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Worry: A Cognitive Phenomenon Intimately Linked to Affective, Physiological, and Interpersonal Behavioral Processes

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Abstract

Research on worry during the past 15 years has revealed a remarkable amount of knowledge about this pervasive human phenomenon. Worry involves a predominance of verbal thought activity, functions as a type of cognitive avoidance, and inhibits emotional processing. Worry also produces not only anxious experience but depressive affect as well. Recent evidence suggests that the very private experience of worry is developmentally connected to enmeshed childhood relationships with the primary caregiver and is currently associated with significant interpersonal problems, especially those involving tendency to be overly nurturing to others. At the physiological level, worry is characterized peripherally by parasympathetic deficiency and autonomic rigidity and centrally by left-frontal activation.

Keywords: worry; anxiety; cognition; emotional processing; childhood development; physiology.

INTRODUCTION

Worry is a common human experience. Everyone worries every once in a while. When it becomes excessive, uncontrollable, and chronically present, however, the constant discomfort, disruption, and loss of joy in life can become intolerable and may result in a condition known diagnostically as generalized anxiety disorder (GAD) whose central characteristic is chronic worry [see *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.), abbreviated DSM-IV; American Psychiatric Association, 1994].

Despite the commonplace nature of worry, systematic investigation devoted to understanding the phenomenon did not begin until the early 1980s. Prior to that time, most of the available research came from the test anxiety literature, wherein the distinction was made between the cognitive (or worry) components of anxiety and its emotional (or physiological) components. Significantly, correlational studies indicated that it was the former, and not the latter, elements that predicted poor test performance and low grade point average (cf. Deffenbacher, 1980; Hembree, 1988; Seipp, 1991). Our own research group became interested in worry as a consequence of earlier research on insomnia and its treatment that found relationships similar to those determined for test anxiety. A series of investigations ultimately led to the conclusion that many psychologically based insomnias were caused, not by peripheral physiological hyperactivity as had been previously supposed (Monroe, 1967), but by intrusive cognitive activity at bedtime (cf. Borkovec, 1979). A significant portion of that cognitive activity seemed to be best described as worrying, and not surprisingly the topic about which insomniacs most often worried was whether or not they would be able to get to sleep that night.

Since the early 1980s, research on worry has grown considerably, and a great deal has been learned about its nature, functions, consequences, and origins. There is one remarkable feature associated with this area of investigation that is worthy of comment, a feature likely due to its relative newcomer status in the scientific domain. Increasingly in recent years, psychology has been viewing human beings are nonlinear dynamical systems involving the moment-to-moment interactions among multiple levels of responding (e.g., attentional, conceptual, imaginal, affective, physiological, and behavioral) to constantly changing environments. What we think affects how we feel, what we feel affects how we think, how we think and feel affect how we behave, how we behave affects how we feel, etc. Thus, although it is often necessary to go deeply into the investigation of particular systems (as often seen in cognitive psychology, psychology of emotions, and psychophysiology) to learn intimate things about their operation, eventually we will need to

return to the whole individual, realizing that everything connects to everything else. Research has found that worry is associated with distinctive characteristics in each of these various systems. Thus, continued investigation of worry can potentially tell a great deal us about the mutually interactive influences of these processes in human beings.

The present article has two, related goals. First, we wish to describe those distinctive processes in various response systems that are characteristic of worry and that may make up the elements of a dynamical relationship that possibly underlies its occurrence. Second, we will attempt to show how these interactive elements may contribute to the maintenance, persistence, and even strengthening of this distressing activity.

THE NATURE AND FUNCTIONS OF WORRY: PREDOMINANCE OF THOUGHT, COGNITIVE AVOIDANCE, AND THE INHIBITION OF EMOTIONAL PROCESSING

Descriptively, worry involves a predominance of negatively valenced verbal thought activity. When we worry, we are talking to ourselves a lot about negative things, most often about negative events that we are afraid might happen in the future. Imagery is less noticed in worry. The first demonstration of this dominance of thought came from comparisons of mental samples obtained from GAD clients and control participants during self-relaxation and worry induction periods (Borkovec & Inz, 1990). Nonanxious people reported mostly positive imagery and little thought during relaxation, whereas GAD clients reported equal amounts of thoughts and images, both of which were negative in emotional tone. When asked to worry about a current concern, a shift to a marked predominance of negative thought over images occurred for both groups. Importantly, successful therapy changed the clients' thought/imagery ratios; they were no longer different from those of nonanxious people.

The distinction between the two cognitive phenomena of thought and imagery is of crucial functional importance for understanding their respective roles in emotional disturbance and its treatment. Verbal thoughts about emotional material elicit very little cardiovascular response, whereas images of the same material evoke significantly greater response (Vrana, Cuthbert, & Lang, 1986). Moreover, people spontaneously use verbalization as a strategy for abstraction, disengagement, and emotion control that can decrease sympathetic arousal to aversive material (Tucker & Newman, 1981). The abstract conceptual system, including the verbal system, is therefore less closely connected to efferent command into affective, physiological, and behavioral systems than images are.

The relative isolation of the verbal system is evolutionarily significant, because it gives

humans a capability to inhibit responding, to search memory, and to experiment in the mind with different possible responses without immediate environmental consequence. If every thought we ever had was immediately expressed, successful adaptation (especially interpersonal) would be very difficult, and environmental and social punishment would be frequent. So having a thought system that is somewhat remote from other systems is adaptive. However, this feature has a potential negative consequence for any emotional disorder that is characterized by thought predominance. It means that emotional processing will be inhibited, and thus negative emotional meaning and emotional disturbance will be maintained. As Foa and Kozak (1986) have argued, for repeated exposures to phobic stimuli to be therapeutic, it is necessary that complete emotional processing of fear-related material occur. Absence of physiological response during the presentation of emotional material is taken as evidence that the entire fear structure stored in memory has not been accessed and that extinction will therefore not take place. We have to confront not only feared situations to overcome our fear of them, but we also have to feel the fear during the confrontations. Interestingly, Mowrer's (1947) two-stage theory of anxiety, upon which so much of modern behavior therapy was based in its development of therapeutic exposure techniques, explicitly stated that the conditioned response is part of the conditioned stimulus. Exposure to the response-produced cues of the conditioned response is therefore an important element of extinction process. If, then, worry is predominantly thought and if thought is a poor vehicle for processing emotional information for the sake of changing emotional meanings, then worrisome ways of dealing with emotional material may actively inhibit emotional processing and create maintaining conditions for emotional disturbance. In this functional way, worry may be a type of cognitive avoidance to perceived dangers.

If worry partly functions as a cognitive avoidance response to threatening stimuli, what might worry be trying to avoid? There may be several functional levels to this question.

Worry Suppresses Somatic Anxiety

At a short-term level, we do know that worry suppresses cardiovascular response to threatening images. Speech-anxious participants who engage in worrisome thinking just prior to phobic image presentations show no cardiovascular response at all to the images. On the other hand, participants who think relaxing thoughts or neutral thoughts do show significant heart rate reactions to the images, with the relaxation condition showing signs of extinction during repeated exposures (Borkovec & Hu, 1990). Furthermore, the amount of thinking taking place during worry predicts the extent to which such physiological responses are muted (Borkovec, Lyonfields, Wiser, & Diehl,

1993). "Cogito, ergo I can suppress affect." If worry as an avoidance response does immediately suppress somatic/affective aspects of anxious experience, it may thereby be negatively reinforced.

At this point, how worry provides this suppression is speculative. It may involve the actual suppression of aversive images, but this seems unlikely. Worry may well prime catastrophic images so that they happen at an increased frequency during a worrisome episode. It is more likely that worrisome thinking is the immediate cognitive avoidance response to such images when they do occur. The demonstrated suppressive effects of worry on somatic anxiety could also be due to the fact that worry uses up significant amounts of attentional resource (Mathews, 1990), is difficult to shift away from (Parkinson & Rachman, 1981), insulates its thoughts from affective meaning through the semantic satiation inherent in its repetitive verbal activity (Smith, 1984), and creates less mismatch between information expected and • information received (Gray, 1982).

One recent finding may represent a further key for understanding how worry affects imagery: Worrisome thought is characterized by reduced concreteness. Research conducted within the framework of the dual-coding theory (Paivio, 1986) has demonstrated that generating images from abstract (as compared to concrete) words and sentences requires greater time and produces images that are more abstract and less vivid. Whether abstract or concrete, however, verbal thoughts and images are always processed integratively (Paivio & Marschark, 1991). Thus, if worry involves thought, it can still prime catastrophic images. Yet, if worrisome thought is abstract, the associated imagery will be less vivid and therefore less intrusive and attention-grabbing. Being of reduced concreteness, worrisome thought would not suppress imagery but would merely activate images that are less concrete and vivid. This reasoning would also explain why research participants have reported lessened imagery after the experimental induction of worry (Borkovec & Inz, 1990); it is harder to detect or easier to ignore. In sum, worriers may escape fearful imagery by focusing on the verbal channel while thinking about the future in more abstract terms, e.g., "something awful will happen," with few concrete details.

In support of this line of reasoning, Stöber (1997) has demonstrated that worrisome thought is indeed less concrete. Participants in these studies selected topics about which they did and did not worry and then elaborated on the problems present in these topics by listing possible risks and negative consequences. For example, job loss could be a risk for a financial worry, and moving into a smaller apartment could be one of its negative consequences. All answers were rated for concreteness and imagery by independent judges. Elaborations on worry topics were found to be of lower concrete ness and lessened imagery quality than for nonworry topics. Moreover, the more

participants worried about the topic, the less concrete and imagery-eliciting were the associated problem elaborations. This outcome suggests that, in response to initial aversive images, worry might mitigate the vividness of further negative images and thereby mute physiological reaction to their occurrence.

Regardless of how the suppression of affect occurs, the most significant consequence for worry's avoidant function and preclusion of emotional processing is that anxious meanings are maintained. Worry is in this way no different from Mowrer's (1947) behavioral avoidance of phobic stimuli in its functions and consequences: Despite creating conditions that restrict the individual's life and/or generate other kinds of disturbance, s/he can reduce some distressing experiences by avoiding their source. As in Mowrer's theory, however, maintenance of fear is the consequence.

It has also been found that worry that precedes exposures to actual (instead of imaginal) phobic events generates a somewhat different process that results all the same in a similar perseveration of anxious meanings. Although worry just prior to actual speech presentations does not inhibit the cardiovascular response of speech phobics, subjective anxiety increases upon repetitious exposures (Hazlett-Stevens, 1997b). Speech phobics who relax or engaged in neutral activity prior to each exposure, on the other hand, show declines in anxious experience. Moreover, worrying just after exposure to a stressor increases cognitive intrusions about the stressor over the subsequent three days, whereas imaginal rehearsals of the stressor or merely neutral conditions just after the stress event do not generate such intrusions (Butler, Wells, & Dewick, 1995). Thus, worry before or after emotional events precludes adaptive processing of the material and contributes to a maintenance or even an increase in the emotional disturbance generated by those events.

Worry as an Attempt to Avoid Negative Events or to Prepare for the Worst

At a second, more long-term level of identifying the source of worry's cognitive avoidance function, people do attribute avoidant functions to their worrying, and there may be good reasons for these attributions. The highest rated reasons for worrying given by both GAD and nonanxious individuals are that (a) it helps them discover ways of avoiding negative future events and (b) it prepares them for the worst if they cannot avoid it (Borkovec & Roemer, 1995). Eysenck (1992) has presented a cognitive model of worry process that captures these phenomena. In his model, worry had three major functions: alarm, prompt, and preparation. Upon external or internal detection of threat, the alarm function introduces information about the threat into awareness. The prompt function then brings threat-related thoughts and images from long-term memory into conscious awareness. The preparation function finally permits the individual to anticipate negative scenarios

of the future (catastrophizing). This function allows him/her to initiate anticipatory coping either by acting to prevent the anticipated negative developments (prevention) or by preparing for the expected negative consequences (anticipatory coping). Eysenck conceded that the evidence for the third function is rather inconsistent. However, the findings that worry is associated with problem elaborations of reduced concreteness (Stöber, 1997) may provide a basis for it. When forming internal task models and action plans for prevention and preparation, concreteness is a crucial variable (Schönpflug, 1989). Abstract models are unlikely to lead to concrete actions. Worry, characterized by low concreteness, is unlikely to provide a solid basis for the implementation of concrete steps for coping with the problem. Without the selection of an appropriate coping strategy, the threat is preserved, and worry continues.

Still, it is understandable that worriers may think that worry involves anticipatory problem solving when one considers the situation commonly faced by someone in the midst of a worrisome episode. S/he is detecting threat cues that warn of some possible future catastrophe. Detection of threat naturally generates a primitive fight-or-flight response. Because the threat refers to a nonexistent future and is frequently about events that cannot be controlled and are not going to happen anyway (cf. Borkovec & Newman, in press), there is no one to fight and no where to flee. The threat still exists in the person's mind, and s/he therefore remains convinced that it must be avoided. In this circumstance, mentally trying to determine how to avoid the threat or to prepare for its occurrence remains as one of the few coping responses available.

A final way in which worry may function as avoidance at this long-term level is found in the superstitious reinforcement paradigm inherent in its occurrence. Because very few things about which people worry actually turn out bad, the majority of worry is eventually negatively reinforced by the nonoccurrence of the feared events. This environmental contingency may well be the foundation for reports by people that they worry because it feels as if the worrying makes the occurrence of the feared event less likely, even though they admit that no logical connection exists (Borkovec & Roemer, 1995).

Although rather straightforward applications of Mowrer's two-stage learning theory of fear and avoidance and negative reinforcement principles underlying superstitious behavior can provide an understandable basis for the origins and maintaining conditions of worry, cognitive processes at higher levels can eventually become functionally implicated. If chronic worriers come to believe that worry somehow has positive consequences, prevents bad things from happening, prepares them for the worst, or is a major distressing problem in and of itself, such underlying beliefs can

contribute further to the maintenance of worrisome process. Wells (1995) in particular has discussed the potential role of such "meta-worry" in changing normal worries into the kind of excessive and uncontrollable worry characteristic of generalized anxiety disorder.

Worry as a Distraction from More Emotionally Laden Topics

At a third level, it may be that people, especially for severe GAD individuals, worry about superficial things that serve to distract them from the real problem. In a certain sense, such a function appears to be inherent to any anxiety problem from the point of view of cognitive behavioral therapy. Its theoretical context suggests that moment-to-moment self-talk is merely a reflection of deeper belief structures and that what people report about what it is that they fear is really somewhat remote from the underlying fear. Thus it is that decatastrophizing method is used in an effort to help the client identify what that deeper fear might be. For example, a person who is afraid of giving speeches likely has brief thoughts and images that indicate possible poor performance and negative reactions by the audience. But such cognitions are negative only to the extent that they are associated with the potential for the occurrence of even more significant negative events that might follow from these. It is not so much another's negative evaluation that is feared but rather what might happen because of that evaluation (e.g., abandonment, being fired from a job). And each of these underlying fears may have deeper layers of catastrophe that drive their significance (e.g., loss of job might mean inability to care for oneself or family). We do know that worriers have much richer associative networks in this regard: They generate significantly more decatastrophization steps that do nonworriers (Vasey & Borkovec, 1992). But in daily life, people are largely aware only of the more surface fears and rarely access thoughts about what the bottom-line catastrophe actually might be.

GAD individuals also differ from nonanxious people on only one item among the above-mentioned rating scales regarding reasons for worrying: "Worrying about most of the things I worry about is a way to distract myself from worrying about even more emotional things, things that I don't want to think about." No direct evidence exists to support the validity of this report. However, if it is a valid observation, then other research has provided clues about what these underlying problems might be. First, GAD clients report the historical occurrence of more frequent traumas than do nonanxious people, yet they worry less about illness/death/injury themes than any other topic category (Roemer, Molina, & Borkovec, 1997; Roemer, Molina, Litz, & Borkovec, 1997). So the worries that they now have may have originated from actual traumatic events that provided evidence that dangers exist in the world (and thus they need to anticipate other future

dangers) and may at the same time provide distraction from the even more emotionally disturbing events of their past. The second possible source of worry resides in the problematic relationships that GAD clients have had in the past and continue to have in their present interpersonal relationships (discussed later). In either of case, worrying about other things allows avoidance of the more threatening material.

WORRY, HIGHER-ORDER CONDITIONING, AND THE SPREADING OF ANXIOUS MEANINGS

The negative reinforcement of worrisome activity described above in its various versions would provide one mechanism for the strengthening of the activity and thus contribute to the maintenance of both the worrying itself and the anxious meanings associated with its topics. Another potential mechanism that contributes to further elaborations of anxious meaning was revealed in a laboratory investigation of higher-order conditioning among GAD clients and matched control participants (Thayer & Borkovec, 1995). In this procedure, one type of conditional stimulus preceded the presentation of neutral words, whereas a different type of conditional stimulus preceded the presentation of threatening words. Controls displayed habituation of the cardiovascular orienting response over all trials, but GAD clients did not. GAD clients showed defensive responses to threat words but not to nonthreat words, whereas controls had no defensive response to any word stimulus. Most significantly, GAD clients developed an orienting response to the conditional stimuli associated with the threat words. Thus, aversive words can yield classically conditioned attentional responses to previously neutral stimuli. This suggests that, as GAD clients engage in their constant negative internal dialogue, there are conditioning processes taking place that can be reasonably viewed as partly responsible for the development of their characteristic hypervigilance for threat and for the generalization of threatening cues.

WORRY AND OTHER INFORMATION PROCESSING TASKS

The past decade and a half has also given rise to a considerable amount of research on GAD and/or worry as they relate to other information processing phenomena. Much of this literature has been reviewed by Mathews (1990) and Mathews and MacLeod (1994). For example, GAD clients interpret ambiguous information in a negative way, and they predict greater likelihood of negative events happening in their futures. GAD clients also more rapidly identify and react to threat cues in their environments than nonanxious people, and they are not aware that they are doing so. Despite such identifications, they do not explicitly recall the threat stimuli seen, but implicit memory for the threats is enhanced. Thus, once again, we see in these memory results the avoidant properties of

worrisome activity. Most of the studies documenting memory effects such as these have used very brief exposures to threatening stimuli and/or active response requirements. Our own work has found the opposite effects in the above-mentioned higher-order conditioning study, wherein lengthy (8-s) exposures to the threat words and passive observation of them without a response requirement resulted in significantly greater explicit recall of the threat words than the nonthreat words for GAD clients than for their matched controls.

The constant negatively valenced content of their cognitions and their attentional and interpretive biases toward threat suggest a kind of affective and cognitive inflexibility in GAD and worry. Further support for such rigidity has been found in two recent studies directly aimed at cognitive flexibility: GAD clients report lower levels of cognitive flexibility on a questionnaire designed to measure this construct (Hazlett-Stevens, 1997a), and worry induces lowered variability of topics mentioned in stream of consciousness reports compared to streams obtained during rest periods (Molina, Borkovec, Peasely, & Person, 1998).

Finally, worry has been demonstrated to affect decision-making speed (Metzger, Miller, Cohen, Sofka, & Borkovec, 1990). Chronic worriers take longer than nonworriers to decide whether a geometric stimulus does or does not match a training stimulus, increasingly so as the ambiguity of the test stimuli increases. This effect appears to be caused by worry: Nonworriers who worry for a few minutes before engaging in the task show the same effect. Also of interest is the fact that a relaxation induction preceding the task causes a normalization of the reaction times of chronic worriers. The delayed decision making associated with worry in this study has its more molar clinical representation in the frequent procrastination reported by our GAD clients in therapy. Such procrastination appears to be due to their fear of failure and its underlying social evaluative concerns. A recent study supported the intimate relationship between worry, procrastination, and evaluative concerns (Joormann & Stöber, 1997). High worriers reported more procrastination and higher perfectionism. Analyses of the individual dimensions of perfectionism (Frost, Marten, Lahart, & Rosenblate, 1990) showed that the correlation between worry and perfectionism was not due to higher personal standards but rather to increased concerns about mistakes and doubts about actions. Moreover, partial correlations indicated that these characteristics were specific for worriers: When controlling for anxiety and depression, the correlations with worry were hardly attenuated. When controlling for worry, however, the previously significant correlations of anxiety and depression with procrastination and perfectionism dropped to values around zero.

WORRY AND DEPRESSION

As is obvious from the review thus far, much of the worry literature has focused on its role in anxiety and anxiety disorders. Its inhibition of emotional processing may well be relevant, however, to any emotional problem wherein emotional processing is a necessary therapeutic event. That is, worry may maintain other emotional disorders, like panic disorder and obsessive compulsive disorder; its presence may maintain or strengthen the anxious meanings characteristic of these disorders and preclude therapeutic change during exposures to relevant fear stimuli.

It appears that worry may also play a role in depression. Nolen-Hoeksema's (1996) research suggests that depressive rumination, which maybe similar in process and content to the worrisome thinking studied in GAD, is a factor that can maintain the depressive state. Moreover, laboratory inductions of worry with normal participants elicit both anxiety and depression in nearly equal amounts (Andrews & Borkovec, 1988). This finding raises some interesting possibilities. It may be that the study of worry can contribute to our understanding of the frequent coincidence of anxious and depressed states. For example, the content of worry may alternate between thoughts of future feared events (and thus generate anxiety) and thoughts of past negative events (and thus create depression). Additionally, a sense of hopelessness and hence depression may often occur in chronic worriers when they periodically realize that there is realistically nothing that can be done to avoid the many uncontrollable future events that they fear might happen. Irrespective of how worry can generate both anxiety and depression, the fact that it does suggests that it may be responsible for some instances of their co-occurrence.

Although the review thus far has identified the variety of ways in which worry may involve interactions among several types of cognitive and affective processes, it turns out that worry is not solely an intrapersonal process. Moment-to-moment interactions with the environment, specifically one's interpersonal world, appear to play a highly significant role in the origins and maintenance of worry and GAD.

WORRY AND INTERPERSONAL FACTORS

GAD has been found to be associated with a particular form of insecure childhood attachment, and this developmental precursor relates quite closely with the kinds of interpersonal difficulties that they experience in current interpersonal relationships. Cassidy (1995) found that GAD clients recalled a greater degree of role reversal and enmeshment with their primary caregivers. Thus, in childhood they had to take care of, and anticipate dangers for, not only themselves but also their parent(s). Such a history could reasonably lead to an adulthood wherein the world is viewed as a potentially dangerous place and one's ability to cope is constantly

questioned. Intriguingly, the majority of adult GAD clients also fall into the overly nurturing cluster (Pincus & Borkovec, 1994) on the Inventory of Interpersonal Problems (Horowitz, Rosenberg, & Bartholomew, 1993). So many individuals with GAD may have learned as youngsters that taking care of others is necessary in order to receive love and approval, and they continue to do this in adulthood. Unfortunately, their overnurturance actually results in lessened likelihood of having their interpersonal needs met; they are often seen by others as intrusive in their caring attempts.

PHYSIOLOGICAL CHARACTERISTICS OF WORRY AND GAD

GAD and worry also appear to be strongly link to a distinctive psychophysiology whose characteristics may provide the foundation for other associated attentional and interpersonal maladaptive processes. GAD individuals do not show the typical sympathetic activation in response to threat or challenge as do individuals with the other anxiety disorders. Instead, they show a reduction in the range of physiological variability, leading Hoehn-Saric and colleagues (Hoehn-Saric & McLeod, 1988; Hoehn-Saric, McLeod, & Zimmerli, 1989) to conclude that they are chronically in a state of sympathetic inhibition. Given that GAD clients are constantly detecting threat, yet that threat cannot be avoided because it exists only in their minds and only in the future, fight-or-flight reactions serve no useful purpose and can only be suppressed. Worrisome thinking is one way to provide that suppression. These individuals' restricted range of peripheral physiological variability appears to be due to a vagal (parasympathetic) deficiency. GAD clients display lower parasympathetic tone at rest than do nonanxious individuals, and an induced state of worry can phasically create a reduction in vagal tone (Lyonfields, Borkovec, & Thayer, 1995; Thayer, Friedman, & Borkovec, 1996). The importance of parasympathetic deficiency in GAD becomes clearer when one considers other research that indicates that stronger vagal tone is significantly related to more adaptive attentional deployment (Porges, 1992; Richards, 1987).

There may also be important brain wave characteristics associated with GAD. Understanding central nervous system contributions to anxiety has been based largely on global connections made in research studying negative emotionality and neuroticism. However, the EEG literature on anxiety has unfortunately used too broad of a definition of anxiety, leading to a confusing electrocortical picture which lacks specificity. More recent speculation using the basic two-dimensional structure of emotion suggests that valence (positive and negative) and activation (or arousal) are reflected in different cortical areas [cf. Osgood, Suci, & Tannebaum (1957) for a discussion of the two-factor theory of emotionality]. Current speculation suggests the frontal system of the cortex is sensitive to valance, whereas the more parietal areas are associated with activation

[cf. Pribram (1981) for a discussion of arousal and activation]. In terms of valance, for example, Davidson (1992) suggested negative affectivity and avoidance are associated with a right frontal cortical involvement, whereas positivity and approach are associated with left frontal cortical involvement. Emotional involvement in these studies is indexed through relative frontal hemispheric EEG alpha. Others have emphasized parietal or temporal differences in the processing of emotional activity (e.g., Ray & Cole, 1985; Tucker, 1981). The literature further suggests a reciprocal relationship between frontal and parietal areas.

In an evaluation of current anxiety research, Heller and her colleagues (Heller, Etienne, & Miller, 1995; Heller, Nitschke, Etienne, & Miller, 1997) suggested that part of the lack of clarity lies with the field's undifferentiated approach to anxiety that ignores differences in anxious arousal (panic) and anxious apprehension (worry). That is to say, studies exploring situations which increase arousal may result in differential cortical activation than those focused on worry or GAD. At present, few electrocortical studies have examined the arousal dimension (like that found in panic disorder), whereas the anxious apprehension dimension has been more thoroughly explored. Previous work examining anxious apprehension (e.g., Carter, Johnson, & Borkovec, 1986; Heller et al., 1997; Tucker, Antes, Stenslie, & Barnhardt, 1978; Tyler & Tucker, 1982) has found a greater frontal asymmetry involving left hemispheric activity in anxious apprehension groups.

In a recent preliminary GAD study from our lab, we compared GAD clients prior to and following 14 sessions of therapy and with a control group. Comparing pre-therapy GAD and control individuals in each of the three tasks employed (baseline, relaxation, and worry) produced a picture of differential EEG activity between GAD and control individuals. It was found that GAD and control individuals both worry and relax in different ways, particularly in the EEG alpha bands (8 to 13 Hz). This finding was consistent with the suggestion that GAD individuals engage less in imagery processes, supporting the earlier demonstrations of greater verbal and less imaginal activity in worry and GAD. Also, consistent with previous research, GAD clients displayed more left frontal beta activity during the worry task, whereas controls showed more theta. These differences suggest that controls are able to focus on the worry task in a manner different from the GAD individuals. Further, the EEGs of GAD clients appeared more like controls during the post-therapy laboratory session than they did during the pre-therapy session; brain wave patterns had normalized.

Using an additional signal processing measure, that of coherence, i.e., the degree of shared activity between two signals, is mathematically similar to the correlation coefficient. The intriguing coherence picture that is emerging suggests that pre-therapy GAD clients show less cortical

inhibition (little time delay for the similar signal to appear throughout the cortex) in comparison to controls. Although additional research is required, these results may help to shed light on the finding that GAD is associated with pre attentive bias (e.g., shorter reactions times) and would suggest that GAD individuals have fewer inhibitory processes. Less cortical inhibition in our GAD group may help us to understand the excessive emotionality or thought processes seen in GAD. This finding is also consistent with speculation that the EEG seen in anxiety is driven by the limbic system in an undifferentiated manner. Following therapy, GAD clients showed more differentiated coherence patterns, particularly those representing longer distance connections, suggesting a return of inhibitory processes in the brain. Another potentially important coherence finding is that control and GAD groups showed differential directional patterns. For example, whereas control individuals displayed a pattern of EEG activity moving from more frontal areas of the brain to posterior areas, GAD clients showed the opposite directionality. This result suggests that controls have faster access to limbic system processes, whereas GAD clients delay such emotional influence on frontal lobe processes. Whatever the exact meaning of this directional differentiation between GAD and control groups, it is consistent with GAD individuals displaying less executive control of mental activities and may provide a basis for the uncontrollability of worry that is diagnostically characteristic of GAD.

In contrast to the traditional signal processing procedures which decompose (through Fourier analysis or a similar technique) the component frequencies in the EEG and thus reflect a limited amount of information (one dimensional), the dynamic view suggests that a time series may be seen to reflect the marks of all other variables participating in the dynamics of the system. From this perspective, nonlinear dynamical models may well offer a characterization of behavior that is far richer than that obtained by classical measures. In our research, the derived EEG measure used is the pointwise or fractal dimension [cf. Lutzenberger, Elbert, Birbaumer, Ray, & Schupp (1992) for a description of the exact mathematical procedure]. This measure reflects information about the number of quasi-independent cell assemblies involved in the performance of a particular task (Lutzenberger, Preissl, & Pulvermuller, 1995).

The nonlinear perspective suggests that the EEG reflects complex processes that appear random but may contain a hidden order. Part of the randomness comes from the brain's ability to shift abruptly and simultaneously from one activity pattern to another. It is suggested that contained within the brain's potential is the ability to organize itself in relation to internal and external input and be directed by that organization. Furthermore, it is suggested that the apparently chaotic

switching of processes may also contain a mechanism allowing the brain to move beyond a deterministic history and to initiate novel acts perceived as new ideas and creativity. In the language of chaos, it is the attractor that maintains or reflects a consistency of processing associated with a behavioral sequence. Thus, our task is to determine if a simple underlying structure can be seen to underlie the seemingly endless variation that one observes in the EEG.

Fractal dimensionality measures (chaos) showed a differential pattern of activity from pre- to post-therapy for our GAD clients. Following therapy, the GAD group displayed lower dimensionality measures in the frontal areas during baseline measurements. Further, the GAD group showed greater differentiation as measured by the fractal dimension between relaxation and worry tasks following therapy. Again, this suggests that therapy helped the GAD individual to differentiate processing requirements rather than constantly respond with an anxious mindset. Although the neuroscience literature is just beginning to discuss the functional significance of EEG chaos measures, these results are consistent with a picture of less cortical rigidity following therapy. These data overall suggest that consideration of a variety of psychophysiological measures are important for understanding anxiety processes.

SUMMARY AND CONCLUSION

Worry distinctively involves a predominance of verbal thought whose function appears to be the cognitive avoidance of threat. Thus, like the avoidant motor behavior present in the phobias, worry can be negatively reinforced and thus strengthened and maintained. This functional effect occurs because of its attenuation of somatic reactions to aversive images, its flight to abstractness, its superstitious association with the nonoccurrence of feared outcomes, and its possible service as a distracter from more distressing emotional material. Behaviorally, worry is associated with procrastination and rigid, maladaptive, interpersonal patterns often involving intrusive, overly nurturant behavior. Hypothetically, the delayed decision making in procrastination delays punishment for mistakes, and taking care of others prevents social criticism or interpersonal rejection. The occurrence of worry before or after threatening events lessens the emotional processing of those events and can lead to an increase in the anxious meanings surrounding those events. Worry also appears to contain mechanisms by which threatening meanings generalize to other stimuli: Chronic worriers become pre attentively biased toward detecting cues associated with threat, and higher-order conditioning involving worrisome words as the unconditional stimuli can generate increased vigilance to stimuli paired with those words. Recently discovered differences in autonomic nervous system and brain wave activity in GAD clients are beginning to offer glimpses

into the possible physiological substrates of many of the above psychological characteristics of worry.

As can be seen from the above review, worry and its clinical manifestation in GAD involve rich and complex phenomena, just like any other human process. In worry, thought, attention, imagery, memory, affect, central and peripheral physiology, and behavior are all characteristically involved. Consequently, further experimental pursuit of this phenomenon is likely to teach us a great deal about the dynamical nature of worry and human anxiety. It is quite remarkable how much has been learned from empirical research on the topic in a relatively short period of time, but it is also clear that a complete understanding of this complex human process will require considerably more thought and investigation. The effort will be worthwhile. Upon greater understanding of the process of worry, we can build increasingly effective therapies for GAD and for the other anxiety and mood disorders wherein worry plays a significant role.

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