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# Social Exclusion and the Hierarchical Defense System: Comment on MacDonald and Leary (2005)

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G. MacDonald and M. R. Leary (2005) hypothesized that physical pain and social exclusion share many affective features in common. In this comment, the author discusses the implications of J. A. Gray and N. McNaughton's (2000) hierarchical defense system model, which MacDonald and Leary used in the development of their theoretical claims. Issues are discussed that require, at least, clarification; but more substantive problems need closer consideration of hierarchically organized defense. It is argued that research findings may be better understood (a) by systems of interacting neural modules, which lead to state dissociations between affective states, and (b) by general modulatory influences on the entire defense system that lead to trait associations (i.e., personality) between physical pain and emotional distress.

Everyone has experienced physical pain and emotional distress. A person may prick a finger or have a serious injury, and a person may hear a critical comment from a friend or grieve the loss of a loved one. One does not usually consider these affective states to be the same, or indeed very similar. MacDonald and Leary (2005) attempted to show that physical pain and one form of emotional distress, namely social exclusion, share much more in common than typically thought. They noted that emotional distress is often verbalized in pain-related terms (e.g., *hurt feelings*, *broken heart*). According to their hypothesis, these observations reveal something important about emotional distress in general and social exclusion in particular: They share affective qualities and motivations that are mediated, in part, by the same neural circuits.

Many fundamental issues are raised in their article, and the details of their hypothesis are based on a long and rich experimental literature. At the outset, it should be stated that MacDonald and Leary have addressed an important issue, with theoretical and applied applications. In this comment, I focus on issues that need clarification and problems that may be better tackled from the perspective of the entire defense system, not selective parts of it. In particular, what is the precise overlap of physical pain and social pain and under what conditions do these relations change? Clarification of this literature should throw new light on the neuropsychological nature of one major form of socially derived emotional distress, namely, social exclusion.

In building their hypothesis, MacDonald and Leary (2005) discussed parts of the hierarchical defense system model of Gray and McNaughton (2000), which makes explicit links between neural systems mediating physical pain and the various forms of emotional distress (principally, fear and anxiety), including social exclusion. I consider the implications of the entire Gray–McNaughton model for their hypothesis, contending that, in parts, this hypothesis has substantial empirical support but that, in other parts, it needs elaboration and refinement.

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## Assumptions: Agreement and Disagreement

It is helpful to first clear the grounds by identifying points of agreement and disagreement.

### *Evolution of Emotion*

MacDonald and Leary (2005) made a strong case for the evolution of the affective states associated with social exclusion. It may be assumed that this threat to viability and fecundity influenced the natural (and possibly sexual) selection of the emotions and behaviors associated with being excluded from social groups and the resulting withdrawal of protection and resources. However, it does not necessarily follow that emotions and behaviors related to threat (i.e., potential punishment), as opposed to physical pain, resulted in threat-related emotions being closely coupled to the (preadaptive) affective states of physical pain. The origins of language, which are probably based on preadaptations of physical signaling, are not tied to this foundation phenotype, although people often make bodily gestures when verbalizing—a theoretical analysis that attempted to explain language in terms of bodily gestures would be found wanting. In the context of evolution, the association of physical pain and social exclusion (a complex emotion) may be seen in a similar light.

However, the strength of MacDonald and Leary's hypothesis lies in its attempt to unify affective reactions that are often seen to be at opposite ends of an aversive dimension. As I discuss in this comment, there are links between the different forms of emotional distress and physical pain, but the forms that these links take are complex and dependent on dispositional and situational factors. Arguably, the assumption of homology, if only in parts, between the affective states of physical pain and social exclusion may conceal more than it reveals.

### *The Pain-Related Language of Social Exclusion*

MacDonald and Leary (2005) argued that the language of social exclusion in particular, and emotional distress in general, reveals a deeper reality, namely that such distress is built on a preadaptation

of a physical pain system. As I write this comment I am in physical pain (from soft tissue damage to my back as a result of a fall); and in common with most people, I have experienced various forms of (relatively mild) emotional distress. Following MacDonald and Leary's strategy of quoting personal accounts, have I learned anything from my own affective states? In particular, how do these experiences compare? My experience of the subjective features (i.e., qualia) of physical pain and emotional distress are not the same, although they both share an unpleasant quality and influence avoidance motivation. Within a broad approach–avoidance classification, they could be identified as similar or, at least, very distinct from the experience of approach emotion and motivation; but even within the avoidance dimension, they have different affective and behavioral consequences. Far from experiencing emotional distress, my involuntary affective reaction to my back pain has been resigned annoyance and irritation (i.e., lowered thresholds to aversive stimuli)—although, as I discuss below (see Sensitization), my defense system has been "primed" for other negative emotional states.

Verbalizations (or thoughts) may be positively misleading, reflecting an economy of language that reduces emotional distress to concrete terms (e.g., *hurt feelings*)—possibly serving a communicative function. Linguistic incompetence is seen in verbal emotional expression (Corr, 2001)—people are often lost for words to express their feelings—and this alone could account for pain-related verbalizations. Calling emotional distress emotional "pain," or a "deep aching" leaves room for confusion and puts the proverbial cart before the horse. The "deep aching" of my back injury and social exclusion feel very different to me, and, I assume, to other people (however, under certain conditions, they may have many features in common; see *Personality*).

I find difficult to comprehend the assertion that "the aversive emotional state of social pain is the same unpleasantness that is experienced in response to physical pain" (MacDonald & Leary, 2005, p. 203)—it is not for me! I also doubt the claim that "referring to these responses to social exclusion, rejection, or loss as *pain* is more than just a metaphor" (p. 202); and I puzzle somewhat at the statement, "In fact, in our analysis, it is most accurate to say that the affective responses to physical trauma usually described as physical pain are themselves a subcategory of emotional pain, albeit a fundamental one" (MacDonald & Leary, 2005, p. 203). Whatever the truth value of these statements, the affective nature of the term *social pain* needs to be clarified further.

There are similarities between physical pain and emotional distress. The task for MacDonald and Leary is to delineate the similarities and differences between the psychological experience of what one would call physical pain and what one would call social pain.

### *Social Exclusion or Emotional Distress?*

The general form of the specific hypothesis advanced by MacDonald and Leary (2005) seems relevant not only to the relationship between physical pain and social exclusion but also to that between physical pain and all forms of emotional distress. They argued that threats to social connections "are partly mediated by the same system that processes physical pain because the pain system was already in place when social animals evolved adaptations for responding to social exclusion" (MacDonald & Leary, 2005, p. 202). Accepting the truth of this statement, then many other forms of emotional distress would similarly be related to physical pain. As I emphasize in this comment, there is more than a grain of truth in this position, but it is a vague claim that does not specify the degree of overlap, either with the pain system or with other forms of "social pain" (e.g., embarrassment, shame, guilt, and jealousy).

Focus on only one form of emotional distress, and a rather complex one at that, is bound to lead to problems of interpretation. Focus on a simpler emotion such as fear would have been desirable. In particular, consideration of various forms of emotional distress and physical pain would help to provide convergent and discriminant validity to their hypothesis. Do fear and anxiety have the same associations with physical pain as social exclusion?

Given the assumptions of a hierarchical defense system, which MacDonald and Leary seemed to endorse in their discussion of the Gray–McNaughton model, it is undesirable to take only one form of emotional distress, especially one so complex as social exclusion, and attempt to relate it to physical pain. Theoretical problems are almost inevitable. The remainder of this comment elaborates on this crucial point.

## Two Dimensions of Hierarchical Defense

The Gray and McNaughton (2000) neuropsychological model of hierarchical defense is based on two fundamental dimensions (for a summary of this model, see McNaughton & Corr, 2004). The first dimension is categorical, resting on a distinction between (a) behaviors that remove an animal from a dangerous environment and (b) behaviors that allow it to enter a potentially dangerous environment. Two parallel neural systems mediate these different defensive functions, one controlling fear and one controlling anxiety, respectively. The second dimension is continuous, applying equally to both fear and anxiety, resting on a functional hierarchy that controls defensive behaviors in relation to "defensive distance" (i.e., actual or perceived distance from threat). A neural hierarchy controls behaviors appropriate to different defensive distances.

One strength of this two-dimensional formulation is that it covers essentially all of the conventionally recognized defense-related disorders (panic; phobias; and the various anxiety disorders, including those relating to social exclusion, e.g., separation anxiety). It is important to note that within this formulation, social exclusion is not a simple threat and is not solely related to fear. Furthermore, this model distances social exclusion from physical pain because the latter is part of a fear system, whereas the former is part, to some extent, of an anxiety system—as discussed below, often these systems are in opposition: In some crucial respects, social exclusion is unlike physical pain.

## Three Systems of Emotion and Motivation

The Gray–McNaughton theory, which provides a substantial revision of the *behavioral inhibition system* (BIS) proposed by Gray (1976, 1982), postulates three systems. The *fight–flight–freeze system* (FFFS) is responsible for mediating reactions to all aversive stimuli, conditioned and unconditioned. A hierarchical array of neural modules composes the FFFS, which is responsible

for avoidance and escape behaviors. It is important to note that the FFFS does not mediate anxiety—it is associated with the emotion of fear. The *behavioral approach system* (BAS) is responsible for mediating reactions to all appetitive stimuli, unconditioned and conditioned. In general terms it mediates the emotion of "anticipatory pleasure." The third system, the BIS, is not sensitive to punishing stimuli per se—this is the responsibility of the FFFS—but is responsible for resolving goal conflict in general, and conflict between the BAS (approach) and FFFS (avoidance) in particular. This process of goal conflict generates the state of anxiety. The BIS inhibits prepotent conflicting behaviors and initiates risk-assessment scanning of memory to resolve the goal conflict. Subjectively this state is experienced as worry and rumination and a feeling of possible danger or loss.

In defensive situations activation of the BIS (anxiety) depends on simultaneous and equal activation of the FFFS and BAS, and the BIS resolves conflict by recursively increasing the valence of negative associations until conflict is resolved in favor of either FFFS-mediated avoidance or elimination of the perception of threat. During this process, the FFFS is activated by the BIS, and activity in the entire defensive system is increased. It is thus easy, indeed conceptually tempting, to relate fear and anxiety to a single defensive system and thus to physical pain (which, as shown below, is part of the FFFS). However, the price of this decision would be obfuscation of a number of important distinctions.

For example, when defensive distance is low, then the FFFS panic response (i.e., undirected escape) comes close to resembling affective reactions to physical pain, although the identity of these states must still be questioned; but, with longer defensive distances, does the same relationship hold? If the painlike emotion recedes with lengthening defensive distance, then does this not undermine the central assumption of MacDonald and Leary's (2005) hypothesis? That is, do affective states elicited by social exclusion resemble physical pain in some important respects?

### *Neural Structures*

The neural structures of the Gray–McNaughton defensive hierarchy range from, at the top, the prefrontal cortex to, at the bottom, the periaqueductal gray (PAG). At the lowest level of the FFFS is the PAG, which mediates, in addition to pain, undirected escape/panic; then above this level of control is the medial hypothalamus, responsible for directed escape/phobic escape; and at the next step up is the amygdala, which controls active avoidance/phobic avoidance; and above the amygdala is the anterior cingulate, which is assigned a more complex active avoidance that requires a greater degree of anticipation and a less tight temporal linkage of warning stimuli with actual threat than the amygdala (e.g., as seen in obsessive–compulsive disorder).

For sure, higher level processing does not imply less involvement in basic features of defense; for example, the anterior cingulate is involved in the perception of pain, the production of anger, Pavlovian fear conditioning, and avoidance learning. It also deals with fundamental outputs of the FFFS, and is involved in stimulus inputs that may be as complex as guilt. Thus, fear-related emotions and the affective aspects of physical pain are related to some extent.

In contrast to the neural structures mediating the FFFS, the BIS involves the septohippocampal system (responsible for goal conflict processing) and the amygdala (responsible for emotional activation). The distributed nature of the neural structures subserving FFFS functions updates Gray's (1971) earlier assertion of a single punishment mechanism underlying the "fear equals frustration hypothesis" (however, at a higher order of conceptual analysis, punishment sensitivity remains an important construct in terms of the sensitivity of the whole defensive system, conceptualized as perceived defensive distance; McNaughton & Corr, 2004).

### *Personality*

As noted by MacDonald and Leary (2005), the same personality factors (e.g., introversion–extraversion) are related both to physical pain and emotional distress. But, what do these associations imply?

The Gray–McNaughton theory unifies the separate defensive neural modules within an integrated defense system, which works effectively by having inhibitory links between modules. The whole defensive structure is affected by slow-action pharmacological systems (particularly, 5-hydroxytryptamine [5-HT]) that modulate all levels of the defensive hierarchy—this gives rise to the role played by 5-HT agents (especially the selective serotonin reuptake inhibitors) in many affective disorders (it also explains the role of 5-HT genes in trait dimensions of general emotional distress; e.g., neuroticism; Flint, 2004; Lesch, Greenberg, Higley, Bennett, & Murphy, 2002).

Trait differences in personality reflect these general modulatory processes and conceptually reflect perceived defensive distance (Corr, 2004; McNaughton & Corr, 2004). In contrast to these trait effects, state activation of specific neural modules (e.g., PAG) may not be related to personality dimensions (although they may be related to lower order factors of special importance in psychiatric disorders). Sometimes, state (chronic) activation spills over into other neural modules, finally leading to system-wide changes in the whole defensive system, leading to a long-term change in personality. This account implies that even when different emotions are mediated by different neural systems, the overall system (including subsystems) is innervated by common pharmacological influences. Thus, personality factors are expected to be associated with physical pain and all forms of emotional distress, including social exclusion.

This theoretical approach helps to account (a) for the extensive comorbidity found among psychiatric disorders, supported by quantitative genetic studies (Kendler, Prescott, Myers, & Neale, 2003); (b) the relative specificity of such disorders; and (c) their links to physical pain.

## Defensive Approach (Anxiety) and Social Exclusion

Social behavior is sufficiently complex that different aspects of it must be controlled at multiple levels of the defense system. Social exclusion is a complex phenomenon. It can be perceived as an immediate threat, but it also has an important conflict component; indeed, it may be defined in terms of conflict: The excluded individual wants to rejoin the group and is likely to approach the group in the knowledge that this is potentially dangerous behavior (ex hypothesi, BIS mediated). The Gray–McNaughton theory highlights the need for inhibitory links to exist between the neural modules. For example, (fear-related) active avoidance needs to be

inhibited when (anxiety-related) cautious approach is appropriate (e.g., foraging in a new environment). Under many conditions, physical pain (FFFS–fear system) and social exclusion (BIS–anxiety system) will be opposed.

Thus, within the Gray–McNaughton framework, it is important for MacDonald and Leary to state when social exclusion is related to FFFS–fear, when it is related to BIS–anxiety, and when it is related to both. Given acceptance of the Gray–McNaughton model, clarification of this issue has a direct bearing on the relationship of social exclusion to physical pain.

If the emotion of social exclusion is considered a form of anxiety (which in some, if not most, situations it must be) then physical pain and social exclusion are, in some fundamental respects, opposing defensive behaviors and emotions, not positively related ones. To engage in anxiety-related cautious approach behavior, the FFFS–fear system must be inhibited: Cautious approach is not possible when avoidance motivation is strong. Such inhibition is suggested by the phenomenon of relaxation-induced panic, sometimes experienced upon the commencement of sleep (Gray & McNaughton, 2000): A reduction in anxiety releases inhibition on the FFFS, and thus the PAG panic response is disinhibited. Conversely, there is reason to believe the physical pain of self-injury is effective in reducing anxiety, putatively resulting from the inhibition of the BIS by the FFFS, as well as higher levels of the hierarchy within the FFFS (this further points to a dissociation of physical pain and FFFS-related fear aspect of social exclusion).

It is difficult to relate the complex and changing situational parameters (e.g., defensive distance, approach strength) of social exclusion to one defensive control system, and it is no less easy to relate it to the lowest control system of physical pain. Physical pain is distributed across structures, from PAG to cingulate cortex, but so too are other forms of emotional distress: Why not also relate it to fear and anxiety? By focusing on its relationship to physical pain only, its important relationship to other emotions is ignored. This partial view of the defensive literature may only serve to obscure the true relationship between the affective states of physical pain and social exclusion.

## Sensitization

MacDonald and Leary (2005) presented evidence to show that social exclusion can both lower and raise pain thresholds, which seems contradictory. However, on the basis of the above analysis, these observations start to make sense.

There is an important way in which physical pain (mediated by the PAG of the FFFS) and social exclusion (putatively mediated by the BIS–anxiety system and/or higher levels of the FFFS) are similar. Activation of the FFFS activates the BIS under conflict (e.g., as seen in social exclusion), and BIS activation stimulates the FFFS. In this circumscribed sense, the emotional distress of social exclusion shares the emotional state associated with the FFFS, including physical pain: The whole system is on heightened alert and a diffuse negative emotional state is engendered.

In addition to this acute process, chronic activation may lead to a process of sensitization of the whole defense system. 5-HT and norepinephrine innervates all levels of the defensive hierarchy, and personality differences may be conceived in terms of differences in these modulatory influences, the values of which can be altered by sensitization. This process may account for the personality differences observed in physical pain and emotional distress.

For example, there is evidence from posttraumatic stress disorder, which contains a cluster of separate fear and anxiety disorders reflecting not a single disorder but a change in the pharmacological modulation of the entire defensive system. Posttraumatic stress disorder patients show the whole range of pathological defensive behaviors appropriate to defensive distance (McNaughton & Corr, 2004). In this respect, they have undergone a change in their position on the major dimensions of personality (introversion–extraversion and neuroticism) due to changes in the sensitivity of their entire defensive system.

As noted by MacDonald and Leary, acute stressors can activate the analgesic response, revealed as higher pain thresholds. This process makes good evolutionary sense, as pain-induced "licking of wounds" is not adaptive when faced by immediate threat. But then it is noted that extraverts (not introverts), who are relatively insensitive to aversive stimuli of all kinds (Corr, 2004), have higher pain thresholds. These data are compatible with the view that acute stressors elicit reactions that are different to chronic stressors (Dickerson & Kemeny, 2004).

### *Personality*

At any one time, reactions to stressors differ among individuals. For example, when exposed to examination stress, immune system natural killer cells (that attach to certain types of tumor cells) are activated in emotionally stable individuals but decreased in emotionally unstable individuals (Borella et al., 1999). It seems that some individuals respond to acute stressors as if they were chronic (which, for them, they may well be because of their relatively short perceived defensive distances and continual state of emotional activation). In emotionally reactive individuals (i.e., those high in neuroticism), there seems to be a close coupling of defensive modules as a result of the whole defensive system being on alert. Thus, for some emotionally reactive people, many forms of emotional distress may have more of a physical pain element.

As an example of the value of considering the whole defensive system rather than part of it, the role played by appetitive motivation in defensive reactions needs to be considered. Much experimental research shows that the BIS can inhibit the BAS, and vice versa (for a review, see Corr, 2004). The fact that social support leads to increased pain thresholds could be interpreted as inhibition of the FFFS by the BAS: Being verbally supported and physically touched are quite different, yet they can have the same effects. Although physical touch does reduce pain, perhaps by activation of large-diameter fibers, the same cannot be said of verbal or social support that is perceived and mediated by the BAS. Thus, it is difficult to interpret (nonphysical) social support in terms of a physical pain system. Space prevents adequate discussion of these inhibitory effects between the BAS and FFFS/BIS. Suffice it to say that BAS activation by perceived social support should inhibit all levels of the defensive hierarchy, not just the perception of pain.

The relationship between personality and different forms of aversive and appetitive motivation is complex. Research has pointed to the necessity of considering the joint influences of the FFFS/BIS/BAS systems; focusing on parts of the system is prone to produce inconsistent and puzzling findings. Arguably, the problems raised in MacDonald and Leary's (2005) article, which they

themselves highlighted, result from their focus on only parts of the defensive literature: This outcome is almost inevitable given the nature of this field of inquiry.

### *State and Trait Effects*

It would be appropriate for future work to be directed at dissociating the state effects of physical pain and emotional distress (and between the various forms of emotional distress), reflecting the activity of specific neural systems and trait effects of general sensitivity of the whole defensive system. Dissociations should be observable in within-subject variance, reflecting specific (especially inhibitory) interactions in the defensive hierarchy; but associations should be observable between subjects, reflecting excitatory interactions and general sensitivity of the hierarchical system. This state–trait distinction helps resolve the problems of assuming that physical pain and emotional distress are either fundamentally the same or different affective states. In different respects, they are both. A similar Janus-faced approach is seen in different people: Individuals high in neuroticism are likely to have more closely coupled defensive modules than those low in this trait because their entire defense system is in a heightened state of alert.

## Testing Systems: Possible Experimental Tests

Challenge tests can be used to test the activity of the different neural circuits thought to underlie specific emotions. The major problem is to devise tests that circumvent the interconnectedness of structures. As discussed by McNaughton and Corr (2004), the experimental isolation of a system requires challenge under conditions of nonactivation: Once activated the entire defensive hierarchy is involved, and under these conditions only trait effects of a more general nature are observed.

With respect to the PAG, what is required is a stimulus maximally activating this region accompanied by minimal activation of other parts of the defense system. The aim of this challenge is to identify which individuals have a hyperactive PAG when the rest of the defensive system is nonactive. As the PAG controls fight and flight reactions to impending danger, pain, and asphyxia, it should be possible to determine threshold levels of carbon dioxide reaction in vulnerable individuals. Assuming the same regions of the PAG are involved, it would also be desirable to relate carbon dioxide thresholds to pain thresholds. If individuals highly reactive to social exclusion could be identified, then MacDonald and Leary's (2005) hypothesis would seem to predict a set of strong reactions to these challenge tests. This would provide convergent validity to their hypothesis.

It would also be desirable to provide evidence of divergent validity. PAG-relevant challenge tests could be compared with anxiolytic sensitive (anxiety) tests, for example affective modulation of the acoustic startle reflex, which is sensitive to the arousal component of the amygdala but not the hippocampus. Enhanced startle to aversive stimuli should be observed if social exclusion is BIS-mediated and dissociable from FFFS–fear (although in this respect, the involvement of the PAG has not been adequately tested—it is known to be implicated in the basic startle reflex). With respect to challenge tests to the septohippocampal system, mediating goal conflict without the arousal component of emotion, spatial navigation, delayed matching to sample, or behavior on a fixed-interval schedule of reward may be used (McNaughton & Corr, 2004)—delayed matching to sample need not involve any anxiety, thus circumventing the potential spillover of anxiety to the FFFS.

If hyperactivity in the septohippocampal system and/or amygdala could be isolated from pain thresholds and other PAG challenge tests, then this would provide compelling evidence for the fundamental state dissociation of physical pain and social exclusion. However, when the entire defensive system is activated then indices of physical pain and social exclusion should be expected to be positively correlated, and it should be possible to estimate trait (personality) differences between subjects. There is the problem of being able to define, in precise-enough operational terms, "individual highly reactive to social exclusion": If it is a compound of separate fear and anxiety emotions, then this might not be possible.

An alternative strategy that overcomes this methodological problem of defining low and high social exclusion-sensitive individuals is to observe patterns of brain activation during the elicitation of emotions relating specifically to social exclusion. Functional neuroimaging (e.g., functional magnetic resonance imaging) could be used to determine patterns of neural activation: (a) under non-emotion-inducing challenge tests and (b) under different emotion-induction conditions (e.g., social exclusion vs. immediate threat). Within the limitations of spatial resolution, this research strategy has the benefit of allowing the partialing out of other specific emotional states and of general activation of the defensive hierarchy.

## Conclusion

MacDonald and Leary (2005) made a strong case for linking the affective states of physical pain and social exclusion—and, by inference, physical pain and emotional distress in general. Their article raised many fundamental issues that should lead to theoretical clarification. Further knowledge of the links between physical pain and emotional distress hold important implications for therapeutic understanding and intervention, and to this end MacDonald and Leary's article serves an important purpose. This comment has raised issues that require clarification, as well as more substantive theoretical problems that may need to be considered within a more integrated model of hierarchically organized defense.

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