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Scientific Life

Semantics, Surplus Meaning, and the Science of Fear

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When subjective state words are used to describe behaviors, or brain circuits that control them nonconsciously, the behaviors and circuits take on properties of the subjective state. Research on fear illustrates the problems that can result. Subjective state words should be limited to the description of inner experiences, and avoided when referring to circuits underlying nonsubjectively controlled behaviors.

We are in a golden age of technical innovation in neuroscience. However, our ability to use these advances to understand brain function is only as good as our understanding of the function we are studying. Application of sophisticated technologies to misconstrued psychological processes creates a false sense of progress, and ultimately leads to confusion rather than to deep understanding. In areas where basic science findings are used to understand and treat clinical problems, this kind of confusion has real-world consequences. I think this is where we are in the study of 'fear' today, a field I have worked in for more than three decades.

The common meaning of the word 'fear' is the feeling that invades your conscious mind when you are in danger. You recognize it in yourself by the inner experience, and in others by outward manifestations associated with the feeling, such as freezing, fleeing, trembling, or a fearful facial expression. Inner experiences of this type are often the inspiration for research in psychology and neuroscience, but pose special problems as research topics. How can research be done on something that cannot be observed?

'Intervening variables' are often used for this purpose. These were introduced by Edward Tolman during the 1930s in an effort to get past the behaviorists' insistence on explaining behavior without calling upon inner factors (including mental and neural events [1]). Tolman viewed intervening variables (sometimes called 'mediating variables' by statisticians) as a way of explaining the empirical relation between stimuli and responses. These were psychological, in the sense that they accounted for behavior, but were not subjective, in the sense that they did not imply any real or hypothetical subjective state. Nevertheless, subjective terms were often retained as labels for the states. Fear, for example, was said to meditate between a harmful stimulus and defensive response. Later researchers introduced 'hypothetical constructs', which sought physiological grounding for intervening variables. Fear, in this approach became hypothetical physiological motivational state that connected threats with behavior [2]. However, as was quickly noted, there is a semantic danger that results when a common language term is used as a scientific name for an intervening variable or hypothetical construct [3]. In such a situation some will be inclined to apply the common meaning. Indeed, in the case of "fear", the common meaning is often taken to be the intended meaning. When this happens, the variable or construct becomes infected with the subjective properties that the scientist was trying to avoid.

With the rise of neuroscience, hypothetical physiological states were replaced by neural activity in brain circuits (Figure 1). For example, 'fear' came to refer to a physiological state of a neural circuit in the amygdala that mediates between threats and defense responses [4]. For some, the amygdala fear state offers an objective (nonsubjective) account that replaces 'inaccurate subjective explanations' of fear as a conscious feeling [5]. However, others reject this approach and treat fear in the conventional way, as a conscious feeling instantiated in the amygdala circuit [6]. Still another approach rejects both of the amygdala views of fear and instead treats it as a conscious experience cognitively assembled in cortical circuits [7,8]. Clearly, the opportunity for confusion is high when so many scientific meanings are available, and some of these overlap with the common meaning of fear as a conscious experience, but others do not, and among those that do, different neural circuits are proposed.

I have long been a proponent of a cognitive view of emotions [9,10]. Specifically, several decades ago, I proposed that objectively measurable behavioral and physiological responses elicited by emotional stimuli were controlled nonconsciously by subcortical circuits, such as those involving the amygdala, while the conscious emotional experience was the result of cortical (mostly prefrontal) circuits that contribute to working memory and related higher cognitive functions. Building on a distinction emerging in the study of memory, I referred to these as implicit (nonconscious) and explicit (conscious) fear circuits [10].

However, I came to realize that the implicit–explicit distinction had less traction in the case of emotions than in memory. The vernacular meaning of emotion words is simply too strong. When we hear the word 'fear', the default interpretation is the conscious experience of being in danger, and this meaning dominates. For example, although I consistently emphasized that the amygdala circuits operate nonconsciously, I was often described in both lay and scientific contexts as having shown how feelings of fear emerge from the amygdala. Even researchers working in the objective tradition sometimes appear confused about what they mean by fear; papers in the field commonly refer to 'frightened rats' that 'freeze in fear'. A

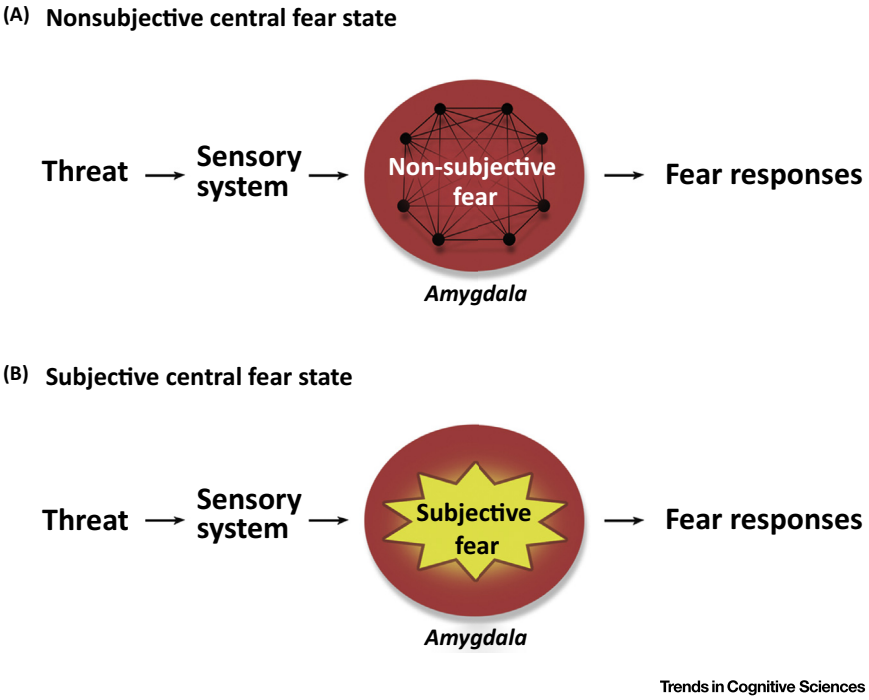

Figure 1. Contrasting Views of the Amygdala Central Fear State. (A) For some, the amygdala state of fear is a nonsubjective (nonconscious) neural event that connects threats with defense responses. (B) Others treat the amygdala state as the neural instantiation of a subjective (conscious) fearful experience.

naïve reader naturally thinks of frightened rats as feeling 'fear'. As noted above, using mental state terms to describe the function of brain circuits infects the circuit with surplus meaning (psychological properties of the mental state) and confusion invariably results.

Recently, I have thus abandoned the implicit–explicit fear approach in favor of a conception that restricts the use of mental state terms to conscious mental states [7,11]. I now only use 'fear' to refer to the experience of fear. It is common these days to argue that folk psychological ideas will be replaced with more accurate scientific constructs as the field matures. Indeed, for nonsubjective brain functions, subjective state labels should be eliminated. This is what I had in mind when I proposed calling the amygdala circuit a defensive survival circuit instead of a fear circuit [11] (Figure 2A). However, the language of folk psychology describes conscious experiences, such as fear, just fine [12].

I have argued elsewhere that the dual-circuit approach, which separates circuits underlying fearful feelings and defense responses, accounts for certain puzzles in the field [7,13]: (i) subjective experiences of fear and anxiety do not correlate well with measures of behavioral and physiological defense responses; (ii) patients with amygdala damage do not exhibit physiological defense responses to threats, but still can feel fear and panic; (iii) threats processed nonconsciously increase amygdala activity and trigger peripheral physiological responses, even when the person remains unaware of the stimulus and lacks feelings of fear; and (iv) the experience of fear is not tied to a single subcortical circuit; it can come about from circuit activity related to energy management, fluid balance, and thermoregulation (fear of starving, dehydrating, or freezing to death), as well as the predatory defense circuits most commonly discussed.

Another important problem that the dual-circuit approach helps explain is why drug discovery research based on animal behavior has come up with medications that are more likely to change behavioral tendencies than conscious feelings of fear [14]. Pharmaceutical companies, researchers, therapists, and patients are all disappointed, but this is due to misconceptions about what the animal research can and cannot reveal: changing avoidant behavior and physiological arousal is not the same thing as relieving uncontrolled feelings of fear or anxiety. Changing behavior and physiology is useful and important, but it is not normally sufficient to relieve fear itself in a lasting way. Because it has been based on confusion about what fear and anxeity are, the entire approach to the development of treatments (psychological and pharmaceutical) for problems related to the experience of fear or anxiety needs to be reevaluated.

Given that words matter, scientists have an obligation to be as clear as possible when defining and using terms. Imprecise terms create barriers to clear conceptions, and can also hinder reproducibility of research based on the terms. When scientists talk about fear as a function of the amygdala, they will often be interpreted as meaning the amygdala is responsible for the feeling of fear, even if this is not what was intended. In addition, because subjective fear is the common received meaning, scientists, wittingly or unwittingly, slip between subjective and objective meanings, sometimes at the behest of funding agencies that demand promissory notes that cannot be paid: proposing that research on defensive behavior in animals will help understand and treat pathological feelings of fear, as opposed to changing pathological behaviors and hyperarousal, glosses over the fact that the circuits that control defensive behavior are not the circuits underlying subjective feelings of fear [7,13,14]. Subjective state terms are needed to account for subjective experiences [12]. However, to do their job