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You Can't Run, But You Can Hide: A Critical Look at the Fight or Flight Response in Psychophysiological Detection of Deception

In an earlier paper (Handler & Honts, 2008) we offered a theoretical explanation of the physiological changes observed in PDD testing. We noted that there were likely emotional and cognitive pathways that were involved in the production of observed PDD phenomena. The emotional pathway could be characterized as generally unconscious and automatic while the processes in the cognitive pathway were relatively more accessible to the consciousness of the subject. Our earlier work focused on the cognitive pathway. Here we would like to offer some theoretical speculations about the unconscious emotional automatic pathways suggesting conditioning may play a role in generation of arousal in the PDD context.

Fight, Flight or Freeze

Cannon (1927) described fear reactions as an overall sympathetic nervous system (SNS) arousal resulting behaviorally in what he called "fight or flight". When presented with an emergency situation, Cannon felt the animal can choose to fight the danger or attempt to flee. Fighting and running away both involve an initiation of movement, where immobility is just the opposite. However, as early as the 1970s Jeffrey Gray (1976) introduced the term Behavioral Inhibition System (BIS) to describe a series of responses to fear stimuli that include increases in arousal, behavioral inhibition, and increases in attention. Smith (2006) discussed fight or flight as an "active defense response" and freeze as a "passive defense response" to a perceived threat, and used telemetry to study the physiological responses of animals in the wild.

The "freeze" response became an integral part of Gray's early BIS hypothesis and described an inhibition of ongoing behavior. Updated descriptions of the BIS (Gray & McNaughton, 2003) discussed behavioral inhibition as decreased motor activity when presented with fear associated with an approach-based conflict. The updated theory separated pure "freeze" reactions from those that were behaviorally inhibited.

Gray and McNaughton (2003) noted freeze and behavioral inhibition were physiologically so similar as to make them very difficult to differentiate, especially in humans. The difference between the two in the causation of arousal was conceptualized as a difference between freezing proper and defensive quiescence. The freeze response (freeze proper) occurred when an animal was placed in the immediate proximity of a highly fearful stimulus, and was followed immediately by a fight or flight reaction. Additionally, this freezing proper was insensitive to anxiolytic (anti-anxiety) drugs. Behavior inhibition (defensive quiescence) was observed when the animal was forced into an approach-avoidance situation presumably resulting from the anxiety (fear) of a desire to interact with a potentially aversive stimulus and was *inhibited* by anxiolytics.

Gray and McNaughton (2003) observed that cases of conditioned "freezing" were found to be inhibited by anxiolytic drugs and are thus likely to be defensive quiescence that resulted from activation of the BIS. They observed defensive posture differences in rats that were freezing proper (freeze likely associated with fight, flight or freeze) and those that were engaged in defensive quiescence (freeze associated with BIS), They theorized the amygdala and septo-hippocampal structure interacted at higher sub-cortical levels in response to approach-based conflict.

Throughout this paper, when we discuss "anxiety" we are referring to "state anxiety", which can occur in milliseconds when an animal or human perceives an appropriate stimulus. The Oxford Dictionary of Psychology defines state anxiety as "A temporary form of anxiety related to a particular situation or condition that a person is currently in" (Coleman 2001). Clinicians may tend to use the word anxiety to refer either to "trait anxiety" (a tendency to a greater anxious reaction even if you are not anxious right now) or to chronic, and hence pathological, state anxiety. "Trait anxiety" is defined as "A person's general or characteristic level of anxiety." (Coleman 2001) We address anxiety in the tightly defined context of state anxiety. We will differentiate between extreme fear normally associated with fight or flight and mild fear that may accompany anxiety. Extreme fear is what one may feel when experiencing something that makes one want to run away. Mild fear or anxiety is what one is likely to feel when placed in an approach-avoidance situation where one is compelled to attend to a stimulus but do so with trepidation.

PDD examiners may be tempted to account for polygraph reactions using "fight, flight, or freeze" construct explanations. PDD examiners often cite situational examples in which the fight or flight response was activated during the pre-test interview to introduce the examinee to polygraph principles. The Defense Academy for Credibility Assessment (DACA), formerly the Department of Defense Polygraph Institute (DoDPI) *Anatomy and Physiology for the Forensic Psychophysiologist* chapter handout (DoDPI, 1994) states the reactions expected (or hoped for) during a polygraph examination result from fight, flight or freeze reactions.

These reactions include blood pressure (BP) increase, heart rate (HR) increase, an increase in the contractile force (CF) of the heart, a redistribution of blood in the body, increase in skin conductance (SC), a decrease in skin resistance (SR), dilation of the bronchi and *faster deeper breathing* (pages 47-48).

Responses commonly associated with fight or flight reactions include increased heart rate, increased blood pressure, increased muscle tension, increased contractile force in the heart, vasoconstriction in the blood vessels supplying the skin and viscera (except the heart and lungs), vasodilatation in the blood vessels supplying the skeletal muscles and brain, transformation of glycogen into glucose which is released into the bloodstream for energy, sympathetic impulses to the adrenal medulla to cause the release of epinephrine and norepinephrine into the bloodstream, reduction in digestive actions, increase in respiratory passageways and an *increase in the rate of respiration* (Cannon 1929; Tortora & Grabowski 1993; Rathus 2001).

However, BIS responses have been associated with an increase in blood pressure, a sensory orienting response and *decrease in respiratory activity* (Janig

2006, Fried & Grimaldi 1993). Bronchioles dilate, allowing more oxygen to enter the lungs with less movement. Slower and shallower breathing is thought not only to minimize movement, but to result in quieted system and focused attention to the surroundings. It may be safer for animals experiencing a threat to inhibit movement; crouch, wait, and hope to become more difficult to detect, while they assess the situation and deciding the best course of action. A reasonable conclusion is that the freeze response is either a genetically hardwired response (developed through evolution) or one acquired through association (Le Doux 1996). Animals who did not freeze when warned of an impending danger may not have survived. Freeze-type or BIS responses are accompanied by heightened arousal, awareness and alertness allowing risk assessment and preparation for action (Boucsein 1992, Boucsein & Backs 2008, Gray 1982, Gray 1987, Gray & McNaughton 2003).

According to Gray (1982), the BIS prepares the animal to better survive a potentially threatening encounter with a larger predator through more than simply reducing behavioral movement. There are a number of physiological changes that occur in anticipation of a potential negative encounter. This feed-forward type of physiological preparation is referred to by Peter Sterling and Joseph Eyer as *allostasis* (Sterling & Eyer 1988; Sterling 2004; Sapolsky 2004; Schulkin 2003). Allostasis is described as a centrally mediated, integrated brain-body response geared towards viability or survival. Imagine a rabbit feeding in a field that hears a noise it associates with a coyote. The rabbit has an appetitive desire to stay and eat, but this may conflict with the possibly aversive stimulus of the coyote. Bolting outright has some obvious potential disadvantages for the rabbit. The sound or movement of running may attract the coyote's attention or the rabbit may run closer to where the coyote is located surely reducing the chance of survival. On the fight side, the rabbit has only very limited options. Decreased behavioral activity and increased alertness serves to lower the rabbit's detection probability and maximize the sensitivity of its sensory systems. Increased blood pressure and muscular blood flow prepares the rabbit to flee or fight, but only if those responses are appropriate. All of these responses can be considered an allostatic change in preparation for a potentially threatening encounter.

Classical and Operant Conditioning

Classical conditioning involves an automatic response to an unconditioned stimulus. Early in the 20th century, Russian physiologist Ivan Pavlov (1927) studied digestive processes in dogs by giving them meat powder and then measuring salivation. Pavlov observed that over time his laboratory dogs

would begin to salivate before they were given the powder, a response that prepared the mouth for the dried powder. Saliva cleanses the mouth, dissolves the food so it may be better tasted, moistens food to allow compacting and contains enzymes that begin the chemical breakdown of food (Tortora & Grabowski 1994). Pavlov speculated that the dogs associated the appearance of the researcher with meat powder and the natural digestion process of salivation occurred because of the association. Pavlov went on to systematically pair neutral stimuli (for example a bell) with the subsequent presentation of meat powder and measured the salivary response. Pavlov called the meat powder an Unconditioned Stimulus (US), because it required no learning to produce salivation. Pavlov found that after pairing the ringing bell with the meat powder on several occasions, the ringing bell would elicit salivation without the presentation of meat powder. Pavlov called the ringing of the bell the Conditioned Stimulus (CS) and salivation the Conditioned Response (CR) because salivating to the sound of the bell was conditional on its temporal proximity to the meat powder.

Fear can be conditioned using the same classical conditioning procedures. Fear conditioning theory (Le Doux 1996) involves constructs of fear and anticipation, and applies the terms US, CS and CR in the same way as Pavlov's original experiment. Fear-conditioning experiments attempt to exploit unconditioned responses (UR) to better understand causes of arousal. A caged rat subjected to a painful foot-shock (US) generally responds with a great increase in activity directed towards escape from the situation, frantic jumping or scampering or by attacking something in the immediate vicinity (Gray 1982, 1987). If that shock is paired with a neutral stimulus (i.e. the sound of a bell) just prior to applying a foot-shock, the rat associates the shock with the bell (Le Doux 1996). A very interesting observation is the physical response to the bell once it has been paired with the shock. The bell (CS) causes immobility in the rat, a polar opposite of the physical response to the foot shock (US). Le Doux (1996) called the painful foot shock a "natural trigger" in that it requires no conditioning and is thus considered an US. The bell sound (CS) he called a "learned trigger" that becomes significant to the rat and warns of an impending shock (US). The rat is conditioned to respond to the sound of the bell because of the fear associated with the painful shock. This fear conditioning occurs quickly, is long lasting, and has obvious evolutionary benefits.

Where classical conditioning involved a pair of stimuli in an anticipatory learning context, operant conditioning allows for behavioral adjustment based on the consequences of the particular behavior. Operant behavioral conditioning (Rathus 2001) involves reinforcements and punishments and also the learning about the effects or results of particular behaviors.

Reinforcements are stimuli that encourage the continuance of a particular behavior (Rathus 2001) and can be either positive or negative as long as they encourage the subject to maintain that behavior as a result of their presentation, or omission, respectively. Harvard psychologist B.F. Skinner showed that a rat in a cage may be taught to repeatedly press a bar (Rathus 2001) by reinforcing the bar-pressing with food pellets (positive reinforcement). While food pellets are a desirable or positive reinforcement, that same rat would perceive a mild electrical shock to its feet as aversive and something it would like to avoid or mitigate. If the rat learns that pressing a bar stops the shock, it will press the bar repeatedly to avoid the unpleasant shock experience. The rat's behavior of pressing the bar is strengthened by the consequence of the stopping of the shock. This negative reinforcement occurs only after the rat has made the proper behavior choice.

Models of Arousal

There have been a number of models proposed to describe arousal and their neuropsychophysiological foundations. The Penguin Dictionary of Psychology (Reber, 1995) defines arousal as;

"A dimension of activity or readiness for activity based on the level of sensory excitability, glandular and hormonal levels and muscular readiness." (Page 54)

The terms "arousal" or "activation" have been used to describe intensity of behavior (Boucsein & Backs 2008). Arousal theories attempt to explain how the subsystems of the brain integrate to allocate resources directed to processing information and responding to stimuli. The Boucsein model (1992, also Boucsein & Backs 2008) divides arousal into four sub-systems and incorporates many of the features of earlier models including: the two-arousal system of Routtenberg (1968), the three-arousal systems of Pribram and McGuinness (1975) and Fowles (1980), the behavioral inhibition system of Gray (1982), the amygdala centered system (Le Doux 1996) and the circuits between basal ganglia and frontal cortex after De Long, Georgopoulos and Crutcher (1983).

In the Boucsein model (Boucsein 1992; Boucsein & Backs 2008), Arousal System 1 is referred to as the *affect arousal system* and is centered on the amygdala. The amygdala is considered to be one of the primary processes involved in the fight or flight response (Gray 1982, 1987) and the fight, flight or freeze response (Le Doux 1996, Boucsein & Backs 2008), and separate nuclei in the amygdala are arguably the main arousal component of anxiety. Cholinergic fibers originating in the reticular formation activate the affect arousal system via the amygdala that in turn activates the comparator system of the

hippocampus in the effort system resulting in increased focus and attention (Boucsein 1992; Boucsein & Backs 2008).

Arousal System 2 is centered on the hippocampus and is called the *effort system*. Gray (1982, 1987) and Gray and McNaughton (2003) proposed the septo-hippocampal stop system was responsible for the BIS and was the primary process involved in behavioral inhibition. The Boucsein *effort system* is not inconsistent with the BIS model in that they both ascribe primary responsibility for inhibition to the hippocampus and both are highly involved in arousal. If the subject perceives a potentially threatening stimulus, there is an increased flow of information to the hippocampus. Here a comparison process begins to assess the potential threat of the stimulus by comparing stored information to recently acquired information. That information is shared with parts of the brain that are involved in motor plans (the prefrontal cortex) and classically conditioned behavioral responses (via the basal ganglia in the cognitive loop). This comparator system does not interfere if the stored and incoming information match. If, however, there is discordance between the information, the BIS activates, resulting in motor inhibition, increased alertness, internal memory scanning and an increase in arousal.

Arousal System 3 is labeled the *preparatory activation system*, is centered on the basil ganglia system and is involved in somatomotor activity. When this system activates, it prepares the body for action by alerting the central nervous system processes involved in movement. If situational circumstances alert the *affect arousal system* (Arousal system 1) attention is shifted towards the alerting stimulus and this *preparatory activation system* prepares the body for movement. *Arousal system 2* (effort system) can block Arousal systems 1 (affect arousal system) and 3 (preparatory activation system) to prevent immediate movement. This disconnection is reflected in behavior inhibition that may be observed at the presentation of a stimulus associated with potential punishment or non-reward.

The fourth and final sub-system is Arousal System 4 and it is generally based around the Reticular Activation System (RAS) whose general function is to increase or decrease general arousal. This system is referred to as *general arousal system* and has a reciprocal relationship to the *effort system*. General arousal has the ability to inhibit motivational arousal (Boucsein & Backs 2008; Routtenberg, 1968).

Both the Boucsein (1992) and Gray (1982, 1987) models held that different parts of the brain were held responsible for mediating these two different reactions of fight or flight and behavioral inhibition. These models suggest that unconditioned aversive stimulus or non-reward US are processed largely in the amygdala, resulting in fight or flight behavior and conditioned fear stim-

uli that result in behavioral inhibition activate processes in the hippocampus. In the new model (Gray & Mc Naughtorn 2003) fight, flight or freeze and BIS were differentiated based on the context in which the stimulus is presented. If the situation were one that involved an all-out avoidance to potentially aversive stimuli, fight, flight or freeze is activated. If however, the subject is placed in an approach-avoidance dilemma, the BIS then activates.

It is clear that there are separate fear and anxiety processes in the amygdala (Le Doux 1996; Gray & McNaughton 2003). It is possible the hippocampus, particularly the ventral hippocampus (which has strong connections to the amygdala) contributes to *amygdala arousal* rather than controlling the decision aspects of anxiety. If this is the case, the hippocampus is still the controlling feature, and does so by acting on the amygdala.

Polygraph Test Questions and Conditioning

Relevant Questions

Earlier theories (Davis, 1961) suggested that consciously appreciated fear might have become a conditioned response associated with the relevant questions because of the fear and arousal experienced by the perpetrator at the time of the commission of the crime. Thus mentioning the crime in a question was a conditioned stimulus associated with the fear felt while engaging in the crime act. However, that view has been generally dismissed as at best incomplete and naďve, as some criminals may not be fearful during the criminal act and this explanation cannot apply to laboratory settings where no fear is involved in perpetrating the mock crime. Nevertheless, we propose that classical conditioning may well be involved in many PDD examinations, including laboratory studies, but different processes are involved.

People are social creatures and for the most part seek the approval and acceptance of their fellow humans (Ruch 1953, Rathus 2001). Most children are taught from an early age to equate honesty with honor and goodness. They learn that dishonesty is frowned upon and are often punished for lying. In most Western societies lying in formal settings such as in discussions with a person in a position of authority is frowned upon and in many cases such lying is punished severely when it is discovered (for example, lying to a federal law enforcement officer during the course of an investigation is a felony in itself.) Milgram (1963) suggests there is deal of potential anxiety associated with openly breaching such societal rules (Buck 1985).

In our view self-awareness of the act of lying can cause the test questions to function as the conditioned stimulus. Over the course of a lifetime the

fear, conflict and anxiety associated with lying may well in most, if not all, people have created a significant amount of conditioning. Just the possibility of getting caught in a lie and/or the punishment associated with being caught can generate anxiety. Thus even during an acquaintance test and/or in a laboratory setting (where there is little jeopardy) the act of lying may create substantial anxiety or conflict responses, and associated physiological sequelae. This is not to say that associated current consequences are without power or importance in any complete conceptualization of PDD. Clearly they are. However, their effect may be primarily in the cognitive pathway and may function independently, but additively with conditioning phenomena. Moreover, other cognitive processes are also likely to modulate these conditioning phenomena. Anticipation may certainly come into play, but most likely does so at a more conscious level.

During the testing phase of the polygraph examination the innocent person is not lying to the relevant questions of the examination, and thus the unconscious/emotional/conditioning pathway is not active. The innocent examinee generally wants to take the test to prove their innocence. There is no lying to the relevant questions and thus there is no unconscious conditioned fear response. This is not to say that the cognitive/conscious pathway may not be active as the examinee assesses the likelihood that the examiner will make an error and the consequences of such and error, only that a pathway to response that is likely active for the guilty is not present for the innocent. Also, there is no doubt that conscious anticipation of salient stimuli can exacerbate arousal.

The deceptive examinee is presented with (and has lied about) the relevant questions. They too have to attend to the test questions with the hope that they can pass the test. Both classes of examinee desire a "truthful" outcome, and both must accept the risk of approaching something (test questions) they probably prefer to avoid in order to achieve their hopeful truthful outcome.

Comparison Questions

In Probable Lie Comparison Question tests examinees are encouraged and led to believe that they must deny any transgression similar in nature to the one under investigation (Raskin & Honts 2002). The comparison questions in this case are broad in scope and encompass transgressions that most people would find impossible to honestly deny. The examinee is then led to believe that lying to these questions will result in their being considered a person who would engage in the type of activity under investigation. The innocent examinee has lied during the pre-test when denying comparison question type transgressions. They find themselves maneuvered into lying to the com-

parison questions in order to convince the examiner that they are not capable of engaging in behavior similar to the crime issue. For the innocent, this act of lying would trigger a conditioned fear response through classical conditioning processes. Activity in the cognitive/conscious channel will modulate this response as the person processes the memory necessary to assess the broad comparison questions. Lying to the comparison questions can cause arousal due to conflict, risk assessment, trepidation and anxiety about not passing the test.

For the guilty person, although the comparison question is responded to with a lie, the motivation and memorial context of the test is such that the relevant questions should present themselves as a much more powerful CS as they are central to the test outcome. In a sense this represents a discrimination problem in classical conditioning where a tone closer to the original tone used to establish conditioning will elicit a large, stronger and longer-lasting CR than will a tone more disparate from the original tone.

The Directed Lie Test (DLT) is a variant of comparison question PDD testing in which the examinee is instructed to lie regarding minor transgressions to the comparison questions (Raskin & Honts 2002). During DLT, the comparison questions may cause arousal through the same process of classical conditioning. We see no fundamental differences in the logic of why these two comparisons questions work.

General Discussion

We have presented information to suggest that the fight or flight response is not a satisfactory description of responses observed during polygraph testing. Scientific evidence suggests fight or flight behaviors and behavioral inhibition are mediated somewhat differently in the central nervous system, although there will be considerable overlap in their effects on autonomic output. Theoretically, fight, flight, and freeze reactions do not seem to represent a single construct, and appear to have distinct evolutionary bases.

General psychological theories suggest that we can consider the observable phenomena of response to test questions in the light of behavioral theories such as classical and operant conditioning, other theories involving emotions such as fear or anxiety, within the context of cognitive behavioral theory and also in neurophysiological theory. We would not recommend a simplistic adoption of any of these theories, but favor movement towards an integrative understanding of the role of each of these explanations when we seek to understand PDD phenomena.

In the light of conditioned response theory applied to PDD testing, it seems more likely that the test questions function as a conditioned stimulus than an unconditioned stimulus. Fight or flight responses are found to be activated in the face of an unconditioned fear stimulus, like pain inflicted by a predator. The BIS (freeze) response has been found to be associated with a CS, such as the light warning of an impending shock. When faced with stimuli that warn of impending danger it makes good adaptive sense to freeze and possibly escape the predator's attention. Importantly, the BIS is driven by the conflict created by activating the two systems of approach and avoidance. This conflict creates arousal via the hippocampus that either directly affects or contributes to anxiety in the amygdala. This is different from the traditional fight, flight or freeze paradigm.

The conceptual separation of fight or flight responses from freeze responses fits nicely with theories of different arousal systems (Boucsein & Backs 2008; Gray & McNaughton 2003). We have attempted to make a distinction between emotional and cognitive paths of arousal incorporating them into the "parallel path" conception from our earlier work (see Handler & Honts 2008). Whether arousal is reflected in different psychophysiological patterns by either of these branches has yet to be determined. There are physiological measurements (heart rate variability and EDA recovery times) that have shown promise in their ability to discriminate between a fight or flight (affect arousal system) response and a BIS (effort system) response (Boucsein & Backs 2008). It may be prudent to investigate these variables during PDD testing with an eye towards discriminating fight or flight from behavioral inhibition.

It may also be possible to exploit the phenomenon of habituation in an attempt to differentiate between areas of the brain controlling processing. Orienting is merely determined by the amygdala, while the hippocampus plays a major role in habituation (Boucsein, 1992). LeDoux's work with rats (1990, 1996) found that there was a "quick and dirty" neural link from the auditory pathway in the thalamus to the fear-controlling systems in the amygdala. He postulated that this immediate transmission served to get the rat's attention. The monosynaptic transmission did not transmit a great deal of information, but it sent a fast warning signal to the animal. The information bypassed the usual cortical-thalamic pathway that traditionally gives full meaning to the stimulus. This pre-attentive arousal has been linked to the orienting response (OR) and described as a high pass filter (Graham, 1997). Graham (1997) states that the purpose of the pre-attentive processing is to interrupt any current processing, initiate sensory intake and engage a protective gating that is postulated to prevent processing of weak stimuli. Once the animal's attention was aroused, it could conduct a more thorough neural investigation of the stimulus.

During PDD testing, this cortical-thalamic pathway would obviously play a role as the examinee would have to process and recognize the test question. It is unlikely that Le Doux's "low road" of direct connection from the auditory thalamus to the amygdala is what causes arousal during polygraph testing. Examinees hear the question and process the meaning. This processing often occurs before we finish speaking the question, but generally incurs some latency while the examinee recognizes the stimulus. If the examinee has lied during the pre-test interview and question review, the presentation of the stimulus and the recognition of the act of lying can create the CR. Indeed it is not even necessary for the examinee to utter the lie during the polygraph, as has been demonstrated by the "silent answer" variant of test question presentation. Truthful and deceptive examinees can produce reactions to test questions which they have lied about (without necessarily responding verbally) through classical conditioning.

We submit that there are a number of potential causes for arousal during PDD testing – some functioning consciously, others subconsciously. In our earlier work (Handler & Honts 2008) we started to clarify our understanding of arousal observed during PDD testing. We began by analyzing work from other disciplines that could help shed light and continue to explore areas outside of the polygraph for our answers. In this paper we examined the work of scientists in those sister disciplines that closely relate to the polygraph.

Our first goal in this paper was to submit that the act of lying, either explicitly during the test or implicitly during the question review, can function as a CS. We suggest that this CS occurs unconsciously and automatically and is related to emotion associated with the act of lying (fear, guilt, embarrassment, conflict, anxiety etc.) Our second goal was to review the work of neurobiologists and psychologists in search of theories that relate to arousal observed during PDD testing. We believe that we found examples of such theories in the work of Gray (1982, 1987), Gray and McNaughton (2003), Boucsein (1992), Boucsein and Backs (2008) and Le Doux (1996). A number of the physiological and psychological aspects of the effort system (Boucsein & Backs, 2008) or BIS (Gray and McNaughton) seem highly congruent with those of PDD testing. In both of those arousal theories, arousal to CS and to US is mediated differently by the brain. The amygdala is generally held responsible for fight or flight responses, while the effort system or BIS include the hippocampus.

While we continue to lack a higher and purely psychological explanation for PDD responses, we are not alone. Other branches of behavioral science are faced with the same challenge and shortcoming in their ability to clearly delineate higher level processes. Psychophysiology is particularly impoverished

in theoretical development. Years ago when the polygraph profession sought an explanation for what was measured, they embraced the current scientific knowledge and conjecture of the time. We have attempted take advantage of the advances made in neighboring scientific disciplines that directly relate to PDD and offer the capability of enhancing our understanding of the psychological and physiological basis for observable responses to PDD test stimuli. It is through a continued search for the most parsimonious psychophysiological explanations that we will solidify our understanding of the construct validity of PDD testing.

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