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Philip S. Wong

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ANXIETY, SIGNAL ANXIETY, AND UNCONSCIOUS ANTICIPATION: NEUROSCIENTIFIC EVIDENCE FOR AN UNCONSCIOUS SIGNAL FUNCTION IN HUMANS

A central tenet of psychoanalysis, and arguably of any comprehensive theory of mind, is the existence of a psychological unconscious. Years of clinical investigation into the nature of unconscious processes have facilitated the development of psychoanalysis as a clinical method. Empirical investigations of unconscious mental processes, however, have lagged behind clinical inquiry. With few exceptions, attempts to understand unconscious processes using rigorous experimental controls have remained sequestered in scientific domains other than psychoanalysis, where they have proliferated recently. In view of this recent upsurge of research on unconscious processes outside of psychoanalysis, efforts to integrate such knowledge into general theories of psychopathology and clinical investigation are critical. In this paper, an interdisciplinary approach is taken to the study of one aspect of unconscious mental functioning—what Freud originally termed *signal anxiety*. Signal anxiety is examined using information from cognitive psychology and learning theory, psychophysiology, behavioral neuroscience, and psychoanalytic theory. Though the original concept of signal anxiety is supported by recent research, it is concluded that signal anxiety is probably best thought of not as the affect of anxiety but as a subset of unconscious mental processes that have a signal function of anticipating danger. Such unconscious anticipatory processes are a general feature of the mind that includes responses to both real and imagined (neurotic) appraisals of a situation. The neurophysiological structures and processes associated with unconscious anticipation in humans are just beginning to be understood.

> Anxiety is . . . on the one hand an expectation of a trauma, and on the other a repetition of it in a mitigated form. . . . A danger situation is a recognized, remembered, expected situation of helplessness. Anxiety is the original reaction to helplessness in the trauma and is reproduced later on in the danger-situation as a signal for help. The ego, which experienced the trauma passively, now repeats it actively in a weakened version, in the hope of being able itself to direct its course [Freud 1926, pp. 166–167].

> Anxiety, we say, is a signal of impending danger, an anticipation of unpleasure. . . . In the case of anxiety, a major distinguishing feature is the anticipatory quality. The anticipation of pain, guilt, or even anxiety can lead to anxiety [Compton 1980, pp. 740–741].

Anxiety is a cornerstone in the foundation of psychoanalytic theory and practice. The concept has evolved over many years, from a primarily biological energic concept in the topographical model to a conflict-based concept in the structural model. Although significant advances have been made in clarifying its role in behavior, it is clear that anxiety has varied referents and functions. In his extensive review of the history of anxiety in psychoanalytic theory, Compton (1972a,b) details the progression of theories of anxiety from the earlier energic-economic models to later signal-conflict models. This progression parallels the broader evolution of psychoanalytic theory from drive to ego psychology and illustrates the centrality of anxiety in nearly all psychoanalytic models of the mind.

The evolution of psychoanalytic theory from the topographic model to the structural model hinged on an important shift in Freud's understanding of anxiety. Freud initially developed the topographic model in part as an attempt to explain the subjective experience of anxiety. Anxiety is the symptomatic consequence of the latent, or unconscious, buildup of energy that emerged from excessive internal (instinctual) or external stimulation related to trauma. Anxiety is described primarily as an *experience-near* concept that involves overwhelming apprehension, dread of the future, and concomitant physiological reactions; it is an affect,

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Graduate Faculty of Political and Social Science, Department of Psychology, New School for Social Research.

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with its meaning best understood from a subjective frame of reference (Kagan 1992).[1]

An important perspectival shift then occurred in the conceptual framework of anxiety and of Freud's model of mind, which was most clearly reflected in the progression of ideas from *The Ego and the Id* (1923) to "Inhibitions, Symptoms and Anxiety" (1926) and articulated most directly in the anxiety chapter of *New Introductory Lectures on Psycho-Analysis* (1933). Here, as is well known (Arlow and Brenner 1964), Freud shifts his model of the mind to incorporate the tripartite structural concepts of id, ego, and superego. Among the many changes in this new model is a greater emphasis on psychological forces that develop from, and are in conflict with, drives and drive derivatives. As articulated by Arlow and Brenner, this evolution allowed for better conceptual clarity in explaining the role of psychological conflict in shaping behavior. Underlying structural theory is a new understanding of anxiety that has been a source of persistent debate in the literature (see Compton 1972a,b; Schur 1953, 1969).

Freud now distinguished between two kinds of anxiety. The first corresponded to the original notion of anxiety—that it was a passive reaction to trauma involving most prominently an experience of helplessness, "the original reaction to helplessness in the trauma" (1926, p. 167). This first view of anxiety still retained essential elements of the economic principles associated with the topographic model. The second, newer view of anxiety contained the idea of the ego actively reproducing a danger situation, re-creating a weaker and perhaps distorted version of an original trauma in order to manage it differently: anxiety "is reproduced later on in the danger situation as a signal for help" (p. 167). The ego's reaction to the re-created danger situation was labeled "anxiety" and further understood as a signal that precipitated defense. This second view of anxiety introduced the concept of anxiety as signal—hence, "signal anxiety."

This second conceptualization of anxiety—as signal anxiety—is a radical reformulation not only of anxiety, but of Freud's model of mind and of the nature of unconscious processes. Anxiety in this new sense is a precipitant of other mental processes—defenses—and not just a symptomatic consequence of trauma. Anxiety, in other words, is

[1]By *experience-near* we mean conscious-experience-near, agreeing with Pulver (1971), among others, that experience can have both conscious and unconscious dimensions.

a signal in response to the perception of danger—a formulation that does not require conscious subjective referents (although on this issue Freud wavered, as discussed below). This second definition of anxiety differs from the first in that it takes as its starting point an objective frame of reference; it is an *experience-distant* concept embedded within a specific theory of mind.[2]

The concept of signal anxiety furthered our understanding of anxiety and mental processes in noteworthy ways—e.g., by leading to the development and ascendance of structural theory in psychoanalysis. However, there are various conceptual problems with signal anxiety, some of which I will now highlight.

In Freud's description of the two different origins of anxiety (especially in "Inhibitions, Symptoms and Anxiety"), he refers to the signal concept and ego functions in ambiguous ways. In distinguishing between a traumatic situation and a danger situation, Freud describes the process as one in which the ego both brings about a weakened image of the original trauma and then also reacts to this image (labeled a danger situation) in order to master it actively (via defenses). The process of anticipating a danger situation (the distant memory of an original trauma) and then reacting to it is obviously much more complex than the process of reacting to an externally generated trauma or perception. This dilemma is encountered by most theorists who attempt to understand the link between original perceptions of and reactions to the external world, and phenomena involving memory, representation, and motive. These difficulties aside, what is noteworthy for our purposes is that Freud described the signal anxiety concept as involving both the anticipation of and the reaction to a danger situation.[3]

Although Freud remarks in several places in "Inhibitions, Symptoms and Anxiety" that anxiety (including anxiety as signal) is the "reaction to danger," it is clear that this is not all of what he meant (see Shur 1953; Compton 1980). The signal concept refers also to the anticipatory quality of mental experience connected to the appraisal that a (re-created) danger situation is on the horizon.

Another area of ambiguity in the signal concept concerns the mechanisms involved, especially in relation to conscious experience.

[2]By *experience-distant* we mean a phenomenon that does not need to involve conscious experience, or that can be described without reference to conscious experience.

[3]Gillett (1990) identifies other logical inconsistencies in Freud's attribution of causality in discussing the signal anxiety concept.

In an oft-cited passage, Freud (1926) states that "the ego subjects itself to anxiety as a sort of inoculation, submitting to a slight attack of the illness in order to escape its full strength. It vividly imagines the danger-situation, as it were, with the unmistakable purpose of restricting that distressing experience to a mere indication, a signal" (p.162). Such passages, and numerous others, imply that anxiety is experienced consciously, if briefly, in order to precipitate defensive reactions. However, as has been noted by many—including Freud himself—such processes need not involve the conscious experience of anxiety. In fact, it may be more common to observe a person completely unaware of an emerging instinctual demand that elicits defense (see Shur 1969) than it is to observe a consciously mediated process. The currently accepted view that repression and other defense mechanisms are unconscious processes stems from such observations (e.g., A. Freud 1936).

So the signal anxiety concept does not require the conscious experience of anxiety to prompt defensive responses. How, then, are we to understand and label a process that occurs unconsciously? This issue cuts to the heart of the still unresolved debate in the literature concerning the nature of unconscious affect (see, e.g., Pulver 1971; Gillett 1990). Freud himself wavered on this issue, at one time denying the possibility of unconscious affect (1915, pp. 178–179) and at another time acknowledging its clinical reality (1930, p. 135).

With reference to the affect of anxiety and its status regarding consciousness, similar ambiguities can be found. For example, Pulver (1971) cites Reid (1956) as follows:

> As generally used, outside of Freudian circles, the qualification of 'conscious' is redundant, for the term 'anxiety' refers, by well-established usage, to a felt state of mind that is consciously suffered. If this usage is followed, and the definitional rule implied is adopted as our standard, then it obviously becomes inconsistent—it is logically impossible—for us to speak of unconscious anxiety. . . . to avoid this logical consequence, we must change our definition of 'anxiety', so as to permit it to be without being experienced [p. 42].

Pulver noted that while Reid makes an important point about the semantic use of anxiety, he, "unfortunately, misses the real semantic point. . . . what really must be changed is not our definition of anxiety, but our persistent oversight of the fact that we may experience on either a conscious or unconscious level" (p. 349).

One of the thorny problems with the concepts of anxiety and signal anxiety is that the term *anxiety* serves double duty. Anxiety refers to both a conscious feeling state and, in its signal concept form, to an unconscious response to an internally elicited danger situation. Further complicating the ambiguous usage of anxiety is Reid's point: the most common and accepted use of the term is as a conscious feeling state—an affect. This common usage undoubtedly sets the stage for confusion between what is available consciously as a feeling (experience-near) and specific unconscious processes that involve anticipation of and response to a danger situation (experience-distant or, to acknowledge Pulver's concern, conscious-experience-distant). To avoid some of these definitional pitfalls, I will argue for restricting the term *anxiety* to descriptions of a conscious feeling state.

Despite the thorny conceptual questions concerning the nature of signal anxiety, much work has taken place in the years since Freud's initial articulation of the concept. It should be noted, however, that though the signal anxiety concept has been supported through years of clinical investigation during which the psychological principles of the structural model have been refined, the corresponding neurobiological principles have gone unexamined. Indeed, most view the structural model primarily through a clinical lens, while minimizing the relevance of other explanatory levels—such as biology—to the model. Thus, one shortcoming of the structural model has been its tenuous link to neural processes. In contrast, although the topographic model is limited in many ways (Arlow and Brenner 1964), it does provide a conceptual link to basic neurobiological principles. These ties can be viewed as a strength of the model, even though the neural principles themselves (derived partly from Freud's 1895 Project) may be questionable (Holt 1965; Solms and Saling 1986; cf. Solms 1997; Opatow 1997). One aim of the present paper is to forge new links between concepts like signal anxiety, which derive from the structural model, and the neurobiological processes associated with these mental activities.

Historically, the signal anxiety concept was the fulcrum for increased exploration of unconscious processes and for articulation of how these processes influence waking life. In an ego psychological framework, clinical investigations of the situations that trigger signal anxiety have developed amply over the years. Signal anxiety is thought to be prompted by the combined activity of childhood wishes and dangers. The classic childhood dangers include overwhelming excitation,

loss of object (separation), loss of love, castration, and guilt (superego). In the adult, activation of any of these wishes and associated dangers can occur via symbolic or associative links, and can lead to symptomatic anxiety. The expression of the wish-danger is mediated by defensive processes (signaled by the unconscious expectation of danger); is a compromise formation that is at some derivative distance from the source of the worry (Brenner 1982), and serves as partial gratification of the wish.

In an attempt to revise our conceptual understanding of signal anxiety, Schur (1953, 1969) argued that signal anxiety really involves two separate ego activities: evaluation of danger and response to danger. By the second he meant an ideational or behavioral response tied to the concept of defense. A full discussion of this second activity is best left for another time. In what follows, the focus will be primarily on recent attempts to advance our clinical-theoretical understanding of the first ego activity—the mind's effort to evaluate the nature of the danger signal. In considering this ego activity—the evaluation of danger—we will examine two questions: (1) What is the specific nature of the wish-danger situation (i.e., the signal) that is the subject of the ego's activity? (2) What process mediates detection and discrimination of the signal?

Considerable understanding of the nature of the wish-danger situation has developed in psychoanalytic theory. The nature of the situation is most often described as an unconscious cognitive representation (Michels, Frances, and Shear 1985). One can examine unconscious representations from several vantage points. As noted previously, from a genetic perspective in ego psychology, the signal is thought to reflect classic childhood wishes and fantasied dangers. Elaborations of these childhood dangers have included emphasis on aggression (Klein 1957) and on loss of object from an attachment perspective (Bowlby 1973). Other theorists might debate the exact nature of the danger situation, highlighting instead factors such as the dangers inherent in a fractured self (Kohut and Wolf 1978) or in interpersonal relationships (Sullivan 1964). However, since for all of these theorists the existence of unconscious processes is critical (Shevrin et al. 1996), a mental process such as signal anxiety is needed to distinguish conscious from unconscious, and to assess which unconscious contents are dangerous.

From a descriptive perspective, Compton (1972b, 1980) distinguished between a "danger situation response" and an "anxiety

response." A danger situation response is a fundamental reaction to a real perception of danger, and appears to be a basic, global process of which an anxiety response is a specialized part. An anxiety response stems from intrapsychic conflict and the representation of danger associated with an infantile fantasy. Of note is that either response can occur completely unconsciously. Further, a danger situation response is not connected to the person's subjective experience of anxiety or any other affect, whereas an anxiety response can involve the affect of anxiety in addition to other mechanisms. Thus, Compton's anxiety response refers to both experience-distant and experience-near aspects of the mind, and is directly comparable to Freud's second meaning of anxiety. As noted previously, a potential complication of labeling a process an "anxiety response" is that it biases one toward the common, experience-near understanding of anxiety as an affect only. Reference to a process—the unconscious anticipation of danger—that seems central to the original signal anxiety concept is then potentially obscured.

Other theorists too have broadened our understanding of signal anxiety and the nature of the wish-danger situation. Schur (1969) elaborated Freud's observation that the notion of a signal may pertain not only to anxiety, but to other affects. Guilt, for example, can elicit the unconscious anticipation of danger as readily as anxiety, which leads one to the term *signal guilt* or, more generally, *signal affect.* Shevrin (1978) introduced the concept of a "semblance" of feeling, which refers to the notion that affect can be experienced at various representational levels. In Shevrin's view, a signal might refer to several things: to a primitive "iconic" affect representation or, on a more abstract level, to a "semblance" of a feeling. To put it more generally, a signal should be considered at various representational levels. Each of these theorists—Compton, Schur, and Shevrin—has attempted to reframe the original understanding of signal anxiety to make it consistent with current psychological thinking and recent developments in ego psychology. Each has attempted to further our understanding of the nature of the signal in signal anxiety.

In light of these considerations, signal anxiety is probably best thought of not as the affect of anxiety (consistent with Compton's suggestions) but as a subset of unconscious mental processes that have a *signal function* of anticipating danger and/or responding to it. Such unconscious anticipatory processes have no direct link to subjective,

conscious experience and so do not necessarily involve the experience of anxiety. Unconscious mental processes that have a signal function of anticipating danger can be described in any number of ways, depending on the nature of the signal. Hence, some unconscious anticipatory processes might be called signal "anxiety," while others might be called signal "guilt." Some processes can be organized as a primitive representation (an "iconic" signal) and others more like a feeling state (a "semblance" signal). Each of these processes can have an unconscious signal function, anticipating danger and leading to subsequent defensive operations. Earlier uses of the term *signal anxiety* now may be understood as referring to a signal function of anticipating danger, with the nature of the danger varying according to context.

In the conceptualization put forth here, unconscious anticipatory processes are directly analogous to Compton's danger situation response and are understood as universal mental processes that have the function of anticipating danger. Dangers can be either real or imagined; either internal or external. I do not differentiate further between realistic or imagined (neurotic) dangers—as Compton does by coining the term *anxiety response* for neurotic danger—because such a distinction potentially obscures the term *anxiety* by extending its meaning to cover more than consciously experienced affect.

Another important issue concerns the experiential nature of an unconscious anticipatory process that one might label, for example, "guilt." It is not at all clear whether an unconscious anticipatory process in which the danger situation involves guilt (signal guilt) corresponds to a particular kind of experience. Is unconscious guilt the same as conscious guilt, only less intense? Or is it to be regarded as more intense because it precipitates defense? In a related discussion, Grossman and Simon (1969) note that "'unconscious affects' have their value in organizing the clinical data. Yet they introduce a certain ambiguity. That ambiguity resides in the fact that the theoretical term is modeled upon the conscious experience. Thus, when we refer to 'conscious guilt' we make a descriptive statement. 'Unconscious guilt' postulates a theoretical entity whose precise relationship to its model in consciousness is not entirely specified" (p. 102). This question leads us again to the difficult issue on which Freud contradicted himself in several places, stating on the one hand that the idea of unconscious affect is incoherent, and on the other that unconscious experiences can involve a sense of guilt. For present purposes, I will emphasize the

identification of unconscious anticipation as central to the signal concept, and leave discussion of the experiential nature of such processes for another time.

The question may now be asked, What processes mediate the detection and discrimination of the danger signal? At the core of the signal function is the concept of unconscious expectation or anticipation. We come to expect, as a result of fears innate or learned, that danger is around the corner in a specific situation. We detect the emergence of a conflicted wish, or of the possibility of abandonment, or of a tiger approaching and—based on an existing memory (either learned or inherited)—expect that danger will follow. We react accordingly, by relying on psychological defenses or by physically fleeing. In humans, it is possible to distinguish between conscious and unconscious expectation. While expectation certainly can occur consciously, unconscious expectation is the essence of the psychoanalytic signal function.

Expectation is a key concept in learning theory, and is important as a potential link to other fields in psychology. Attempts to integrate learning theory with psychoanalytic concepts have shed some light on the signal function (Gillett 1996; Schwartz 1987). Modern theories of learning, having evolved considerably since the days of strict stimulus-response behaviorism, now include consideration of how the organism comes to know relationships in the world through acquiring information and representing it in memory. Processes of associative learning such as respondent (Pavlovian) and instrumental (Skinnerian) conditioning constitute basic ways in which organisms, from amoebae to human beings, receive and respond to internal and external stimuli. According to Gillett (1996), we may now, by using the principles of associative learning, conceptualize Pavlovian conditioning as expectancy learning. In other words, what the organism learns is a set of relationships that form the basis for a subsequent expectation, triggered by stimuli associated with the original stimuli or conditions. The mental processes that form an expectation can be understood as similar, if not identical, to the processes involved in forming an *unconscious* expectation of danger (i.e., the signal function). Though Gillett (1996) focuses more on the clinical implications of learned expectations, the important concept for integrating the idea of signal anxiety with similar notions in other disciplines is that of expectation. Little in the psychoanalytic literature has addressed the idea of expectation, either conscious or unconscious, in an interdisciplinary fashion.

NEUROBIOLOGICAL APPROACHES TO ANXIETY IN NONHUMANS

> . . . anxiety . . . [is] a behavioral state that occurs in response to signals of danger and that entails a special set of response tendencies that have resulted in avoidance of similar dangers during events in the organism's past development and in the evolution of the species. The nature of the signals, of the dangers, of the responses, and of the events in the individual's past history changes during evolution and varies across species and even across individuals [Hofer 1995 p. 36].

In the preceding discussion of the signal anxiety concept, an important distinction was made between anxiety as an affect—as subjectively experienced—and unconscious anticipatory processes that have been loosely labeled signal anxiety. Before exploring the interdisciplinary support for the unconscious signal function in humans, I will discuss anxiety from an evolutionary perspective, taking into account selected research on nonhumans. Our understanding of anxiety, and of the unconscious signal function, should be consistent with existing theory and research based on nonhuman species.

As noted by Hofer (1995) and others, research on species other than humans allows us to explore the essential behavioral elements of a state that can be labeled anxiety and/or the anxiety state. Of course, a critical difference between humans and nonhumans is the ability to communicate via language, which allows for a window into the subjective state of the other. Given that we cannot know the subjective state of members of other species as well as we can that of fellow humans, we are making a distinction that bears similarity to that between subjective and objective frames. That is, we can objectively observe behaviors in an individual from another species that seem to reflect anxiety (or perhaps other "mental" processes); however, we can never really know the subjective experience of that individual. With fellow humans, we can objectively observe the behaviors of another (and conclude that those behaviors do or do not indicate anxiety or other mental processes), and we can know something about the subjective experience of that person given the possibility of communicating via language (with the person either endorsing or denying subjective feelings of anxiety). A potentially useful approach, then, is to identify perspectives in the objective frame of reference that are similar in humans and nonhumans. For humans, the objective frame includes, among several perspectives,

unconscious processes that serve a signal function of anticipating danger; for nonhumans, it is the behaviors that have been labeled the anxiety state. As we shall see, there is considerable conceptual overlap between the two.

How can we describe what has been labeled the anxiety state in nonhumans (and, thus, at some level in humans)? There are three essential aspects of an anxiety state: (1) detecting signals; (2) discriminating danger from no danger; and (3) the capacity to take steps to avoid the danger. In examining the course of evolution from single-celled to multicellular organisms, Hofer (1995) identified these essential elements at different levels of the evolutionary hierarchy. The processes by which organisms deal with danger situations vary considerably according to specifics of both the situation and the organism, yet the essential elements of detecting, discriminating, and acting are consistent. Relevant to this topic is work by Kandel (1983) and colleagues illustrating important principles of learning and anxiety in a marine invertebrate.

In a series of elegant studies using the sea snail *Aplysia californicus*, Kandel and associates (Kandel 1983; Walters, Carew, and Kandel 1981) demonstrated that *Aplysia* exhibits behavioral states that may correspond to anticipatory anxiety (using a classical conditioning paradigm) and chronic anxiety (using a long-term sensitization paradigm). To demonstrate anticipatory anxiety, a neutral chemical—shrimp juice—was used as the conditional stimulus linked to an aversive unconditioned stimulus—a shock to the head. Motor activity or escape locomotion served as the index of learning. Animals initially trained with the stimuli in a classical conditioning paradigm later showed increased escape locomotion during the presence of the shrimp juice signal. The shrimp juice had become a meaningful signal to the snail, eliciting a kind of anticipatory anxiety reflected by increased locomotion. To demonstrate chronic anxiety, no signals or cues were used in the learning phase. Later, the animals showed heightened motor responsiveness regardless of whether the cue was present. This generalized responsivity was understood as an analogue to chronic anxiety. Further work by Walters, Carew, and Kandel (1981) demonstrated that the presence of the cue not only affected locomotion but also activated other defensive systems and suppressed appetitive systems. These results solidified the link between motivational states and anxiety.

The research on *Aplysia* clearly informs our understanding of the anxiety state. Of course, there is quite a difference between anxiety states in a marine invertebrate and in a human. An aspect of this difference includes the evolutionary development in humans of highly complex brain structures. Structures like the neocortex contributed to the emergence of higher-order mental processes and the capacity to communicate subjective experience. With the advent of symbolizing capacities and the ability to communicate with others via language, one can make a ready distinction between subjective and objective frames. Anxiety as subjectively experienced very likely is linked complexly, and perhaps only distantly, to anxiety (or other states of response-readiness) as objectively described. In other words, the affect of anxiety may or may not be linked directly to an observed anticipatory state.

Despite great differences between species, a comparison of the anxiety state from evolutionary-neurobiological and psychoanalytic perspectives yields virtually identical conclusions when we examine the central activities involved. Signal anxiety in psychoanalysis includes the evaluation of danger (detection and discrimination) and the ideational or behavioral response (Schur 1953). Again, the features of an anxiety state common to all species include detecting signals, discriminating danger from no danger, and the capacity to take steps to avoid the danger (Hofer 1995). Thus, any anxiety state—including anxiety as signal—involves detection, discrimination, and action.

In humans, these common features of an anxiety state are more challenging to elucidate, in part because of the highly complex nature of the neural system that gives rise to the phenomenon of consciousness (and thus to the distinction between conscious and unconscious processes). For example, can detection, discrimination, and response occur unconsciously in humans? As critical as it is to understanding the nature of anxiety, neurobiological research like the work of Kandel and colleagues is intrinsically limited to the objective frame and cannot address issues of awareness or unawareness. There is no way to examine data from the subjective frame, no way to differentiate experienced from observed in a marine invertebrate. In contrast, psychoanalytic clinical perspectives—or any clinical theory about the human condition—has available, and arguably needs to explain, both objective and subjective frames. Psychoanalysis thus far has maintained much of its focus on the subjective frame, using observation of what occurs in awareness (subjectively) to develop concepts, such as signal anxiety, that refer

to activity outside awareness. Strong links have yet to be made between mental processes serving a signal function and empirical data from the objective frame.

In humans, a key aspect of signal functions is that these mental processes occur outside awareness. Although we cannot know the status of awareness in *Aplysia*, its anticipatory response seems conceptually close to the processes involved in the psychoanalytic signal function. The organism detects a signal, and on the basis of previous experience expects that danger is imminent. Responses then emerge, reflecting an attempt to adapt to the anticipated danger. The anticipatory aspects of anxiety are critical. One link, then, between the neurobiological and the signal models of anxiety is *how the mental state of expectation is formed, maintained, and elicited.* The added critical twist for the signal function in humans is how the formation, maintenance, and elicitation of the mental state of expectation *occurs unconsciously.*

AN UNCONSCIOUS SIGNAL FUNCTION IN HUMANS

The centrality of the conscious/unconscious distinction in humans presents a methodological challenge in exploring the anxiety state. Within a subjective frame, one need only ask a person whether he or she experiences anxiety. Within an objective frame, however, the issues quickly become complicated. One can objectively measure physiological responses that correspond to an individual reporting a subjective anxiety state (Barlow 1988). Yet, in theory and in practice, mental processes serving a signal function go beyond these conditions to one in which a person reports no subjective experience of anxiety despite some theoretical or observational indication that the anxiety state (or some other anticipatory state) is active. This mental state, reflected in the process of unconscious expectation, is of central concern here. The question now arises of how one might begin to explore, in controlled laboratory conditions with humans, mental processes serving a signal function. To be useful, this would have to be done in ways conceptually consistent with the clinical inferences of the consulting room and with neurobiological research on nonhumans.

The history of the experimental investigation of unconscious processes is lengthy and controversial (Dixon 1981). For many years, researchers argued that one cannot demonstrate the occurrence of *anything* outside awareness, thereby disregarding the results of research

into concepts such as "preattentive" or "automatic" processes (Holender 1986; Kihlstrom 1987). In recent years, however, interest has developed in more direct investigation of conscious and unconscious processes. One line of research, found in disciplines such as psychology of perception (Cheesman and Merikle 1984), social psychology (Murphy and Zajonc 1993), psychophysiology (Ohman and Soares 1994), and clinical psychology (Shevrin et al. 1992), is based on manipulating the perceptual accessibility of stimuli in order to activate mental processes outside awareness. This technique, using "subliminal" presentations, has been of interest to psychoanalysts for some time (Fisher 1988; Shevrin 1973). Research using the subliminal technique has contributed to an important perspectival shift in academic psychology; most experimental psychologists now acknowledge the importance of unconscious processes in models of the mind. Current issues stirring experimenter interest concern the exact nature of differences between conscious and unconscious processes (Shevrin et al. 1996; Merikle, Joordens, and Stoltz 1995), with debate focusing on questions such as the complexity of unconscious processes (Greenwald 1992).

Although experimental psychologists continue to debate the complexity of unconscious processes, there is nonetheless some consensus that certain basic processes do exist outside awareness. Some of these likely include the kind of processing discussed previously, involving the overlap between neurobiological models of anxiety and the psychoanalytic signal function. For example, one might speculate that activating human mental processes outside awareness triggers a primitive, iconic, or core anxiety state similar to that found in other organisms (though such activation would not necessarily be limited to such primitive states). Perhaps processes such as unconscious expectation serve as a substrate for the signal concept.

We now turn to the use of classical conditioning and visual perceptual techniques in humans, which illustrate certain principles of an anxiety state that correspond to the processes explored by Kandel and colleagues in invertebrates. In recent years, renewed interest in the nature of Pavlovian conditioning has led to a recasting of the conditioning process into informational terms (Rescorla 1988). The organism is no longer viewed simply as a bundle of reflexes; rather, it is seen as seeking to extract relations among events for the purpose of representing its world.

Investigators have relied on classical conditioning paradigms to explore the nature of conscious and unconscious processes. Several

studies over the years have examined the extent to which a response established to stimuli presented in awareness can be elicited when the stimuli are presented at a later time outside awareness (Lazarus and McCleary 1951; Corteen and Wood 1972; Dawson and Schell 1982). In a typical experiment on auditory attention, participants are told to attend to stimuli presented to one ear, performing a task that requires full attention to that ear. Meanwhile, other stimuli, including key stimuli previously linked to a shock, are presented to the unattended ear. Presentations of the key stimuli result in disrupted attention to the main task, whereas neutral stimuli result in no disruption. This disruption of attentional processes is taken to indicate processing "preattentively" or, perhaps, unconsciously. Other studies, notably by Ohman and Soares (1993, 1994), have relied on visual perceptual manipulations rather than attentional manipulations to demonstrate similar effects. Visual masking techniques are used to render stimuli perceptually inaccessible or "subliminal," and can allow for increased accuracy in measuring awareness. Ohman and Soares demonstrated electrodermal responsivity to subliminal presentations of visual stimuli previously conditioned to an aversive shock, extending to perceptual manipulations in the visual sphere earlier investigations that relied on attentional manipulations in the auditory sphere.

Recently my colleagues and I conducted a study that paralleled the Ohman and Soares work in humans by using visually masked pleasant and unpleasant facial schematics in a differential conditioning paradigm (Wong, Shevrin, and Williams 1994). In addition to implementing several methodological procedures to improve measures of awareness, we monitored brain activity (event-related potential) and electrodermal activity in order to examine the phenomenon in different neural systems. In brief, there were three experimental phases (see Figure 1). In the initial, preconditioning phase, participants viewed subliminal (unconscious) facial schematics to determine baseline functioning. From an experiential perspective, participants looked at a screen and were aware of seeing only a fixation point, even though the faces were presented briefly. In the second phase, conditioning was established to supraliminal (conscious) presentations of the schematics by linking an aversive finger shock to an unpleasant face. In this phase, participants clearly saw the faces, and also learned quickly that the mild shock followed several seconds after the unpleasant face. The final, postconditioning phase involved subliminal (unconscious)

presentations of the previously conditioned stimuli without link to a shock. Responses in this phase were compared to baseline, preconditioning-phase responses to assess how the conditional effect established first within awareness might be evident when the stimuli were later presented outside awareness. From an experiential perspective, participants again were unaware of the subliminal stimuli in the postconditioning phase.

The physiological results revealed that the shock-linked stimulus—the facial schematic with the unpleasant expression—changed more significantly in predicted directions from the preconditioning to postconditioning phase than did the non-shock-linked pleasant schematic. The electrodermal results essentially replicated previous findings (Ohman and Soares 1993, 1994). A new finding emerged for the

FIGURE 1

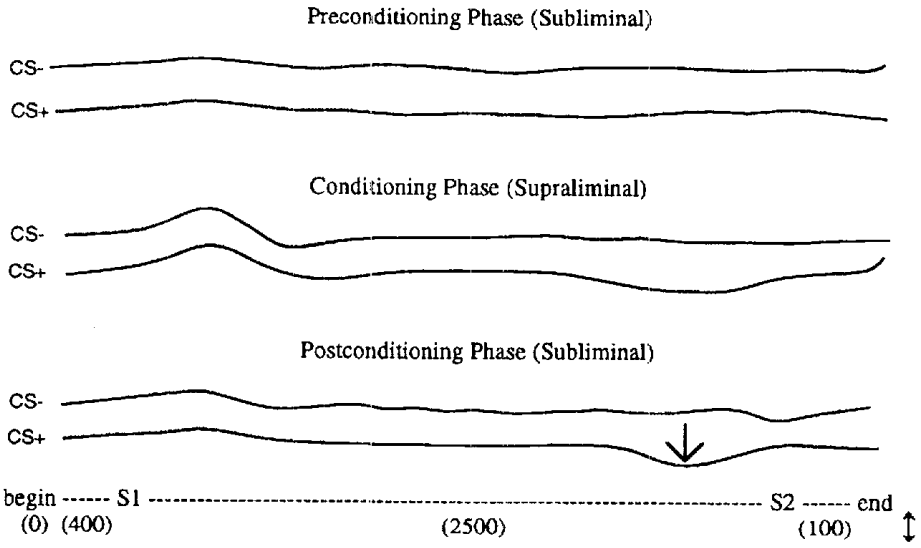

FIGURE 1. Schematic illustration of ERP grand average response indexing an unconscious expectancy-wave (at arrow) in the postconditioning phase for CS+; x-axis = individual trial data collection sequence; S1 = pleasant (CS) or unpleasant (CS+) facial schematic (sub- or supraliminal); S2 = aversive finger shock linked to CS+ in conditioning phase only; time (in parentheses) = milliseconds; y-axis (double arrow) = 5 microvolts (adapted from Wong, Shevrin, and Williams 1994).

event-related brain responses that shed light on the nature of processing outside awareness. For the unpleasant face in the postconditioning phase, distinct slow wave brain activity—most prominent at central and parietal electrodes—occurred just before the point at which the shock had been delivered in the conditioning series. No such activity was found for the pleasant face. This slow wave brain activity is similar to what Rohrbaugh et al. (1986) and others have described as an "expectancy wave," which is thought to develop in anticipation of a salient stimulus. Of special note is that this expectancy wave or anticipatory process was elicited unconsciously.

Participants' responses to the presentations were noteworthy. Based on subjective and objective measures of awareness, the participants were unaware of the stimuli in the subliminal phases. All (n=17) reported seeing nothing other than the fixation point on the screen during the subliminal phases (pre- and postconditioning). These subjective report data supported rigorous forced-choice tests of awareness conducted with each participant before and after the three main experimental phases, which indicated participants were perceptually unaware of the stimuli. Additionally, in the postconditioning phase no one reported (upon open-ended retrospective inquiry) a subjective experience of anxiety, tension, or anticipation in response to the stimulus presentation. Although participants were responding physiologically in anticipation of a salient event that had occurred previously, there was no alteration in subjective experience of anxiety.

In sum, the results of this study are notable in several ways. Consistent with earlier studies examining electrodermal reactivity, our findings showed that the neural system reacts to stimuli not consciously perceived that previously have acquired salience in awareness. The study demonstrated not only that this reactivity activated the representation of the stimulus, but also that it reflected the process of anticipation or expectation of a future event. Significant brain activity evolved several seconds after presentation of the conditional stimuli (a long time in event-related response paradigms), indicating that a process had unfolded over time. These temporal dynamics were consistent with the conclusion that the brain processes identified corresponded with anticipatory activity. Thus, we learned that a person can be physiologically reactive to a previously feared object and that this reactivity is likely an index of mental processes such as expectation. *These mental processes and their antecedents occur outside awareness.*

How do the classical conditioning studies by Ohman, Wong, and others bear on our understanding of the anxiety state more broadly and of the psychoanalytic signal function more specifically? An important conceptual link between the neuroscientific and signal function models of the anxiety state is how the mental state of expectation is formed, maintained, and elicited outside awareness. The classical conditioning studies, especially our recent work, demonstrate how an anticipatory mental state can be elicited unconsciously. This is the first demonstration, in humans, that such anticipatory states exist outside awareness; it also provides the first data available that bridge the gap in neuroscientific research between nonhumans (Kandel 1983) and humans while taking consciousness into account.[4]

The Wong, Shevrin, and Williams (1994) study allows for discrimination between mental states in the subjective frame (subjects reported no perceptual awareness of the stimuli and little conscious anticipatory anxiety in response to them) and from the objective frame (subjects' physiological responses indicated that an anticipatory response had been elicited). In the objective frame, the anticipatory response satisfies two of the three basic requirements for an anxiety response (Hofer 1995). The subject (1) has detected a signal outside awareness (a face with an emotional expression) and (2) has discriminated danger / no danger (a face with an unpleasant expression signals danger). The third basic requirement, that the organism have the capacity to initiate behavior to avoid the danger, is not directly evaluated with these data.

The results of our study are consistent with the idea that the signal concept and the processes of detection, discrimination, and response are observable in any organism, regardless of the level of consciousness of which it is capable. That is, the ability to detect, discriminate, and respond to threats is common to all organisms, from marine invertebrates to humans. The critical distinguishing characteristic of humans, compared to nonhumans, is that these processes can operate both in and—especially—outside awareness. That such processes can operate outside awareness is consistent with the original idea of signal anxiety in psychoanalysis. Until recently, there has been no empirical evidence

[4]We recently conducted a study demonstrating that people can learn associations to stimuli outside awareness (Wong et al. 1997), providing evidence that widens the scope of unconscious associative learning. This study, which relied on multiple behavioral and neural measures, also bridges the gap between neuroscientific research on nonhuman learning and that on human learning outside awareness.

in humans to support this idea. With studies such as ours, support for the existence of processes associated with an unconscious signal function is now at hand.

How do the results from these classical conditioning studies fit, or not fit, with psychoanalytic propositions concerning the signal concept? The processes that these studies illuminate—of detection and discrimination outside awareness eventually leading to anticipation—can be understood as a systematic property of the ego. Further, because these activities occur outside awareness, they can be considered unconscious ego processes. Such processes can in theory be recruited in the service of specific responses to reality-based or fantasy-based ideation. To put it differently, these processes likely serve multiple purposes, including mediating transactions between outer and inner worlds, and among various internal processes, any of which can go awry in pathology. Specific subsets of these unconscious ego processes can include simple unconscious biases associated with emotionally valent stimuli ("reality-based" responses; Compton's "danger situation response"), or more complex unconscious biases associated with individual conflict linked to infantile fantasies ("intrapsychically driven" responses; Compton's "anxiety response").

The unconscious ego processes identified in our 1994 study directly parallel what Compton has described as a "danger situation response." The evaluation of the reality-based danger situation (detection and discrimination of the subliminal stimuli and its link to an aversive shock), and the response to the situation, occur completely outside awareness. Whether the unconscious anticipatory process we found ultimately involves the same mechanism as the more complex symbolic anticipatory processes thought to occur in intrapsychically driven ("neurotic") responses is still unknown. Recent research in cognitive psychology, however, suggests that learning of complex sets of rules can occur outside awareness—e.g., with artificial grammar (Reber 1989) or covariation in social judgment (Lewicki, Hill, and Czyzewska 1992). Such research is consistent with the possibility that complex symbolic anticipatory processes exist unconsciously.

The classical conditioning studies discussed here have important theoretical implications, in that they identify and elaborate some neuroscientific correlates of unconscious ego processes, strengthening the biological viability of certain aspects of the structural model. As noted

earlier, the structural model has led to important progress on a psychological level, advancing our understanding of the human mind and its conflicts. A shortcoming of clinical research using this model, however, has been its lack of focus on the neurobiological dimensions of the mind. The studies outlined here can be considered a first step in remedying this gap. The appeal of the structural model would certainly broaden if certain of its features could be shown to have neurobiological correlates. Linking an unconscious anticipatory process to distinct brain activity is a step in the direction of integrating specific psychological and neurobiological features of the structural model. This link provides support for the idea of an unconscious ego process that could be involved in the formation and expression of unconscious conflict and, ultimately, defense.

Noteworthy differences exist, however, between the implications of the classical conditioning studies reported here and the psychoanalytic signal concept (Michels, Frances, and Shear 1985). First and foremost, the nature of the signal is quite different. Faces with positive and negative expressions linked to an aversive shock are at some distance from a wish and danger situation stemming from an early childhood fantasy. In other words, the genetic perspective of the psychoanalytic structural model holds that the nature of the danger signal derives largely from innate factors first expressed in infancy or early childhood; the conditioning studies require no such notion. In fact, classical conditioning models, as a subset of broader learning models, often focus more on acquired expectations than on constitutional or innate factors (Gillett 1996). Second, psychoanalytic theory elaborates significantly on the defensive response to the signal of danger (Schur 1953), as well as to the evaluation of danger itself. Response concepts such as defense and compromise formation, which are derivative expressions of core conflicts, are not addressed by the studies completed to date. Thus far, little is known about how learning theory as reflected by classical conditioning models sheds light on these important concepts.

Despite these differences, the evidence from the classical conditioning studies reported here is highly consistent with basic features of a psychoanalytic model of the mind that involves a signal concept. Demonstration that an anticipatory mental state can be elicited unconsciously in humans provides a critical piece of evidence consistent with the signal concept. Findings from classical conditioning or learning studies may be particularly good at illustrating the

basic mental processes that underlie the formation, maintenance, and elicitation of anxiety or other affects. These processes do not yet tell us whether the content of the signal can include childhood wishes and fears (or any other dangers postulated by psychoanalytic theorists), or whether responses to the signal can distort the essence of the signal. Similarly, we do not know the specific relationship between conscious affects (e.g., anxiety) and unconscious anticipatory processes serving a signal function, nor do we know exactly when and how consciousness is involved. However, that such basic anticipatory processes exist at all is noteworthy. Further, that such processes can operate outside awareness strongly suggests that some kind of unconscious signal function must be a central feature of any comprehensive model of mind.

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Department of Psychology
Graduate Faculty of Political and Social Science
New School for Social Research
65 Fifth Avenue
New York, NY 10003
Fax: 212–989–0846
E-mail: Pswong@newschool.edu

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