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**Thinking Back to Linking: Neuroscientific Correlates of Bion’s Theories of Thought and Object Relating**

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‘Failure to eat, drink or breathe properly has disastrous consequences for life itself. Failure to use the emotional experience produces a comparable disaster in the development of the personality’ (Bion, 1962a).

**Introduction**

A number of efforts are being made to bridge psychoanalytic literature with the developments in neuroscience, allowing for increased sophistication and enrichment in both realms. Prenatal and early life factors lay down the foundation for how the environment and sense of self will be subsequently negotiated. Neuroscience has provided an understanding of how particular neural circuits are strengthened based on environmental conditioning. The ability a person will have to cognitively bind limbic-cortical input, through inhibitory control, informs whether interoceptive and exteroceptive signals will be modified into something ‘thinkable,’ or whether avoidance strategies will be employed, be them behavioral, affective, or cognitive. If early life adversity informs that there is something potentially dangerous or untenable about engaging the thinking apparatus to deal with uncertainty, a template of avoidance may become the norm, resulting in a narrowing of one’s understanding and an intolerance of knowledge.

In object relations theory, there is a close alignment between the notion of the internalized dyad, tinged with a fantasy element, and that of the working model highlighted by attachment theorists. It is a conceptual common ground among many different theories how the earliest object becomes internalized, and whether the child will emerge with a basic sense of safety regarding the world (thus allowing for exploration and discovery of one’s own sense of self with the scaffolding of an other who serves a containing observing role, what Winnicott termed ‘primary maternal preoccupation’) (Winnicott, 1958). Within the realm of early experiential integration, making sense out of a massively complex world into which the child is thrust requires an object into which he or she can deposit anxieties and uncertainties, and have these be adequately processed and contextualized.

This contextualization will be multifaceted and necessarily titrated according to the child’s cognitive developmental level and ability to ‘take back in’ what the caregiver is providing. It is here that Bionian concepts become key. The interpersonal component of thinking is fundamental in Bion’s theory. He speaks of the apparatus of thinking as something necessary to deal with thoughts (i.e., as reality impinges itself on one’s sensory apparatus, it becomes imperative to develop strategies to harness the fullness of what the person is being forced to negotiate). Beta-elements, ‘sense-impressions related to an emotional experience’ (Bion, 1962 (1978)), connect a person to the greater world. It is the alpha-function of the caregiver which initially give scope and meaning to these impressions, as the child cannot make sense of them on his own, thus projecting through body language and inchoate verbalizations his state of mind.

The psychobiologically attuned caregiver (Schore, 2003) will perceive these communications, and digest them in a way that tells the child that they have been understood and can be thought about without succumbing to the incipient terrors they could potentially represent. If beta-elements cannot be turned into thought by one's alpha-function, the projection may be thrown back into the child, resulting in confusion, impotence, and the sense of the other’s impenetrability (Bion, 1959, 1962b). Within this paradigm, the ‘good enough’ caregiver serves the function of containing the fullness of the child’s developing sensorimotor and cognitive quandaries, while serving as a model for optimal metabolizing of the child’s inner world but without excessively forcing his or her own mind into the equation, thus allowing the child a level of freedom to safely explore one’s own individuality and the world to be discovered, while knowing there is a container nearby.

Importantly, the desire to ‘know’ may be either strengthened or shattered as a result of the child’s experiences, as knowledge (+K) will be looked upon as something which can serve to edify one’s sense of self and ability to discover the world and the objects populating it in a consistent and safe manner, or it will be avoided (-K), given its associations with affectively painful experiences which eluded the caregiver’s metabolizing capacities. It is within the matrix of the mother-infant dyad that ‘the earliest and most primitive manifestation of K occurs’ (Bion, 1962a).

**The neurobiology behind the choice to evade or modify experience**

The amygdala matures very early on (some primates have some amygdala nuclei fully developed at birth) (Chareyron et al., 2012, Payne et al., 2010), and conditioned responses to stimuli are expected to be established at a very young age, dictating approach or avoidance behaviors to significant environmental elements. The hippocampus provides contextual and spatial data to these interactions with the environment (Tallot et al., 2016), and as episodic memory is established, there is a greater frame of reference which allows for the immediate salience-based response of the amygdala to be tuned down in light of the hippocampal contribution. It has been shown that the amygdala and the hippocampus can mutually inhibit each other, allowing for either a more affective or cognitive basis for processing stimuli, shifting the balance towards dealing with the world through one’s visceral, fight or flight system, or through higher cortical functioning which allows for an attunement to emotional responses, but avoids being overwhelmed by them.

 Early development being marked as it is by complex sensorimotor appraisal, it would be quite helpful for the hippocampus to allow this context to be present from early on. As it is, early memories formed within the hippocampus are erased by subsequent ones, which is a prevailing hypothesis regarding the phenomenon of infantile amnesia. The hippocampus seems to reach a more stable volume around the age of four years (Ricardo Insausti, 2010). As such, strong conditioned responses, informed by the amygdala, may be set down as a template early on in life, without the contextual input of memory (thought) to mitigate the more automatic response the individual has to the environment. Importantly, the use of splitting may occur in the context of faulty hippocampal development; this makes intuitive sense given what has been outlined, as the conditioned approach/avoidance signals that the amygdala generates will need to be counterbalanced by hippocampal activity. In cases of emotionally driven memory consolidation, context may be lost, and the all-or-none manner of approaching situations may remain. During the compression of information from the dentate gyrus of the hippocampus to layer CA3, faulty information processing can occur, leading to distorted memories much driven by emotional salience (Viamontes and Beitman, 2006a). It is worth noting that both the dentate gyrus and layer CA3 are areas of the hippocampus which have been shown to exhibit decreased volume in individuals who suffered abuse as a child (Teicher et al., 2012).

Higher cortical processing occurs as communication is routed through the anterior cingulate cortex (ACC), an area of the limbic system which serves to integrate subcortical systems with higher cortical areas. The ‘affective’ or ventral subdivision involves the rostral and subgenual ACC (sgACC), and has a key role in regulating visceral and autonomic responses to stress, as well as assigning emotional valence to stimuli. Given this central role in emotional processing, the ACC has connections with areas of the brain involved with instrumental responses to stimuli (amygdala, brainstem nuclei, periaqueductal gray area - PAG) and the risk/reward processing, ultimately dictating approach or avoidance (nucleus accumbens - NAc, orbitofrontal cortex - OFC) (Devinsky et al., 1995). These regions of the ACC have dense connections with the amygdala, and are important in the process of fear extinction. This occurs along with the medial prefrontal cortex (mPFC), which has similar connectivity (though less robustly) with the limbic cortex, and is also involved in modulating the fear appraisal and response (Etkin et al., 2011). As a more interoceptive and emotionally attuned subdivision, the medial PFC [in particular the ventromedial (VM) PFC] generates a cognitive appraisal of stimuli and informs fear responses in a more balanced way.

The ‘cognitive’ subdivision includes the dorsal ACC, the hippocampus, and the dorsolateral (DL) prefrontal cortex. The DLPFC is an area involved in executive functioning and response selection to cognitively challenging stimuli. Relevant to the purposes of this discussion, the DLPFC is involved in attempts to attenuate emotionally charged information through unemotional strategies (Ochsner et al., 2002), in effect attempting to deal with challenging affective information through excessive cognitive control. In other words, the DLPFC may be preferentially engaged in emotional avoidance strategies, and may lead to a lack of one’s attunement and understanding of his/her own emotions. Indeed, this ‘laterally biased’ circuitry has been implicated in a number of different psychiatric conditions (Crocker et al., 2013, Somerville et al., 2004, Lemogne et al., 2010, Nejad et al., 2013, Shin et al., 2004), all which seem to incorporate elements of maladaptive emotional processing and deployment of cognitive networks which perpetuate negative views of self and/or others. In other words, the limbic cortex dictates that certain situations cannot effectively be thought about, and emotionally based processing and responses to the environment become the norm. As Bion stated, ‘An emotional experience that is felt to be painful may initiate an attempt either to evade or modify the pain according to the capacity of the personality to tolerate frustration’ (Bion, 1962 (1978)). Evasion could be viewed as the laterally-biased circuitry engaged when avoiding the fullness of the emotional experience, while modification may allow for a more integrated approach, something ‘possessed of a piece of knowledge’ (Bion, 1962 (1978)), in contact with but not avoiding that of which the individual is being forced to somewhat make sense.

**Attacks on linking**

As mentioned, the interpersonal aspect of thinking is fundamental in terms of making sense of experience. The more experientially informed right hemisphere develops much faster than the left in the late fetal and early postnatal periods (Taylor, 1969, Thatcher et al., 1987). Indeed, the right hemisphere is fundamental in terms of empathic attunement, as it allows for detection of cues in the faces of others and an appropriate affective response (Yeh and Tsai, 2014). There is a very primitive neural circuitry which becomes activated when looking at one’s child, comprising the fusiform gyrus (facial recognition area), the OFC (measuring risk and reward considerations given an environmental stimulus), and the amygdala (associated with conditioned responses to stimuli, attributing either positive or negative valence to the latter) (Parsons et al., 2013, Kringelbach et al., 2008, Leppanen and Nelson, 2009).

In an attuned mother, interacting with her child is processed as a rewarding experience (release of dopamine in the mesolimbic pathway has been observed during these mother-infant interactions) (Insel, 2003). Importantly, the mPFC is an area in the mother’s brain which becomes activated when her child cries (Laurent et al., 2011). It is indeed noteworthy that it is the same area of the PFC which allows both for an empathic response to one’s child and for cortical regulation of amygdala hyperactivity (as mentioned above). In other words, having adequate connectivity between medial PFC and the amygdala allows for access to one’s emotional state in a controlled manner, not becoming overwhelmed by it; this would also permit the individual to appreciate and reflect on the mind states of others, without needing to resort to strategies of cognitive avoidance or all-or-none thinking.

Infant studies have highlighted the importance of maternal attunement to allow the child to develop secure attachment schema. Maternal misattunement, which may take the form of the mother exhibiting disgust, shame, fear, dissociation, or pain when looking at her own child, is predictive of later disorganized attachment in the child (Beebe et al., 2012). This in effect replicates the notion brought forth of a failure of containment. Beebe and colleagues have done extensive work in microattunements in the mother-child dyad, and have traced how a mother who is unable to take in and process the child’s state of mind may lead to a collapse in affective and sensorimotor control (Beebe et al., 2012). Where the template of disavowed thinking comes into play has been shown both in studies examining neurocircuitry in insecurely attached mothers and in children coming from destructive early environments. When an insecurely attached mother looks at her child in distress, the activated circuitry will be that of dorsally-biased cognitive processing, with increased activation of the DLPFC; also, there is hypoactivation in the ventral striatum and hyperactivation in the anterior insula (Strathearn et al., 2009), indicating that this interaction the mother is having with her child does not elicit hedonic responsiveness, and generates feelings of disgust, respectively; it is this subcortical activation which will elicit the higher cortical strategy of emotional avoidance in dealing with the child, as opposed to an empathic and emotionally receptive caregiver reponse, which (as mentioned) would preferentially activate medial circuitry.

The transmission of this template informed by the organizational effects of the early dyad has been shown in studies of childhood abuse. On a circuitry level, the child internalizes the default pattern of processing stimuli which activates lateral circuitry more readily. In effect, child abuse will lead to hyperactivation of the amygdala and hypoactivation of the mPFC, thus limiting the ability to cognitively process a heightened fear response to the environment (Tottenham et al., 2011, De Brito et al., 2013). In addition, it has been demonstrated that insula hyperactivation also occurs (McLaughlin et al., 2015), an area not only involved in the sense of disgust and shame, but in the experience and anticipation of negative outcomes (Crocker et al., 2013). This, coupled with a decrease in the ability to process rewarding cues (as demonstrated by decreased activity in the globus pallidus) (Dillon et al., 2009), speaks to the frightening and unrewarding lens that tinges interactions with others. Indeed, these findings on a structural level speak to Bion’s reflection on the effects of interacting with an inadequately responsive caregiver:

 ‘Projective identification makes it possible for him to investigate his own feelings in a personality powerful enough to contain them. Denial of the use of this mechanism, either by the refusal of the mother to serve as a repository for the infant's feelings, or by the hatred and envy of the patient who cannot allow the mother to exercise this function, leads to a destruction of the link between infant and breast and consequently to a severe disorder of the impulse to be curious on which all learning depends (…) Furthermore, thanks to a denial of the main method open to the infant for dealing with his too powerful emotions, the conduct of emotional life, in any case a severe problem, becomes intolerable. Feelings of hatred are thereupon directed against all emotions including hate itself, and against external reality which stimulates them. It is a short step from hatred of the emotions to hatred of life itself’ (Bion, 1959).

This also represents a neurobiological parallel to the concept of internalizing the bad object, a learned model of negotiating reality which may in effect become the default for the individual moving forward. The transgenerational transmission of models of parenting, applicable to abusive methods of rearing and which belies the lack of cognitive flexibility noted in individuals with violent personality traits, perpetuates this internalization process in which dyadic models are passed down. This lack of attunement with one’s own subcortical areas or with the complexity of the mind of the other has been demonstrated in conditions associated with mindless destructiveness and polarized forms of reacting to others (e.g., borderline and antisocial personality disorders, both associated with a decreased activity of the VMPFC and an impaired ability to mentalize) (Decety et al., 2013, Berdahl, 2010).

It is at the heart of projective identification to induce in the object the same state of mind that was internalized early on; in effect, it becomes necessary to assail the mind of the other, a vital strategy in order to avoid being thought about. The template becomes a vicious cycle of disappointing interpersonal experiences, predicated on the notion that the disturbing elements contained within are toxic and can only result in a familiar reenactment with a misattuned other.

**Attacks on thinking and frontal adrenergic neurotransmission**

Elevated norepinephrine levels have been associated with aggressive behaviors (Siever, 2008, Caspi et al., 2002). Studies assessing the effects of low-functioning monoamine oxidase A (MAO-A) alleles (leading to elevated levels of the monoamine neurotransmitters, including norepinephrine), have found that an adverse environment, in conjunction with this ‘vulnerability gene,’ can lead to higher rates of violent behavior and antisocial personality disorder later in life (Caspi et al., 2002). In contrast, in the presence of an optimal environment which allows for a subjective sense of safety in the child, the vulnerability gene can actually become advantageous to the child, and the rates of violence and personality pathology are actually less than people with normally expressed alleles (Caspi et al., 2002).

In effect, this indicates that the hypoactive allele can either be a risk factor or a benefit to the individual, depending on the environment. This has led Belsky to refer to the so-called ‘vulnerability genes’ as ‘plasticity genes’ (Belsky et al., 2009), a term which indicates that these genes allow for a greater responsiveness to the environment, whether it be good or bad. Indeed, elevated levels of norepinephrine are not ineluctably associated with externalizing behaviors, but can be associated with prosocial behaviors (Beversdorf et al., 1999), depending on how the neurotransmitter is deployed based on the demands of the environment. This would be in line with the Winnicottian notion of allowing the child an optimal environment in which to discover the range of his or her omnipotence (Winnicott, 1990 (1958)), and allowing for a gradual allotment of reality to slowly establish a more grounded knowledge of one’s capabilities, but (importantly) without the premature impingement of an overbearing environment, what Bion would refer to as the ‘parasitic container-contained’ link (Bion, 1970).

Animal studies have indicated that social isolation and chronic stress can lead to elevated levels of norepinephrine (McCarty et al., 1988). Oxytocin (implicated in mother-infant bonding) can decrease synthesis of norepinephrine in the adrenal medulla, thus providing something of a mitigating effect on adrenal hyper-reactivity (Jovanovic et al., 2016). Human studies indicate that having emotional support has a neuroendocrine effect of diminishing cortisol and norepinephrine levels as well, showing the containing and soothing function a ‘good object’ can have on an individual from a physiological standpoint (Grewen et al., 2005, Ditzen et al., 2007).

Traumatic experiences can lead to excessive release of norepinephrine, and subsequent psychopathology may be marked by an inability to process the traumatic event and mollify subcortical hyperactivation with higher cortical inhibition, leading to a default of reactivity as opposed to thought. Interestingly, the PFC has reciprocal connections with the locus coeruleus (LC; the brainstem neurons responsible for release of norepinephrine), one of the few higher cortical areas to have such a bidirectional feedback. The PFC can decrease the tonic activity of the LC, thus decreasing norepinephrine release (Sara and Herve-Minvielle, 1995). Optimal levels of norepinephrine release are key for appropriate PFC activity, allowing for access to working memory and executive functioning. Norepinephrine interacts with three different families of noradrenergic receptors – α1, α2, and β (Ramos and Arnsten, 2007). Norepinephrine has the highest affinity for the α2 receptor family (Gi-protein linked with a downstream effect of decreased cellular excitability) (Insel, 1993), and α2A is the most abundant subtype located in the PFC (Aoki et al., 1994, Ramos and Arnsten, 2007). Par contre, affinity of norepinephrine for α1 and β receptors is lower (these receptor families have a downstream excitatory effect, being linked, respectively, with proteins Gq and Gs) (Ramos and Arnsten, 2007, Insel, 1993).

Thus, at lower levels of stress, the α2 receptors are preferentially engaged, allowing for access to PFC functioning and, in effect, thought. As the stress level rises and more epinephrine is released from the LC, the α1 and β receptors will start being engaged. This leads to a decrease in activation of the PFC and an adaptive strategy of engaging areas of the brain which are more equipped to deal with a potential environmental threat (e.g., limbic system and posterior cortices). The three subtypes of β receptors (β1, β2, and β3) are located in several extraneuronal locations, but all are present in the central nervous system (Insel, 1993).

As β receptors become more activated, there is increased release of cAMP intracellularly and decreased reuptake of glutamate by glial cells (thus increasing the level of excitatory neurotransmission); this occurs in response to a larger release of norepinephrine due to greater stress levels. As an interesting aside, β receptors are located mainly in the intermediate layers of the PFC, which is where thalamic inputs are directed (Goldman-Rakic et al., 1990). The thalamus serves as a relay station and creates a primitive sensory input which will need further discrimination by higher cortical areas in order to allow for appropriate context and salience to be attributed. Bion’s notion of beta-elements has a similar connotation, as he describes that these elements ‘are not felt to be phenomena, but things in themselves’ (Bion, 1962 (1978)) He goes on to state that, ‘Beta-elements are stored but differ from alpha-elements in that they are not so much memories as undigested facts’ (Bion, 1962 (1978)).

It becomes necessary for the ‘thinking apparatus’ to be engaged in order to make sense of these inchoate input data, something which rings true both for Bion’s conceptual characterization as well as the primitive sensory experience being conveyed through thalamic input onto the β receptors. In both cases, the ability to think needs to be summoned, lest evacuation become the only manner of dealing with beta-elements. It does seem rather prescient on his part that the same Greek letter has been employed to describe a concept which would hold a neuroscientific corollary. A very thought-provoking case was made by Mashour in a paper drawing parallels between the anesthetized and the unconscious brain, drawing from Bionian theory to support the cognitive ‘binding’ and ‘unbinding’ that occurs as sensory data / beta-elements are more or less available to conscious representation and alpha functioning (Mashour, 2008); the greater the disconnect between the thalamic relay nuclei and the higher cortical areas, the more inchoate the environmental data will remain (Laureys, 2005). The thalamus has connections with the amygdala, and can also modulate fear learning and expression through its input onto the lateral portion of the central amygdala, an area which can store fear memory (Penzo et al., 2015). This elaborates on the associative learning circuitry outlined earlier, and highlights how environmental stimuli necessarily need to be processed through the subcortical circuitry which has its foundation established through early cognitive learning through dyadic exchange.

Thus, default modes of processing stimuli require the largely unconscious knowledge acquired through an individual’s earliest experiences, those which in effect determined the ‘template’ which serves to negotiate later experience. Sensory impressions are generated, and the manner in which they are processed and thought about will be largely dependent on what has been learned about the safety and the ability one has to think a thought. In a way, a parallel could be drawn with Bion’s descriptions of the different manners of thinking (i.e., pre-conceptions, concepts, and thoughts) (Bion, 1962b). If a pre-conception is not met with its realization, the capacity to tolerate frustration will dictate how the individual handles it. Bion utilized the example of the absent breast, and that frustration can either be modified or evaded (Bion, 1962b). Taking his theory further, when a template is established in the mind of the individual, the lack of correspondence in external reality may lead to the individual needing to attack that reality, as it challenges the assumptions well sedimented from early on.

If someone without the capacity to tolerate thought encounters a thinking individual, the frustration associated with this may be dealt with through attacking the latter individual’s ability to think, something in itself inherently threatening, as it was never modeled by an early containing object. This is where the neurotransmitter theory of frontal adrenergic binding becomes important. In a calm, thinking person, there is a preferential binding of the α2 receptors. If someone is inducing this person to feel frustrated or angry, his or her norepinephrine levels will necessarily rise (Siever, 2008). Thus, brain activation by this neurotransmitter will move to posterior cortical and to subcortical / limbic areas, decreasing one’s ability to sustain complex and abstract thought, and moving to a more ‘survival-oriented’ mode of activation, as α1 and β receptors will be preferentially engaged, as opposed to the PFC (Birnbaum et al., 1999).

It has been shown that preferential engagement of α1 receptors, in addition to weakening the inhibitory function of the PFC, can also strengthen amygdala activity (Ferry et al., 1999), heightening the emotion-based processing of a given situation, as opposed to relying on cognition. This becomes the neurobiological basis for a form of projective identification, as the induced state of heightened norepinephrine release replicates in the other an inability to sustain a thought, resorting to affectively driven responses, a potential repetition of the projector’s own template of being unable to access his or her own thoughts in a manner that doesn’t feel threatening. To quote Bion, ‘Attacks on alpha-function, stimulated by hate or envy, destroy the possibility of the patient’s contact either with himself or another as live objects’ (Bion, 1962a)

**Thinking back to linking – Effects of psychotherapy on neural circuits**

 A number of psychiatric conditions have shown on neuroimaging a ‘lateral bias’ with regards to processing external and internal stimuli. These would include major depressive disorder (MDD), anxiety disorders, and post-traumatic stress disorder (PTSD), all conditions which have a heightened risk in individuals who have experienced early life adversity. Indeed, anxious individuals show an attentional bias towards threatening stimuli, a process which engages the DLPFC and areas of the ACC (rostral and dorsal), and there is a difficulty in disengaging one’s thoughts from these stimuli (Crocker et al., 2013). In addition, hyperactivity of the amygdala and interpretation of neutral or ambiguous stimuli as negatively valenced is shown in anxiety disorders (Somerville et al., 2004), a process which seems to dictate the cognitive apparatus and impair recruitment of other areas of the PFC which may be able to offer some different interpretation (Goldin et al., 2009).

 In effect, thought is kept in the bottom-up direction. Similarly, in MDD, there is an increase in activity in areas associated with emotionally salient stimuli processing, such as the amygdala and sgACC (Victor et al., 2010, Rodriguez-Cano et al., 2014); also, there is preferential activation of the DLPFC over the VMPFC, leading to ruminative negative self-views which the individual has trouble reappraising (Lemogne et al., 2010). In PTSD, there is also evidence of heightened amygdala response and threat processing (Herringa et al., 2013), as well as decreased activation of the VMPFC (Sripada et al., 2012). There is also elevated activity in the insula (Herringa et al., 2013), which may correlate with feelings of self-disgust and shame relating to the traumatic events endured.

 Numerous forms of psychotherapy for the aforementioned conditions have demonstrated that there is a striking similarity in how engaging in ongoing psychotherapy diverts the default network away from the laterally biased circuitry to the medially biased circuitry, creating more of a balance. The ‘entry portal’ for psychotherapy is the very cortical area which is hyperactive in several psychopathological conditions – the DLPFC (in conjunction with the hippocampus) (Viamontes and Beitman, 2006b); this area can also be utilized to reappraise affectively charged memories and, given the appropriately containing setting, can decrease activation of the amygdala and slowly allow the default circuitry to move more medially (Ochsner et al., 2002, Paquette et al., 2003).
 Such effects have been demonstrated in MDD with cognitive behavioral therapy (CBT) (Goldapple et al., 2004) and interpersonal therapy (Brody et al., 2001); in PTSD with CBT (Thomaes et al., 2012, Felmingham et al., 2007), and in anxiety disorders with CBT(Furmark et al., 2002) and intensive exposure (Paquette et al., 2003, Straube et al., 2006). The neurobiological effects of CBT on a number of psychiatric conditions has been systematically reviewed elsewhere (Brooks and Stein, 2015).

A number of studies have also assessed the effects of psychodynamic psychotherapy on neurocircuitry and on monoaminergic transport and receptor availability, with a similar trend being reported in a diverse array of disorders (Abbass et al., 2014, Marini et al., 2016), suggesting a common therapeutic mechanism of altering limbic and prefrontal cortical areas. Panic disorder is characterized by diminished engagement of the mPFC and OFC (Javanmard et al., 1999, Graeff and Del-Ben, 2008), with greater activity noted in the central amygdala, insula, and the PAG (characterizing the heightened state of dread and fear, with limited ability to access thought) (Mobbs et al., 2007, Sakai et al., 2006). Four weeks of inpatient psychodynamic treatment for patients with panic disorder resulted in diminished limbic and increased ventral PFC and OFC activity (Beutel et al., 2010). In patients with somatoform disorder, multimodal psychodynamic psychotherapy (which included individual and group psychodynamic therapy, in addition to other modalities, such as art and music therapy) resulted in improvement in measures of empathy (relating specifically to anger) in treatment responders, which itself correlated with improved modulation of the parahippocampal gyrus (a component of the ventral subdivision discussed previously) (de Greck et al., 2013). This author also demonstrated a normalization of the reward processing circuitry in somatoform disorder patients (de Greck et al., 2011).

In patients with borderline personality disorder (as mentioned), there is heightened amygdala responsiveness and a decrease in the activity of the VMPFC; Lai et al. performed SPECT scans on five patients diagnosed with borderline personality disorder, validating the aforementioned findings, when patients were scanned prior to treatment in a stress-inducing setting (hyperperfusion was noted in limbic areas as well as posterior and inferior cortical areas, with less perfusion of the PFC, which was hypothesized to inform difficulty with emotion and behavior modulation) (Lai et al., 2007). The authors highlighted the patients’ defensive functioning maturity, therapeutic alliance, ability to control impulsiveness, self-destructive behaviors, and affective instability. Two patients completed the proposed protocol of 16 months of weekly psychodynamic therapy, and allowed for repeated SPECT scans to be performed. Improvement on the five clinical parameters were noted, and imaging, though still different from the control group, revealed greater activation in the frontal cortex, suggesting greater limbic modulation and less perceived stress.

There has also been evidence of neurobiological change with psychodynamic therapy in patients with depressive disorders. The study by Buchheim et al. assessed the effects of 15 months of psychodynamic psychotherapy in unmedicated depressed individuals, and demonstrated (on functional magnetic resonance imaging – fMRI) a decrease in amygdala and sgACC hyperactivation in response to treatment; the study indicated a decrease in mPFC activity in treatment responders, but it would appear the study looked more at dorsal areas of the mPFC as opposed to the VMPFC (Buchheim et al., 2012), and this would correlate with a decrease in ruminative self-referential thought, a function of the dorsal medial PFC (Gusnard et al., 2001). Importantly, sgACC hyperactivity may be a predictor of response to psychodynamic therapy (Buchheim et al., 2012); this is particularly germane given that this brain region is involved in poor self-esteem, feelings of guilt, and emotional repression (Schmeing et al., 2013), thus allowing for psychodynamically informed treatments to access areas of the brain elicited in the empathic response.

Additional fMRI studies have shown the efficacy of psychodynamic therapy in diminishing limbic and subcortical hyperactivity in unmedicated patients undergoing treatment for eight months (Wiswede et al., 2014) and three years (Fischmann et al., 2013). Still with regards to depression, SPECT imaging has also been utilized to assess monoamine reuptake and availability in particular regions of the brain. One study demonstrated that a patient diagnosed with a depressive disorder (as well as presumptive borderline personality disorder), after undergoing weekly psychodynamic therapy for one year, showed normalization of serotonin transporter (SERT) density in the mPFC, which correlated with clinical improvement (Viinamäki et al., 1998). This is quite relevant to the present discussion, given that PFC control over the responsiveness of the amygdala is dependent on optimal density of SERT in the frontal cortex (Volman et al., 2013).

A study utilizing PET imaging compared 16 weeks of psychodynamic therapy with fluoxetine (up to 40mg/day) (Karlsson et al., 2010). A remarkable difference between the two modalities was noted in the mPFC and OFC; in the psychotherapy group, greater binding of the serotonin receptor 5-HT1A was observed, statistically separating from the medication group and showing a correlation with clinical improvement. 5-HT1A is an inhibitory serotonin receptor which decreases the cortical tone of glutamate (an excitatory neurotransmitter), as well as its input onto subcortical structures, thus allowing for an anxiolytic effect and greater cortical processing. The authors later correlated this effect on 5-HT1A with an improvement in social functioning capabilities, furthering the concept of internalizing the function of the benign object (Karlsson et al., 2013).

The implication of these effects is that there is less evasive cognitive bias in dealing with stimuli, which heavily favored the DLPFC in a rather inflexible manner driven by amygdala hyperactivation. Through successful psychotherapy, it is possible to allow for the VMPFC to be engaged and decrease limbic hyperactivity (Paquette et al., 2003). The presence of a containing other who can facilitate the process of revisiting distressing memories and emotions is highly relevant across psychotherapeutic modalities, and indeed finds robust grounding in neuroscientific findings. It speaks to the notion that the therapeutic alliance is indeed a very powerful element in the room.

**Concluding remarks**

This paper attempts to add to the unfolding dialog regarding how one’s genetic endowment is in constant interaction with the environment to determine the shaping of neural circuits. Early life experiences induce epigenetic modifications and can lead to selective strengthening of neural pathways deemed necessary for survival. This kindling may establish default activation patterns when subsequently faced with particular stimuli to which conditioned salience is reactively ascribed, determining the approach-avoidance strategies to be adopted.

The enactment of internalized object relations finds a corollary in the subcortical and neuroendocrine reactions taking place in response to interpersonal dynamics throughout life, as mounting pressures emerge to minimize novelty and re-create established templates. The Bionian theory discussed parallels the current understanding about how developing circuits can be kindled to tolerate or avoid negotiating stimuli through cognitive tools. A further resonance applies to the degree of allowance given to the mind of another to aid in metabolizing distressing, inchoate perceptual information, or if interpersonal links need necessarily be disavowed in conjunction with one’s thinking apparatus.

Just as emotional experiences cannot be conceived of without taking an object relationship into account (Bion, 1962a), the neurobiological dimensions illustrated indicate that ‘linking’ and ‘thinking’ mutually inform one another, and that in effect to attack one implicates attacking the other. This has been suggested by Bion in his delineation of the concepts of L, H, and K, affirming that to ‘K’ an other necessarily will imply a linkage and a ‘doing something’ to this other (Bion, 1962a). The psychotherapeutic task of bringing the unthinkable into a cognitive realm engages cortical areas which are also involved in fundamentally interpersonal dynamics (e.g., theory of mind, empathic attunement), which harks back to the mother-infant dyad. It is through the engagement of the ventral system which allows for a more thorough emotional reappraisal and a lessening of affectively driven conditioned responses, decreasing maladaptive cognitive control mechanisms to cope with stressful situations. This speaks to the relational element of therapy, as the presence of someone in the room with the patient, who will not turn away from the emotional chaos which has adaptively been avoided over time, allows for the patient to revisit information and indeed to think about it for the first time.

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