders are primarily defined as disorders of mood. However, there has been an increasing interest in the cognitive impairment associated with affective disorders within the past decade. Recent attempts to integrate theories of cognitive neuropsychology with the underlying brain mechanisms and functions have further contributed to this renewed interest in the field (Austin et al., 1992; Sweeney et al., 1989; Sackeim & Steif, 1988). Consistent with this trend, the objectives of the present study are to better understand the relationship between mood disorders and cognitive functioning and to delineate specific cognitive deficits in depression; to examine the concept of mental effort in relation to information processing within different aspects of mental functioning; and to relate these findings to a theoretical framework of attention (Cohen, 1994). A long-term objective is to facilitate the diagnosis and treatment of affective disorders as well as to stimulate additional research on neuropsychological functioning in affective disorders in particular and in mental disorders in general.

It is now widely accepted that patients with affective disorders manifest a variety of cognitive impairments, particularly with respect to attention, learning, memory and psychomotor functioning. Behavioral observations of hospitalized depressed patients reveal psychomotor retardation or agitation, energy loss, difficulties in learning new information, increased negative thinking, short attention span

and loss of motivation. Previous research on the neuropsychological abnormalities in depression examined a variety of cognitive functions such as audition, vision, pain, cognitive and motor speed, motor laterality, short-and long-term memory, attention as well as general intellectual functioning, providing some preliminary although sometimes conflicting evidence of cognitive deficits in these areas. Findings from these studies suggested that depressed patients show a reduction in auditory sensitivity (Bruder et al, 1975; 1980), prolonged recognition time for common objects (Friedman, 1964), reduced pain sensitivity (Hemphill, Hall, & Crookes, 1952), slowed motor performance (Friedman, 1964; Cornell, Suarez, & Brent, 1984; Raskin et al., 1982; Donnelly et al., 1982), reduced spontaneous activity (Wolff et al., 1985), and increased rates of left-handedness (Flor-Henry, 1979; although other studies showed no difference or even decreased rates in comparison with normals, Merrin, 1984; Fleminger, Dalton, & Standgae, 1977). Further, affective disorder patients have shown deficits in time estimation, and visuo-motor coordination, integration and accuracy (Raskin et al., 1982), deficits in sensory registration, short-term memory retention, long-term memory and semantic storage and retrieval failures as well as disturbances in the efficiency of information processing strategies (Kaszniak, 1986; Mayes, 1986; Weingartner et al., 1981). They also score lower on IQ tests (Payne, 1973; although some studies revealed no IQ differences between patients and normals, Donnelly et al., 1982), have decreased motivation (Cohen et al., 1982), and manifest severe problems in attention, vigilance and concentration (Byrne, 1977; Malone & Helmsley, 1977; Frith et al., 1983; Raskin, 1982).

Neuropsychological studies also indicate that although depressed patients can often successfully attend to information, remember, and perform logical operations under conditions of low information load, they cannot effectively coordinate the cognitive functions necessary for solving problems under more demanding processing conditions (Silberman, Weingartner, & Post, 1983). Many of the cognitive processes tested in the above mentioned studies require subjects to perform on some highly directed task, which involves considerable cognitive capacity, increased concentration and sustained cognitive effort. Sustained cognitive effort is necessary for tasks measuring attention, memory, concept formation, speed of processing, and related behaviors, and depressed patients seem highly sensitive to such conditions of increased effort. Consequently, it is believed that effortful processing plays an important role in affective disorders, magnifying the deficits that already exist.

The Construct of Depression

The term ***depression*** refers to a wide range of emotional and cognitive symptoms, ranging from normal to pathological. It may be viewed as a continuum, where in "normal depression" a person is typically unhappy due to some identifiable source of stress such as following the loss of a loved one, while in "clinical depression," the individual shows - in addition to depressed mood - serious sleep, eating, and psychomotor disturbances as well as mental distortions and feelings of despair and hopelessness, such as in psychotic depression. Depression may co-occur with other psychiatric disorders such as anxiety or psychosis or with medical conditions such as cardiovascular

diseases. It is also associated with eating disorders such as anorexia and with sleeping disturbances and hormonal abnormalities. It may occur once in a lifetime or in recurrent episodes, and commonly termed unipolar depression, Major Depression, or Major Depressive Episode. When depression is complemented by hyperactive, manic episodes it is referred to as Bipolar Depression or Bipolar Disorder. Whatever the manifestation of depression may be, a (significantly) lowered mood is the primary and central feature (Paykel, 1982). According to DSM-III (APA, 1980) depression is defined as a "dysphoric (chronic) feeling of illness and discontented mood and/or a pervasive loss of interest which is characterized by certain symptoms".

It is estimated that from 13 to 20 percent of the population have some depressive symptoms at any given time. The lifetime risk for a single episode of unipolar depression was found to be between 3 to 4 percent for men and from 5 to 9.3 percent for women. The prevalence of bipolar depression in both sexes was found to range from .65 to .88 percent in industrialized nations. At any given time, approximately 2 to 3 percent of the population in the Western world is hospitalized or seriously impaired by affective illness (Gold et al., 1988). Sartorius (1979) reported that each year at least 100 million people worldwide develop clinically recognizable depression, for which the number seems to be increasing. This figure corresponds to the worldwide figures from epidemiological studies which estimate the point-prevalence level between 2 and 4 percent (Katz, 1980). A number of reasons may account for the apparent increase in the prevalence of depression. These include increased life expectancy and a greater risk for age-

related depression; increased morbidity from neurological, cardiovascular, and cerebrovascular diseases which are associated with depression; the rapidly and stressfully changing psychosocial environments and family structure; the stresses of urbanization; and the frequent use of modern medications which induce depressive states (Katz, 1980). Yet, the incidence of depression may not really be increasing, but rather depression is more easily detected today by means of newer and more sensitive assessment methods.

Genetic studies have provided clear evidence that depression is biologically linked. Twin studies have shown that about 65 percent of monozygotic (MZ) twins are concordant for the illness while about 14 percent of dizygotic (DZ) twins are concordant (Nurnberger & Gershon, 1982). Similarly, Danish twin studies have indicated a 0.67 concordance for MZ twins as compared to 0.20 for DZ twins. Further, concordance was higher for bipolar MZ probands (0.79) than for unipolar MZ probands (0.54), while DZ rates were 0.24 and 0.19 respectively (Bertelsen, 1977). The highly significant difference between MZ and DZ supports the argument of heritability in depression as well as suggests some genetic specificity for polarity. Additional studies show consistently that in patients with bipolar illness, the incidence of both bipolar illness (7-10%) and unipolar illness (8-10%) is much higher in first degree relatives than in the general population. First degree relatives of patients with unipolar illness have an increase only in the incidence of unipolar illness (14-18%). A few adoption studies have shown a much higher risk for the occurrence of an affective disorder in biological parents (31 percent) versus adoptive parents (12 percent) of adopted children.

Gold et al. (1988) reports that the heritability of depression was recently established when two RFLP's (variations in the electrophoretic pattern of DNA fragments produced after DNA has been digested by enzymes) on the short arm of chromosome 11 were found in 63 percent of subjects (all members of an Older Order Amish pedigree spanning three generations) with major affective disorder. Such a genomic defect was found in bipolar, unipolar and schizoaffective subjects, suggesting similar underlying genetic bases for these closely related disorders. Moreover, one of the genes located within the defective area on chromosome 11 is responsible for coding an enzyme (tyrosine hydroxylase) involved in catecholamine synthesis. The neurotransmitter norepinephrine, one of the catecholamines, was indeed found to be involved in depression and antidepressant drug action. Gold et al. suggest that the presence of a dominant gene with incomplete penetrance, predisposing environment, other genetic factors, or different combinations of these factors, are necessary for the illness to be expressed. However, it is still possible that a non-genetic biological factor, such as a virus, may stimulate the role of a gene product and induce depression. Other biological explanations of depression rely on the fact that patients show reduced levels of glucose consumption by the brain as seen on PET scans, and researchers hypothesize about a possible dysfunction of pleasure centers in the brain as well as kindling of limbic structures which increases the likelihood for repeated episodes.

Other theories of depression emphasize different aspects of depression. The psychoanalytic theory claims that a disturbed relationship with the primary care giver or a real or imagined

loss of a parent provoke anger and anxiety which are repressed to the unconscious. Subsequent losses trigger such feelings, and the person may try to reduce the anxiety created by identifying with the lost person and turn the feelings of anger and resentment inwards as self-blame and self-hate. According to Behavior theory, depression results from lack of positive reinforcement and deficiency in social skills which lead to learned helplessness due to the fact that such people rely on others for emotional support which is not very easily obtainable. The cognitive theory of depression suggests that it is a learned behavior, while emphasizing thought processes. People develop negative self-concept as children or adolescents accompanied by feelings of incompetence and unworthiness which are maintained by illogical and distorted interpretation of the situation. Depressive patients perceive and recall more negative information, they engage in overgeneralization, magnification of difficulties and failures they encounter and minimization of their successes and accomplishments. Finally, the humanistic approach claims that depression results from a big discrepancy between the real, ideal and public selves. The individual feels inadequate when his real self does not meet the expectations of the ideal self as well as feels incapable of becoming a fully functioning person. Whichever perspective one may hold, it is obvious that depression is manifested by a range of emotional, cognitive, and behavioral deficits, and distorted self-perceptions.

Attention and Information Processing

An approach to studying the role of effort on cognitive impairment in depression that we used in this study comes from information processing theory. The cognitive system is viewed as dealing with the "flow of information" through the person from its initial encoding to storage and retrieval of information. According to this theory, information processing begins with the sensory registration of information as it enters the system through one or more of the five senses. The information can stay in the sensory register for a brief time and unless attended to it will decay. Information that has been recognized and attended to will be passed on and briefly stored in short-term memory for further analysis. Through rehearsal the information is kept active in short-term memory and finally it is sent into long-term memory for deeper analysis and storage. In order to access information stored in memory, retrieval processes such as searching and locating information are employed by the system for recognition or recall. Thus, recognizing a stimulus, attending to a stimulus, rehearsing or retrieving information are processes that embody the flow of information in the system and may vary from one stimulus to another. Further, these processes are affected by the capacity limit of the system, which can be otherwise flooded by information that continuously impinges on our senses. Whether the flow of information is described in terms of stages (Atkinson & Shiffrin, 1968) or levels of processing (Craik & Lockhart, 1972), it can be argued that cognitive operations differ in the amount of attentional capacity they require. This leads to Kahneman's (1973) suggestion that earlier stages of information processing such as

sensory analysis of registered information require very little attention whereas later stages, particularly those that are closer to the response end of the information processing system, require greater attention. Cognitive operations that require minimal attention are referred to as "automatic" while those that require considerable attentional capacity are referred to as "effortful" (Kahneman, 1973), "conscious" (Posner & Snyder, 1975), "deployable" (LaBerge, 1976), or "controlled" (Schneider & Shiffrin, 1977). This dissociation has been shown to operate also in perceptual learning (LaBerge & Samuels, 1974; Shiffrin & Schneider, 1977) and memory (Hirst & Volpe, 1984). Yet, Hasher and Zacks (1979) suggest that automatic versus effortful operations should not be regarded as dichotic processes but rather they represent a continuum of attentional requirements among encoding processes. Further, they claim, in line with Kahneman's theory, that attentional capacity varies both within and among individuals and that it interacts with encoding demands as well.

The automatic-control processing theory assumes that automatic and control processing are qualitatively different processes with different attentional requirements. Automatic processing is a fast, parallel, fairly effortless process that is not limited by short-term memory capacity, is not under conscious control, and is involved in the execution of skilled behaviors. It develops through the processing of stimuli consistently over many trials. In contrast, controlled processing is a relatively slow, effortful, generally serial, capacity-limited, and subject-regulated processing mode that typically deals with novel or inconsistent information (Schneider, Dumais & Shiffrin, 1984). Further, the theory assumes that attentional capacity limitations

are the result of competition between control processes. That is, combining tasks in which control capacity is exceeded would result in reduced performance, since controlled processing resources are severely limited. In contrast, several automatic processes can occur in parallel without decrease in performance while not being limited by control processing resources. This does not imply that automatic processes have no capacity limits, since an increase in the number of stimuli processed automatically in one modality may cause interference, resulting in decreased performance. Also, even though practice can reduce resource requirements in automatic processing, it does not affect controlled processing.

The distinction between automatic and controlled processing can be also described in terms of their attentional requirements, since tasks that are performed automatically generally require less attentional effort. Further, automatic operations may become more effortful and require controlled attention, depending on momentary task demands (i.e., driving a car when road conditions worsen). Consequently, effort can be differentially evident based on the functional attentional component that it requires. Defining effort in terms of attentional components is not an easy task since the construct of attention has been studied by researchers from different fields and orientations. A variety of models have been suggested, describing the significant functional components that operate in the control of attention and selection. For example, Posner and Bois (1971) proposed three functional components of attention, including alertness, selection, and limited processing capacity. They also made a distinction between early selection in attention, where processing has unlimited capacity, and late

selection, where the capacity is limited due to the conscious attention used for the analysis of a stimulus set. Kahneman (1973) made a distinction between voluntary attention, where effort is invested in current activities, plans or intentions, and involuntary attention, where effort is invested in activities related to more enduring dispositions and stimulus properties. Pribram and McGuiness (1975) identified three systems with underlying neural mechanisms responsible for the control of attention, including phasic arousal, tonic activation or readiness, and effort, the coordination of arousal and activation.

Several ways can be used to operationalize effort in accordance with Kahneman's and Hasher and Zack's conceptualizations of effort, some of which were applied in the present study. At the organismic/bodily level, effort can be defined (and indirectly measured) in terms of: 1) Physiological arousal (measured by evoked potentials). 2) Speed of cognitive processing (can be measured by reaction time). 3) Internal motivation to perform on a given task (can be measured by a motivation inventory). 4) Self-rating effort inventory (the individual's self-estimation of effort expenditure on each task). Obviously, a useful organismic measure of cognitive effort must be sensitive to both between task and within task variations as well as reflect between subject differences. Organismic variables are dependent by their nature and can be manipulated by environmental, independent variables, which represent the second level of effort operationalization. At the environmental level, effort can be defined in terms of the demands/requirements of the task imposed on the organism. These include: 1) Temporal variables of a task: a). Interstimulus interval, for series of stimuli; b). Response time c). overall

performance time (time pressure). 2) Degree of difficulty or complexity of a task (i.e., easy vs. difficult arithmetic problems). 3) Momentary effort (i.e., performing on two tasks simultaneously exerts more effort than on one task only). 4) Probability of failure in a task. 5) Incentive/reward (rewarded performance is more likely to increase the amount of effort invested in a task). In other words, time constraints of a task may, for example, limit the sensory registration of information and its retention in short-term memory and therefore exert more effort. Tasks that present greater difficulty such as adding two numbers versus calculating the square root of a number would require more effort. Likewise, tasks that require the utilization of a greater number of controlled operations may limit the attentional capacity allocated to the processing of information (i.e., focusing on one source of information while actively ignoring another). When the probability to make errors on a task increases more effort is required to produce correct responses. And finally, tasks that are boring, unstimulating or that present no reward may affect subject's motivation to perform well. Such measures of effort, both internal and external, were used under the effortful conditions in most of the tasks that we specifically modified for the present study.

In summary, the information-processing framework provides a potentially useful approach to the study of human performance in affective disorders. By using this approach it may be possible to determine the stage of information processing disrupted in patient's performance, whether preliminary (registration of information) or advanced (elaboration and response production). When attention is considered within the information-processing framework, it may

be possible to determine specific attentional components that are disrupted by an affective disorder. Conversely, if attention is disrupted across all tasks, a general attentional dysfunction could be indicated.

Cognitive and Attentional Dysfunction in Depression

The distinction between effortful and automatic processing of information has been used to conceptualize strategies for defining the cognitive impairments in depression. For example, Roy-Byrne et al. (1986), Weingartner et al. (1981), and Cohen et al. (1982) compared depressed patients' performance on automatic processing with their effortful processing of a task. Although findings were not uniform, these studies suggest that cognitive functioning in depression is affected by the amount of effort required to perform on a task, where greater effort will result in reduced cognitive processing in depressed patients. Other studies, as reviewed hereby, have used the levels-of-processing paradigm or a classical neuropsychological approach to study cognitive and attentional deficits in depression. Since such methods offer a general framework under which cognitive deficits in depression are typically assessed, they were adopted in our study. Therefore, the following review is a representative sample of studies from the vast literature on cognitive deficits in depression.

In an early study conducted by Friedman (1964) a large number (33) of cognitive, perceptual, and psychomotor tests were given to 55 depressives and 65 matched normal subjects in order to contrast the minimal effects of severe depression with patients' cognitive functioning, affective responsivity and self-

perception. The depressive group included only diagnostically "pure" cases of psychotic or borderline psychotic depression, manic-depressive psychosis, depressed phase, agitated depression and involutional psychosis. The depressive group was found impaired on a number of specific psychological functions such as: short-term memory or capacity for sustained attention, as measured by the Easy and Hard Associates tests and on the reproduction of the Graham-Kendall designs from memory (both at .05 significance level); psychomotor speed and visual-motor coordination, as measured by the WAIS Digit Symbol test ($p<.05$) and reaction time to a light signal ($p<.01$); shift of mental set and flexibility, rather than perserveration or rigidity, as measured by the Shift test and the number of Necker Cube reversals reported in a 20-second interval (both $p<.05$); orienting behavior, as measured again by Reaction Time test and on the recognition time of a tachistoscopically presented common object, a chair (both $p<.01$); and on binocular far acuity of vision on the Orthorater ($p<.01$). Further, significant differences were found on 63 items of the Clyde Mood Scale ($p<.01$), on which patients described themselves more lonely, helpless, worried, frustrated, slow etc. and less cheerful, pleased, active, happy, lively, etc. to name just a few of the items. In addition, patients were asked to evaluate their own performance on a number of tests on a 5-point rating scale (from "very good" to "very poor"), however, no relationship was found between these ratings and their actual performance, suggesting that they are quite unreliable in assessing their own abilities. Since the depressives performed more poorly on only 4% of the test scores (at $p<.01$) while rating themselves more negatively on 82% of the 77 Clyde Mood Scale, the author