

Brainspotting: Sustained attention, spinothalamic tracts, thalamocortical processing, and the healing of adaptive orientation truncated by traumatic experience



F.M. Corrigan^{a,b,*}, D. Grand^c, R. Raju^a

^a Argyll & Bute Hospital, Lochgilphead, Argyll PA31 8LD, UK

^b Manor Hall Centre for Trauma, Doune, Stirling, UK

^c 350 West 42nd Street, 17B, New York, NY 10036, United States

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ABSTRACT

We set out hypotheses which are based in the technique of Brainspotting (Grand, 2013) [1] but have wider applicability within the range of psychotherapies for post-traumatic and other disorders. We have previously (Corrigan and Grand, 2013) [2] suggested mechanisms by which a Brainspot may be established during traumatic experience and later identified in therapy. Here we seek to formulate mechanisms for the healing processing which occurs during mindful attention to the Brainspot; and we generate hypotheses about what is happening during the time taken for the organic healing process to flow to completion during the therapy session and beyond it.

Full orientation to the aversive memory of a traumatic experience fails to occur when a high level of physiological arousal that is threatening to become overwhelming promotes a neurochemical de-escalation of the activation: there is then no resolution. In Brainspotting, and other trauma psychotherapies, healing can occur when full orientation to the memory is made possible by the superior colliculi-pulvinar, superior colliculi-mediadorsal nucleus, and superior colliculi-intralaminar nuclei pathways being bound together electrophysiologically for coherent thalamocortical processing. The brain's response to the memory is "reset" so that the emotional response experienced in the body, and conveyed through the paleospinothalamic tract to the midbrain and thalamus and on to the basal ganglia and cortex, is no longer disturbing. Completion of the orientation "reset" ensures that the memory is reconsolidated without distress and recollection of the event subsequently is no longer dysphorically activating at a physiological level.

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Introduction

In this paper we argue that a traumatic experience is not fully integrated, and can give rise to clinical features, when some aspect of the experience has not been available for full orientation towards it. Reconnection with the elements hidden from conscious awareness requires a focus on the visceral sensations evoked by fragments of the memory. We suggest that the visceral sensations and the associated feelings evoked when the traumatic experience is brought to mind are conveyed to higher centres by the older, rather than the newer, spinothalamic tracts. The paleospinothalamic tract is extensively interconnected with the brainstem.

Secondly we propose that this implicates the thalamic intralaminar nuclei as important way stations in the healing process: the projections to the striatum being significant in the resolution of motor impulses and in emotional valence. Thirdly we consider the possibility that truncated adaptive orientation blocks information processing and prevents healing from adverse experiences. We define the truncation of adaptive orientation in terms of neurochemical responses to extreme emotional states: the associated memories are susceptible to reconsolidation with no change in their affective loading. Fourthly we consider that the capacity for multi-level processing in the advanced human brain means that orientation can be truncated at different levels. We consider how Brainspotting [1] and other effective trauma psychotherapies may overcome the obstructions and suggest that orientation and its truncation also involve the intralaminar nuclei. The portion of the processing which is accessible to awareness may be relatively small as much of it may occur below the conscious level. This

* Corresponding author at: Argyll & Bute Hospital, Lochgilphead, Argyll PA31 8LD, UK.

E-mail addresses: frank.corrigan@nhs.net (F.M. Corrigan), dgrand1952@aol.com (D. Grand), rajivraju956@googlegmail.com (R. Raju).

differentiates the immediately subconscious, postulated to be mesencephalic, from the unconscious, in which complex information processing occurs without awareness of it. It is proposed that the pulvinar mediates much of the processing while the relevant information file is held open through gaze fixation binding in the intralaminar nuclei. The integrative approach that involves all levels from the spinal cord to the neocortex provides the potential for full resolution and healing with the previously traumatic memories being reconsolidated without associated distress.

Stages of adaptive orientation: Becoming aware of the nature of a threat

“The Orienting Reflex as a complex functional system includes the integrative activities of different brain areas. Its distinguishing characteristic is that it arises in response to novelty...” [3]. Pavlov apparently considered that the Orienting Reflex developed to inquisitiveness in humans, predicting a link between orienting to novelty and activation of the SEEKING system which had not then been defined by Panksepp [4]. The early work on the Orienting Reflex drew attention to the multiple levels in the brain that were engaged by it. When the many levels have to cope with complex information with a high emotional charge we argue that it is possible for there to be a mismatch which blocks the smooth resolution of the orientation to the new information about the environment. Specifically in relation to trauma, Levine [5] described a number of aspects of orienting behaviours which have been staged by Ogden et al. [6]. The stages may occur simultaneously, rather than sequentially, and include: arousal; arrest; alert; muscular change; scanning; locating; identifying; evaluating; taking action; and, finally, reorganisation. Orienting can refer purely to oculomotor behaviour determined at the collicular level; or to head and eye orienting directed from a cortical level; or to direction of attention which may be either based in the midbrain or in the cortex. We seek to clarify by differentiating the stages according to likely neural substrates and argue that orientation of the self towards emotionally-valenced information recruits these orienting, oculomotor, and attentional systems. Furthermore the multiple levels and systems of the brain involved confer the capacity for truncation of a complete response.

Revising the order of the adaptive orientation response on the basis of the anatomical pathways hypothesized to be essential suggests an additional activation before the arrest and arousal stages. The initial responses are mesencephalic, the later responses are cortical. The importance of intermediate response levels in limbic and thalamic structures is less elaborated.

- 1) Activation/**stimulus selection** occurs when the retinocollicular neurons respond to a potentially salient stimulus in the environment which impinges on the retinotopic map in the superficial layer of the superior colliculus. A visual event is selected from the many available as potentially important and the collicular response occurs within a 100 ms. It may be followed by a covert shift of attention based in visuomotor neurons in the intermediate layer of the superior colliculus [7]. The superficial layer of the SC is in close communication with the intermediate and deep collicular layers where visual information is integrated with signals from somatosensory, auditory and olfactory systems.
- 2) The foveating saccade occurs as the **attention shift** becomes overt – even though this may be outside conscious awareness. The initiation of a gaze shift is preceded by a pause in inhibitory activity on the substantia nigra pars compacta within 100 ms of the stimulus presentation [8].

- 3) **Muscular adjustments for facilitating orienting** are made by the colliculi projecting downwards to the brainstem and spinal cord and to the cerebellum. These can occur without conscious intent or voluntary action to maximise the receptivity of the sense organs to the target object. There are also orienting movements derived from the projections of the superior colliculi to the parafascicular nucleus [9]. Involuntary orienting may be followed by voluntary scanning movements. The cortical coordination of the orienting movements of eyes and head is through the outputs of the posterior cingulate cortex to the cingulate motor area. Another level of control is through the frontal eye fields and premotor cortex which are influenced by the parafascicular nucleus [10]. All levels of activity combine to impose a selection task on the superior colliculi so that the appropriate action is taken [11].

- 4) **Muscular adjustments for orientation and defence.** Looped circuits linking midbrain areas, including the SC and the PAG, with the basal ganglia were described by McHaffie et al. [12]: these can be active at a subcortical level without cortical direction. The ascending projections from the SC or PAG target parts of the thalamus which project to the basal ganglia. These in turn project back to the SC or PAG for sequences of orienting and defence response movements to occur with a life-saving rapidity in circumstances where cortical evaluation could be too slow. The projections from the SC to the PAG are critical for the rapid deployment of defence responses – active or passive [13] – if the stimulus is instantly perceived to be dangerous. The main thalamic regions involved are the caudal intralaminar nuclei, the centromedian–parafascicular complex, which projects to caudate–putamen, nucleus accumbens, and the substantia nigra pars reticulata. The pathway from the ventrolateral PAG to the cerebellar vermis activated during freeze responses during both conditioned and unconditioned fear has been recently described [14].

- 5) The mammalian development of the ventral vagal complex integrates information from cranial nerves to facilitate turning of the head towards a novel stimulus with the appropriate **facial expression and vocalization** [15]. The vagal brake on arousal based in the nucleus ambiguus is immediately removed if active defence is required [15]. Nevertheless the tectospinal adjustment of head and neck position is the primary influence when the stimulus carries a significant and immediate threat. The spinotectal pathway provides the information from the spinal cord which allows regulation of the reflex movements of the head and eyes in response to body stimuli [16].

- 6) **Activity arrest** may occur if the stimulus represents a potentially life-threatening danger if onward progress is maintained. Voluntary movements are slowed or completely stilled, and this is possibly mediated by tecto-thalamo-subthalamic circuits. The subthalamic nucleus provides a “hold your horses” signal to allow time for selection of the optimal response [17]. Although it is often assumed that activity arrest facilitates increased sensory processing it may be instead to interrupt ongoing behaviour which is dangerous. It is better to stop to evaluate an ophidian shape than to step on a live snake.

The GABAergic tail of the ventral tegmental area receives somatosensory information from the intermediate layers of the SC [18]. This area is also described as the rostromedial tegmental nucleus (RMTg) and has an inhibitory effect on the dopaminergic neurons of the ventral tegmental area and substantia nigra pars compacta [19]. The RMTg responds

especially to aversive stimuli by reducing the capacity for rewarding feelings and the ability to initiate movement. There are projections to the RMTg from the PAG, the locus coeruleus (LC) and the parabrachial nucleus and from mesencephalic and pontine reticular formations [18]. The RMTg may therefore contribute to the arrest induced by orienting to aversive stimuli both directly in response to information from the SC and indirectly to sudden changes in arousal mediated by other midbrain structures.

- 7) A **drop in heart rate** is stimulated by the reciprocal projection from the superior colliculi to the cuneiform nucleus in the midbrain reticular formation. The bradycardia occurring during orienting in reptiles and mammals is controlled by the dorsal motor nucleus of the vagus [15] but this must occur after the registration of a stimulus as novel by the retinocollicular path. Korte et al. [20] showed that the cuneiform nucleus is instrumental in increasing blood pressure and reducing heart rate during orienting. This is achieved through the projections of the cuneiform nucleus to the parabrachial nucleus and the rostroventrolateral medulla (RVLM), for the pressor response, and to the nucleus of the solitary tract and the dorsal motor nucleus of the vagus for the parasympathetic fall in heart rate. The cuneiform, solitary tract, ambiguus, parabrachial, tegmental nuclei all project to the intralaminar thalamic nuclei, as does the locus coeruleus [10].
- 8) **Arousal** is generated from the brainstem and conveyed to the cortex through ascending tracts to the thalamocortical mantle and from descending pathways to the reticular formation and other brainstem structures. Scaer [21] emphasized the role of the locus coeruleus (LC) in orienting to a threatening stimulus and the pathway from the LC to the amygdala in establishing a memory of the emotionally-charged experience. The LC becomes active <100 ms after stimulus onset. As there are no direct projections from the SC to the LC it is possible that either a defence response, through the PAG, or an increased drive, through dopamine or acetyl choline systems, is needed before arousal occurs. Influences of the SC on the LC are mediated by the PAG and by the pedunculopontine and laterodorsal tegmental nuclei. The locus coeruleus then increases arousal through noradrenergic innervation of the cortex; it inhibits GABAergic sleep-promoting activity and activates cholinergic wakefulness activity in the basal forebrain; it inhibits GABAergic neurons of the ventrolateral preoptic area of the hypothalamus to maintain wakefulness; it has an excitatory effect on the serotonergic dorsal raphe nucleus to promote wakefulness; it activates the amygdala and hippocampus for emotional memory formation and retrieval; it inhibits parasympathetic nuclei and activates sympathetic nuclei; and it projects to some of the sensory and motor nuclei of certain cranial nerves [22]. The LC projects to sensory neurons in the spinal cord, perhaps to inhibit the processing of sensory information if the situation requires that rather than continuing increased openness to potentially salient sensory stimuli. The LC also projects to spinal cord motor neurons for increasing muscle tone and to the sympathetic nuclei for specific organ activation [22]. Both arousal and autonomic nervous system changes are being initiated by LC activation. Brainstem noradrenergic, cholinergic and serotonergic systems all project to the intralaminar thalamic nuclei [10]. Cholinergic mesopontine projections to the anteroventral thalamic nucleus activate cingulate areas [23]. The ascending reticular activating system can be defined as a non-lemniscal projection from the reticular formation of the brainstem and from several brainstem nuclei to the intralaminar nuclei. The brainstem nuclei contributing to this pathway include the locus coeruleus, the dorsal and median raphe, the pedunculopontine and the parabrachial [24]. Much of this paper is therefore about non-lemniscal activation of thalamocortical projections. Other pathways for a sudden increase in **arousal** include the projections from the SC through the ventral medial thalamic nucleus to the neocortex; or from the SC to the gigantocellular reticular nucleus [25]. The nucleus gigantocellularis has excitatory responses to all sensory modalities and contributes to motor and emotional reactions through projections to all levels of the spinal cord and midbrain, pons, basal forebrain and medial thalamus. Some of these neurons even bifurcate so that they can influence higher and lower structures together [26].
- 9) **Identifying and evaluating.** The projection from the SC to the pulvinar conveys information to the amygdala which can further activate the LC if the signal matches stored emotional memory of threat. There is also evaluation in prefrontal cortical areas [27]. Both the basolateral and central nuclei of the amygdala project to the PAG for deployment of defence responses and associated autonomic changes when the situation requires them. Halgren [28] differentiated simple orienting from an Orienting Complex which involved the amygdala in a response to stimuli which had cognitive significance. The amygdala response was between 100 and 200 ms and the impact on awareness was probably between 200 and 400 ms. The interaction with the hippocampus provides contextual information very rapidly.
- 10) **Alertness (with heightened senses)** may reflect increased attention [29] or be part of the sensorimotor integration in the intermediate and deep layers of the SC with information being collected from all sensory modalities and their cortical processors. The collicular projection to the parafascicular nucleus increases readiness for orienting or defensive action.
- 11) **Alertness.** Parietal activity can be picked up within 100 ms of an unexpected visual event [29]. Visual streams, for voluntary control of eye movements and for re-orientation to stimuli of emerging salience [30], overlap in the posterior cingulate cortex and in the superior temporal sulcus. Self-relevant visual information is conveyed to the ventral PCC from the parietal, temporal, occipital and orbitofrontal cortices [23]. Groenewegen & Berendse [31] proposed that the midline–intralaminar complex of the thalamus might bring a state of readiness to the entire basal-ganglia–thalamocortical system. This would be especially true for affectively-loaded visceral information in the spinothalamic tracts terminating in the intralaminar nuclei.
- 12) The dorsal visual pathway through the intraparietal sulcus to the anterior insula also communicates a **body feeling**: this happens between 150 and 200 ms after the stimulus [32]. Insular activation in response to ascending spinothalamic inputs during traumatic experience is likely to precede this.
- 13) **Evaluation of the stimulus** occurs through comparison of it with memories stored in the retrosplenial cortex and through valence stored in the subgenual anterior cingulate cortex [23].
- 14) Information in ventral PCC is shared with dorsal PCC and RSC **for multisensory awareness of the head and body positions** in relation to the visual stimulus [23].
- 15) The dorsal PCC drives the caudal cingulate motor area to make **complex head and body movements** through projections to the spinal cord and supplementary motor areas [23]. (This may be why the eye position for the Brainspot is first

identified with the head still as the SC are engaged but can then be gazed at with the head turned towards it when the cingulate levels are enlisted.)

- 16) **Intentional behaviours** are derived from the rostral cingulate motor area [23]. This stage corresponds with that described by Menon and Uddin [32] in which the anterior cingulate cortex links with midcingulate and other motor areas to facilitate voluntary actions. However at times of danger the efference cascade from which a behavioural response is selected from the mass of information flowing downwards from the cortex is dependent on selection in the SC [11]. There is also recent evidence that the midbrain pedunculopontine tegmental nucleus is involved in learning associations between actions and predicted outcomes [33]. “(B)rainstem systems have a sophisticated capacity to analyse incoming sensory data, understand that input in terms of what is already known and, if appropriate, make an immediate decision to act” [34].
- 17) The brainstem, the cingulate motor areas, the visceromotor prefrontal areas and the cortical projections to the PAG act to provide a **unified defence response** with integrated autonomic, behavioural and emotional components.
- 18) The lateral part of the intermediate grey layer of the superior colliculus is essential for efficient hunting of insects in the rat. Lesions of the lateral SC leave rats unable to quickly orient to prey and their predatory behaviours become clumsy and inefficient [25]. There are projections from this area of SC to the PAG, perhaps contributing an affective quality to the hunt; and to the substantia nigra pars compacta, providing access to the complex motor programmes of the subcortical loops through the basal ganglia. The compacta projection presumably concerns timing signals for salience detection and similar matters related to basal ganglia learning mechanisms. The influence on the SC then ensures an efficient interaction between orienting to the prey, especially if it is moving, and the stereotyped movement sequences. A continuing episode of activity will require interaction between cingulate cortex and brainstem areas, such as the SC and the pedunculopontine tegmental nucleus, for **complex behavioural sequences of response** to sudden changes in the environment.
- 19) **Reorganisation** of the system to restore the appropriate level of autonomic functioning, arousal and activation. It is hypothesized that truncation of the full adaptive orientation sequence leads to energetic, autonomic and sensorimotor residues which present clinically as anxiety, hypervigilance, tension, depression, and a negative valence on the self which may contribute to dysfunctional, relief-seeking behaviours. Whether this is in part because of a lack of harmony among the multiple levels for orientation in the brain remains to be determined.

Truncated adaptive orientation and the residues which drive the clinical sequelae

Modern warfare employs high velocity weapons which can lead to death and injury before a soldier is even aware of the presence of a threat. He may see his colleague collapse with a fatal wound before he has had time to register the presence of a sniper. Similarly in road accidents, especially when the vehicle is hit from behind, there is no time to register what is about to happen. The orientation to threat response is bypassed and the aversive event is concluded. Orientation to the realisation of what has happened may take much longer. Hypervigilance is one consequence of “an amplified, compulsive version of the orienting response” [5, p. 156] that channels some of the posttraumatic arousal energy into

a constant search for threat. Torticollis and persisting neck pain after whiplash injuries may be somatic residues of orienting movements which have failed to complete [21].

In addition to bypassed orienting responses we suggest that trauma can lead to orientation being obstructed or incomplete through other pathways. For example, intrauterine or neonatal trauma can leave an energetic residue which in later life carries a Brainspot, despite there being no external threat to orient towards. Sudden news of the death of a loved one may carry no external point of visual attention, but the interoceptive activation has an associated Brainspot. In these instances the emotional distress has acquired a specific “place” where it can be closely scrutinised – or avoided. The visceral sensations accompanying the autonomic arousal are transmitted to the cortex via the spinothalamic tracts and also passed to the nucleus of the solitary tract (NTS), the parabrachial nucleus, the PAG, and the hypothalamus for modification of autonomic activity through homeostatic circuits in the brainstem. Sensory information from all modalities is integrated in the intermediate and deep layers of the SC and we hypothesize that the Brainspot is acquired at this level, even if it subsequently accessed through the intraparietal sulcus [2]. Of the SC Damasio writes: “There is no other place in the brain where information available from vision, hearing, and multiple aspects of body states is so literally superposed, offering a prospect of efficient integration” [35, p. 84]. Of relevance to Brainspotting he continues: “In all likelihood, the integrated, in-register maps of the superior colliculus generate images as well – nowhere near as rich as those made in the cerebral cortex, but images nonetheless. Some of the beginnings of mind are probably to be found here, and the beginnings of self might be found here too” [35, p. 85].

Unopposed activation of the sympathetic nervous system would lead to death through hypertensive crisis or arrhythmia so the ventral vagal complex must intervene to prevent arousal being fatal. This allows survival in the face of overwhelming activation but the residual autonomic state is unbalanced: the high-revving engine is only just being held by the intense pressure on the brake. This imbalance – as occurs most obviously in states of tonic immobility – is readily triggered in less extreme but nevertheless distressing forms for years or decades afterwards. Endogenous cannabinoids provide a chemical brake on the glutamatergic activation spilling over in excess during the experience of terror [36] and they may contribute to peritraumatic dissociation.

Orientation can be bypassed, incomplete, obstructed or truncated with residual autonomic and energetic burdens which are experienced as clinical symptoms. These all acquire a Brainspot through the body’s activation of brainstem structures. The basic affects stimulated by traumatic experience – separation distress (PANIC/Grief), RAGE, FEAR, SEEKING safety – all have both PAG and hypothalamic components [37]. If the emotions are not fully resolved after the trauma has passed their associated energy and autonomic changes are stored in a dysfunctional form. “Not resolved” here means that the emotions are repeatedly stimulated in a way which does not promote reduction in intensity over time. The memory is repeatedly reconsolidated without change in the affective loading of it. “Dysfunctional storage” implies a ready activation of body responses which may not be appropriate to the particular contemporary situation. The trauma memories intrude through body changes in ways which make, for example, easy interaction with others impossible. It may prove to be clinically useful to separate out those truncated responses occurring during orientation to a specific segment of a trauma from those occurring when the defence responses have been initiated. The grief response to the unbearable news of a death, which is just too much to take in, has a mesodiencephalic generation with autonomic and energetic impacts. Defence responses are not immediately required but may be implemented in an effort to reduce the pain – getting

angry with the bearer of the news or wanting to run from the situation. This dissociation from the truth may be in part neurochemical – the induction of endocannabinoids or endogenous opioids providing analgesia – but its structural roots are in the organisation of the orienting brain. Brainspotting targets the truncation at the neural level at which it has occurred.

Aspects of the orienting response which may be frozen or truncated by neurochemicals mediating stress-induced analgesia and/or peritraumatic dissociation include:

- 1) **Activation/stimulus selection.** The sensitivity of the tectum to specific stimuli may be modified by top-down influences as has been shown for transcranial magnetic stimulation of the frontal eye fields [38].
- 2) The foveating saccade occurs as the **attention shift** becomes overt and a gaze shift is initiated by a pause in inhibitory activity on the substantia nigra pars compacta. There is here the potential for a Brainspot to be established.
- 3) **Muscular adjustments for facilitating orienting** may be frozen and even a microfreeze could establish an affectively-charged Brainspot if there is PAG involvement.
- 4) **Muscular adjustments for orientation and defence.** These are the stuff of sensorimotor psychotherapy and are recognised as potential determinants of the somatic residues of traumatic experience. There is no doubt that a freeze can occur at this stage and clinical experience is of an associated Brainspot. It is postulated that the analgesic and dissociative effects of endogenous opioids and endogenous cannabinoids contribute to the truncation of a motor sequence which is then stored in procedural memory circuits.
- 5) The **facial expression and vocalization** may be triggered by evocation of the original trauma and the associated vocalization may be an important component of processing, for example, “leave me alone”, or simply “no”.
- 6) **Activity arrest.** The PAG is likely to be the key brain structure, as has been shown in animal models of tonic immobility [39], and it possesses both cannabinoids and opioids for stress-induced analgesia.
- 7) **Arousal** generated from the brainstem in noradrenergic, serotonergic and cholinergic centres is conveyed through thalamostriatal and thalamocortical tracts to the upper structures in the brain. This leads to the establishment of emotional memories which may be procedural rather than episodic and may be at the core of what is unprocessed after trauma. The locus coeruleus can be restrained by endogenous cannabinoids which contribute to protection against over-activation [40].
- 8) **Identifying and evaluating.** The amygdala and prefrontal cortex assist in determining the nature of the threat – whether immediate or completed, proximal or distant. It is postulated that an incomplete resolution of this stage of orienting would lead to a state of prolonged hypervigilance. In the rat cannabinoid receptors are present in the amygdala and in the cingulate cortex [41].
- 9) **Alertness (with heightened senses)** may be incompletely resolved and lead to a state of enhanced awareness – a frozen vigilance rather than a narrow attentional field freeze. Of the available routes to cortex from the SC we would favour the ILN and their role in synchronizing eye movement with attentional demands when orienting to a threat may need to be rapid and attention to the environment sustained.
- 10) **Alertness.** This stage can be obstructed in a way which leads to a prolonged attentional field narrowing, possibly a function of the ILN's involvement in visual awareness [42].

- 11) The **body feeling** is activated through different routes but the primary read-out of the body state is in the anterior insular cortex [43]. It is unlikely that any neurochemical truncation occurs in the AIC. A more fundamental consciousness of the body state may be arising from the pulvinar [11], the ILN, or the mediodorsal nucleus [44] and may be subject to peritraumatic disruption at the thalamic level.
- 12) **Evaluation of the stimulus** provided by the trauma memory may be mis-informed and appear present rather than past, for example. In PTSD the functional connectivity of the thalamus with the anterior cingulate cortex (BA32) and ventromedial prefrontal cortex (BA11) is reduced [45]. This component of information processing, when malfunctioning in PTSD, results in continuing physiological activation when the cognitive appraisal is, due to circumstances or internal conflicts, unable to achieve resolution.
- 13) The cingulate motor areas and the visceromotor prefrontal areas and the cortical projections to the PAG act to provide a **unified defence response** with integrated autonomic, behavioural and emotional components. There is here ample scope for dis-aggregation of the elements of the response in the memory of an event.
- 14) A continuing episode of activity will require interaction between cingulate and brainstem areas for **complex behavioural sequences of response** to sudden changes in the environment. Again there is ample scope for dis-aggregation.
- 15) **Reorganisation** of the system to restore the appropriate level of autonomic functioning, arousal and activation. Truncation of the full adaptive orientation sequence leads to energetic, autonomic and sensorimotor residues which present clinically as anxiety, hypervigilance, tension, depression, and a negative valence on the self. The opportunities for truncation in the multi-level complex orienting which engages sensation, defence, attention, arousal, memory, feeling and cognition are many.

Brainspotting as a therapy for experiences which have not been assimilated

Brainspotting (BSP) is a development in psychotherapy which has been originated and described by Grand [1]. It is a novel way to access the brain's intrinsic capacity to heal disturbances of mental and emotional functioning and therefore deserves intense scientific scrutiny. Such investigation will be able to shed light not only on the pathways into healing but illuminate some of the organic aspects of the distress-resolution process itself – perhaps through the kind of neurophenomenological enquiry applied to preictal states in epilepsy [46]. This is of fundamental importance to the essential nature of any effective psychotherapy which aims for healing rather than symptom-reduction.

Distress which swamps the individual's emotion regulation capacities also disrupts the smooth functioning of the brain's information processing streams. While these have evolved to confer on the human brain an astonishing capacity for information analysis and response generation their very complexity can result in different strands remaining separate. This disaggregation sends error messages into consciousness through unwelcome thoughts, images, affects, moods, and body sensations.

Experiences which have not been assimilated are tagged by a body feeling which feels disruptive or distressing. These are accompanied by a Brainspot – a spot in the visual field at which there is resonance with the body activation. For the identification of the Brainspot by the Outside Window method, the client visually tracks the pointer held by the therapist as it is micro-slowly moved across the client's field of vision horizontally at eye level. This

evinces the reflexive response based on eye position in an activated client and this is observed by the therapist. For the Inside Window method the client tracking the pointer identifies the eye position at which the activation is maximal by subjectively experiencing the increase in body activation at a specific eye position. The Brainspot can also be identified by the therapist noticing the eye position selected by the patient's gaze when talking about distressing material (Gazespotting): for this the therapist will typically check with the client whether it is indeed a spot associated with activation. For all of these methods the identification of the Brainspot is followed by fixation of the gaze in that position so that processing will follow. The Outside Window method provides the most reflexive and least consciously chosen Brainspot and is therefore the most likely to involve brainstem structures.

The therapeutic frame is structured through attention to the body feelings emerging during recall of the disturbing experiences. The therapist's attuned attention to the client/patient focused on the Brainspot further deepens, it is postulated, the activity in the midline prefrontal and insular cortical areas. The emotional aspects of this involve the projections from the ventromedial prefrontal cortex to the midbrain periaqueductal gray (PAG). The **deep somatic attunement** in the therapeutic interaction is critical to the success of Brainspotting and is considered to be part of the treatment frame established before processing flows.

Multiple levels of orienting response

While the basic orienting response is an oculomotor response to a particular stimulus there are more elaborate responses which recruit the intralaminar nuclei of the thalamus and the basal ganglia and cerebellum. Truncation of orienting is postulated to establish subcortical circuits through the basal ganglia and intralaminar nuclei which become readily-followed pathways. These may be dysfunctional and maladaptive rather than always smoothly helpful responses to stimuli. Visual stimuli activate the superficial layer of the superior colliculi but there is then the capacity for an integration with auditory, tactile, olfactory and visceral sensations in the deeper layers of the superior colliculi. These deeper layers project to the midline and intralaminar and mediodorsal thalamic nuclei.

Attention to the level of activation in the body during the setting of the therapeutic frame involves the interoceptive loops through the anterior insular cortex. Body sensations are transmitted to the cortex via spinothalamic tracts which originate in the spinal cord and in the nucleus of the solitary tract [43]. Somatic pain is communicated through a posterior part of the ventral medial nucleus (VMpo) or through the ventral posterior medial and lateral thalamic nuclei, VPL and VPM [47]. However, there are also massive subthalamic projections from the spinal cord back to the midbrain, especially to the periaqueductal gray (PAG), for transmission of visceral noxious information [48]. This returns information to the superior colliculi so that there is scope for looping through the body and the midbrain – especially where the PAG is generating emotional responses. We consider here the subthalamic and indirect spinothalamic flows of information through other brainstem structures.

It is possible that the body feelings encountered during the therapeutic discussion of the traumatic experience are in “as-if-body-loops” [49]; that they are held in cortical body maps rather than tracing their original pathways from the body to the cortex. If this is the case the substrates for healing in Brainspotting may be in the intraparietal sulcus and its memory connections with the posterior cingulate cortex. However the interaction with gaze direction necessarily involves the midbrain if not structures below it. There are also movement impulses, changes in muscular tension, visceral sensations and associated behaviours, such as retch-

ing or changes in breath patterns, which argue against a purely cortical processing. When the projections from the superior colliculi to the pulvinar have parallel projections from the colliculi to the intralaminar nuclei, Brainspotting allows the appropriate information file to be opened – and to be kept open while processing occurs.

“The unconscious”, the subcortical, and the journey of healing

Psychodynamic approaches to the psychotherapy of traumatic experience have focused on the material presented from the “unconscious” and used this in various ways to promote healing. These approaches have been largely displaced by top-down regulatory control techniques such as cognitive restructuring. However as the latter are also not 100% effective in all complex trauma disorders [50] there is still a need for psychotherapies which focus on disturbing clinical features that are not readily down-regulated by force of will or the new perspective provided by a clever rationalisation. This particularly applies to self-defining experiences which occurred at times of brain maturation such as during preverbal infancy.

In psychoanalysis there was initially a focus on abreactive catharsis, “bringing directly into focus the moment at which the symptom was formed, and... persistently endeavouring to reproduce the mental processes involved in that situation, in order to direct their discharge along the path of conscious activity.” ([51]; Freud translated by Strachey 1914). Then free association, interpretation, and feedback were used to overcome resistance and to help the patient rediscover “what he failed to remember” [51]. Subsequently interpretations of transference phenomena were still based in the assumption that recognition of a precipitating event was important for clinical recovery. Deterioration during treatment could occur when the “untamed instincts” were released by the emergence of repressed memories without constraint; an early description of affective overwhelm in response to resurfacing of a memory which had precipitated dissociation at the time of the original event.

In Brainspotting the reaction to the spot is made with no conscious or wilful intent, as is best exemplified by the “Outside Window” method in which the reflexive response during the scan of the visual field indicates where processing will best occur.

“The unconscious”, the (just) subconscious, and the healing process

According to Merker [11] the first person perspective integral to consciousness has its origin in the need for action control as the sensory experience of the perceived world is a highly transformed cortical construct. The first action tendency, to orient towards or away from the stimulus, occurs in the midbrain. Orientation towards a place of safety while simultaneously orienting covertly to a pursuing threat may be a special case of dual orientation relevant to trauma or the unresolved memory of it. Every cortical area has descending projections from layer V pyramidal cells to subcortical targets such as the basal ganglia, the diencephalon, the brainstem and the spinal cord. The midbrain, and specifically the superior colliculus (SC), acts as the hub which funnels the massive information load descending from the cortex into an effector output. This in turn influences cortical function via back projection through the thalamus, for example in the pulvinar, to the cortex. The colliculus which forms the pivot in self-awareness at the centre of an individual's multisensory, phenomenal world is itself outside full consciousness [11]. This would imply that the tectal activity could be at times on the verges of consciousness – just subconscious – and contribute to the feeling of something happening

in the hinterlands of awareness that accompanies successful processing in psychotherapies such as Brainspotting.

Merker [11] quotes from a 1962 lecture by Denny-Brown in which he wrote: “Consciousness is a term that implies a subjective element which the physiologist tries to avoid. The mesencephalic tectum is, however, essential for the reactions we call general awareness, for which it has an initiative function, just as its ventral component, the mesencephalic reticular substance, is vital to organisation of movement. Further, though there is reason to believe that the reactions concerned are at the primitive instinctual level, our experiments indicate that they are the essential substrate for all the more highly developed behavioural reactions... The pericanalicular grey matter of the midbrain has long been regarded as the essential area for brain function in fishes but its role has been thought to have been transferred to the hemispheres in all higher vertebrates... In the primate nervous system this is still the vital centre of the brain. Its more differentiated peripheral layers, the reticulum and tectum, are more essential than the immediately peri-aqueductal core... this small area deserves consideration as the most vital for unitary functioning of the organism. It is the physiological ‘ego’... [52].”

Merker [11] favours the pulvinar as the base for the brain’s consciousness space in which feelings and sensations are experienced. This part of higher-order thalamus is connected with both the dorsal and visual cortical visual streams. It is linked with areas integral to memory processing such as the posterior cingulate and parahippocampal cortices. It is linked with frontal and parietal eye fields and with body awareness areas of insular and orbitofrontal cortices. However in the absence of oscillatory binding with the intralaminar nuclei and their projections to cortex the sensory and motor activities of the pulvinar do not impinge on the individual’s awareness [53]. The pulvinar requires the intralaminar nuclei for sustained attentional effort which an individual can perceive and respond to.

This means that information processing engaging the pulvinar in any sustained fashion will have a parallel projection through the intralaminar nuclei to the basal ganglia and cortex. Holding an attentional gaze on a spot requires especially the central lateral and parafascicular nuclei of the ILN [54]. We argue that the intense body feelings experienced at the time of traumatic experience engage the intralaminar nuclei more viscerally than the pulvinar. The capacity for subcortical loops through these nuclei to be established by procedural learning was described by Alexander et al. [55] and by McHaffie et al. [12]. Purpura and Schiff [42] propose that the ILN and the pulvinar may act together in certain tasks in which sustained attention in working memory is required. They influence layer V pyramidal cells of the cortex which then have their output back to the SC and the ILN. As processing takes time in psychotherapy sessions it may be that the oscillatory activity in the thalamocortical projections to a wide variety of cortical areas is gradually synchronizing during this time.

In summary: The first-person perspective on the world is largely unconscious – consciousness comes in upstream of the colliculi possibly in the thalamic pulvinar [11] although visual awareness may have its base in the intralaminar nuclei [42]. This places the midbrain and its operations in the psychotherapy unconscious and Brainspotting directly accesses this. However “all the gaze-related areas in cortex and basal ganglia that receive the collicular signal via the extended intralaminar complex and higher-order thalamus are bound to reflect the play of the collicular attention/orienting pointers in their operation.” [11].

It is possible that in whatever way the Brainspot is formed by traumatic experience the therapy session frame opens parallel pathways in SC-ILN and SC-pulvinar. If the healing is derived from activity at those levels much of the processing involved feels as if it is just on the edge of awareness – or just outside it. The body feel-

ings pulling in memories involve the SC-mediadorsal nucleus pathway also, again initially outside awareness. The healing proceeds at an unconscious level although the subsequent readout of changed feelings and thoughts is necessarily conscious.

Resonating neurons in the insular cortex during attention to the body feelings

A pyramidal neuron with a soma in cortical layer V has an apical dendrite ascending from the top of the soma and an axon descending from the bottom of it [44]. The axon activates a thalamic neuron and the return of this activation to the originating cortical neuron establishes a thalamocortical circuit or loop. The pyramidal neurons are grouped in minicolumns, structures which have cortical functions through their organisation into columns. The ascending apical dendrites oscillate within a narrow frequency range and generally extend to layer I. Their resonating together at a common frequency in a group of columns can be detected by scalp EEG and the connectivity of two different cortical areas can be achieved through oscillatory activity in the thalamic neurons serving them both. Thus activity in the pulvinar may elicit related activity in separated cortical areas during visual attention, for example in the insula and in the parietal eye fields. In complex mental activities “attention selects a multi-column network whose neural elements are all tuned to a common peak frequency” [44]. Minicolumn resonant amplitudes may be increased by inputs to the thalamus from the superior colliculi when orienting occurs and the required cortical areas, even when some distance apart, are then involved through similar resonant activity in the thalamic neurons common to them. The anterior insula has more and larger layer V pyramids than the posterior insula and this may account for the ability to have a deeper awareness of body feelings with a pronounced emotional component. The sustaining of attention during a psychotherapy session with an intense focus on body feelings would require thalamic activity in areas underlying the anterior insula and the anterior cingulate cortices. In addition to those described by Craig [43] for the neospinothalamic tract are the mediadorsal nucleus and the medial pulvinar. Shibata and Yukiie [56] describe projections to anterior cingulate area 24 from midline and intralaminar nuclei; and projections to area 32 from the mediadorsal nucleus, the medial pulvinar and the midline and intralaminar nuclei. Visceral pain of a physical nature is transmitted to the parafascicular nucleus from where the cingulate projections are mainly to area 24 although some are to area 25 [57]. It is then possible that the anterior insula activity is dependent more directly on resonant activity in the medial pulvinar and mediadorsal nucleus; and **indirectly** on the ILN projections via the anterior cingulate cortex and through sustained attention. This polysynaptic pathway may contribute to the difficulty in accessing the body feelings and body sensations arising in response to trauma memory, their persistence in response to triggers, and the difficulty in sustaining attention in the way required for promoting healing.

The body feeling associated with trauma memory activation and the spinothalamic tracts

Trauma therapy emphasises the body feelings and sensations left behind by the adverse experiences which are then brought to awareness by triggers evocative of the original event. The relevance of the triggers – especially with early trauma – is often not recognised in conscious awareness. In 1990 Kurtz [58] described the incorporation of the body into psychotherapy by a number of different approaches and detailed the application of mindfulness. “It is a matter of staying a little longer, gathering more information and allowing things to happen by themselves” [58]. This assisted

meditation approach to body sensations is also at the clinical core of Brainspotting. Somatic Experiencing [5] and Sensorimotor Psychotherapy [6] are among the ways in which therapists can be trained in mindful body approaches to the treatment of emotional trauma.

Many of the body sensations associated with trauma are much less discriminated than those carried by the advanced, in evolutionary terms, neospinothalamic tract to the insular and anterior cingulate cortices through the ventromedial posterior thalamus. They are often diffuse, bilateral, and with an emotional or affective quality which differentiates them from the specific, defined sensations associated with non-sensual touch. We consider here that the less discriminative medial spinothalamic tract or paleospinothalamic tract, which carries information about noxious stimuli experienced in the body [59], may be more relevant for psychotherapy. (These neurons do not respond to innocuous stimuli other than non-painful taps – which may be important to practitioners of the Emotional Freedom Technique [60].) The receptive fields for these pathways are large and usually bilateral so we postulate that they are more likely to be involved in the chest-gripping, stomach-churning, throat-tightening experiences encountered with trauma narratives.

The involvement of older and newer spinothalamic tracts in the processing of emotionally and physically painful stimuli

Primary afferent fibres from the viscera and deep tissues terminate in the spinal cord, mainly in layers 1 and 5 [61]. Lamina 1 neurons project not only to the thalamus but also to the parabrachial nucleus, the nucleus of the solitary tract, the nucleus accumbens, the hypothalamus, the ventrolateral medulla and the cuneiform nucleus. Lamina 5 may represent a meeting place of pain information from the skin and muscles and inputs from the viscera. It is organised somatotopically and projects not only to the thalamus but to the cerebellum, the midbrain, and the parabrachial nucleus.

The evolutionarily older spinothalamic tract is derived from layers 1 and 5 and from layers 4, 7, 8 and 10 [61]. Lamina 7 has motor and autonomic functions: inputs from motor cortex, the red nucleus, and the PAG; and outputs to the amygdala and hypothalamus, the cerebellum, the superior colliculus, the parabrachial nucleus and the PAG. Lamina 8 neurons, which are involved in movement coordination, have input from the PAG and also project to the PAG and the cerebellum. Lamina 10, or area 10 [61], is also of interest as a potential mediator of affectively-charged information from the viscera as it is activated by somatic and visceral pain and projects to the lateral parabrachial nucleus, the nucleus of the solitary tract, the amygdala, the PAG, and the hypothalamus.

It is from the deeper levels of the spinal cord that there are projections to the intralaminar and midline thalamic nuclei and “It is hypothesized that **the deep neurons are related to aversive behaviors in response to pain... Spinothalamic tract neurons in laminae 7–10 have large, frequently bilateral receptive fields and respond to deep somatic... and noxious visceral stimulation**” ([16, p. 239], bold added). These tracts to the intralaminar and midline thalamus also send collaterals to the medullary reticular formation, the parabrachial nucleus, the PAG, and the nucleus accumbens.

It can be seen that the midbrain has the circuitry for processing much of the visceral components of the emotions generated in the PAG and it is able to modify autonomic outputs according to feedback from the body. There are body–spinal cord–midbrain loops engaged in emotional activity in response to internal or external stimuli which are relatively remote from cortical control.

A separate spinomesencephalic tract passes from laminae 1, 5, 6, and 10 to the deep and intermediate layers of the superior colliculi, the PAG, the cuneiform nucleus, and a number of nuclei

concerned with eye movements. Part of this tract is the spinotectal tract to the superior colliculi for reflex movement of the eyes. The terminations of the spinomesencephalic tract in the PAG are in the lateral and ventrolateral columns [48] and are somatotopically organised to convey information about superficial, deep, and cutaneous pain. This tract also promotes reflex movement of the head and eyes in response to somatic stimuli. The PAG influences cortical activity via the intralaminar, midline, mediadorsal and reticular nuclei of the thalamus. Most of the thalamic projection arises in the lateral and ventrolateral columns of the PAG which may link to the paleospinothalamic tract, “**the polysynaptic ascending sensory system thought to mediate diffuse pain and its associated emotional overtones**” ([48, p. 384], bold added).

The projections of the paleospinothalamic tract to the midline and intralaminar thalamic nuclei: implications for information processing

Instead of the ventral posterior (VPL and VPM) or ventromedial posterior (VMpo) nuclei employed by the lateral spinothalamic tract the paleospinothalamic tract involves some of the midline and intralaminar thalamic nuclei. The central lateral (rostral intralaminar), paracentral (rostral intralaminar), and parafascicular (caudal intralaminar) were the first to be described as components of the paleospinothalamic tract [59]. The other caudal intralaminar nucleus is the centromedian nucleus which does not itself have spinothalamic inputs but is functionally paired with the parafascicular nucleus [10]. Other thalamic nuclei which may have paleospinothalamic tract inputs are the paraventricular (midline), the parataenial (midline), and the nucleus reuniens (midline). With the possible exception of the parataenial nucleus, all of these nuclei of the paleospinothalamic tract **also have inputs from the superior colliculi and the periaqueductal gray**. Most also have projections from the parabrachial nucleus in the pons and there are noradrenergic, cholinergic, serotonergic and histaminergic inputs from the brainstem. We consider the intralaminar nuclei and those of the medial nuclei with projections from the colliculi and PAG (paraventricular and reuniens) to be those potentially important for the affectively-loaded body feeling encountered in treatment.

The thalamic intralaminar and midline nuclei in which the paleospinothalamic tract is terminating have the connections needed for registering the affectively-loaded body sensations described in psychotherapies like Brainspotting. As well as their spinal inputs they are informed by the PAG and the deep layers of the SC where the emotional foundation of the Brainspot is thought to reside. Their outputs influence wide areas of limbic cortex for emotional experience and processing and they induce drive, motivational and motor responses to the stimuli via the basal ganglia.

The intralaminar nuclei of the thalamus: responding to threat

There are species-specific motor routines which need to be deployed immediately at times of danger to ensure safety. A duck alerted to movement representative of a potential predator will take flight in a different way from a human in a hostile environment who confronts danger. Similarly the fight responses of a dog and a human will differ in terms of muscle groups preferentially engaged and movements enacted. These routines can be practised by the young of the species during play fighting and it is interesting that Panksepp [4] emphasises the parafascicular thalamic nuclei for the generation of rough-and-tumble PLAY. The parafascicular nucleus is in the group of caudal intralaminar nuclei, with the centre median, or centromedian, nucleus, implicated in limbic motor functions [62]. This group has outputs to motor and

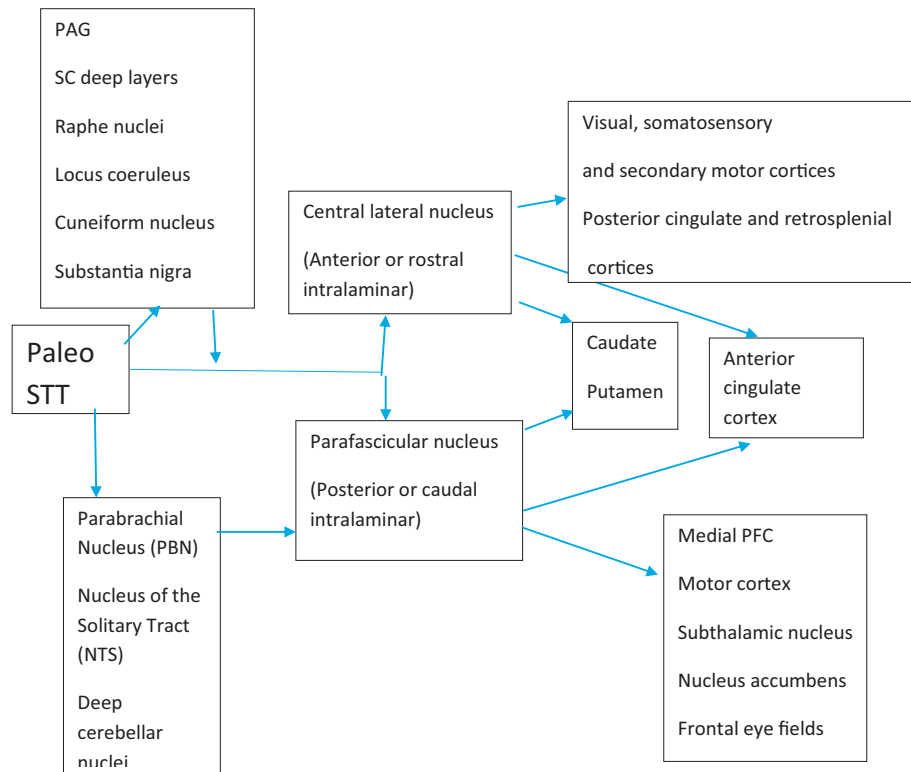


Fig. 1. How affectively loaded information in the paleospinothalamic tract (paleoSTT) can influence orientation, arousal, motor responses, and cognitive awareness and attention through the intralaminar nuclei.

somatosensory cortices and to dorsal and ventral striatal regions. The connections of the caudal intralaminar nuclei confer a role in motor responses to salient stimuli for which cortical processing is potentially too slow. Peritraumatic orienting and defence movements come into this category; and those accompanied by the basic affective responses to trauma engage the caudal intralaminar nuclei in subcortical loops through the basal ganglia as described by Alexander et al. [55]. These same nuclei are also a crucial component of the medial pain system and receive somatosensory information from the intermediate and deep layers of the superior colliculi [63]. Their placement allows them to integrate the cortical and limbic levels above with the brainstem below. They may act in concert with the midline nuclei to raise the level of the entire basal ganglia–thalamocortical system [31]. This is important in terms of the somatic residues of traumatic experience because adversity sufficient to stimulate the noradrenergic, serotonergic and cholinergic systems of the brainstem would increase vigilance, arousal, and the readiness for orienting and defence responses through the midline–intralaminar complex. Sensory information that is more affectively-loaded may be alerting to new and potentially dangerous situations so that the rapid, spontaneous basal ganglia response can occur first and then be rapidly modified by the cortical input. This is dependent on the parafascicular nucleus output to the dorsal striatum.

The parafascicular nucleus has inputs from spinal cord, reticular formation, locus coeruleus, dorsal raphe nuclei, NTS, PBN, substantia nigra pars reticulata (SNpr), zona incerta (ZI), prepectum and striatum. The intermediate and deep layers of the SC project to the parafascicular nuclei [9]. There is a significant input to the parafascicular nucleus from the ventrolateral and lateral columns of the PAG and a lesser input from the dorsolateral and dorsomedial columns. The main output is to the striatum – both dorsal and ventral – and the striatal area served by the parafascicular nucleus receives afferents from prefrontal, entorhinal, perirhinal

and anterior cingulate cortices [64]. There is also a reciprocal connection between the frontal eye fields and the parafascicular nucleus which may be significant for saccadic eye movements [10].

In Brainspotting the inner experience described often includes diffuse peripheral sensations, muscular twitches and motor impulses. These would perhaps fit better with a non-discriminative processing of affective sensory information through the midline–intralaminar thalamic nuclei than the discriminated flow through the dorsomedial and ventromedial nuclei. Vogt and Sikes [65] consider the projections from the parafascicular nucleus in response to a noxious stimulus to induce body orientation through the posterior midcingulate cortex and avoidance behaviour through the anterior midcingulate cortex. There is thus a multi-level motor response that includes, above the brainstem, one from the dorsal striatum and one from the cingulate motor areas. As with orientation the different levels of response available are more likely to result in a failure of integration when levels of affect are very high.

The central lateral nucleus has inputs from the reticular formations, the raphe nuclei, the substantia nigra pars reticulata, the superior colliculi (intermediate and deep layers of the SC [9]), the PAG (all four columns [66]) and the LC. Cortical inputs are from anterior cingulate and retrosplenial cortices but also from some visual, somatosensory, auditory and insular areas. There are outputs to the anterior and posterior cingulate cortices and to the caudate–putamen. The striatum is the main target.

The key intralaminar nuclei are in a position to integrate cortical and brainstem inputs, to have a motor effect through the basal ganglia, and to have a motivational effect through the nucleus accumbens. A functional link between the rostral and caudal ILN is suggested by imaging the impact of deep brain electrical stimulation of the intralaminar nuclei (ILN). Implantation of an electrode into the parafascicular nucleus of the rat leads to increased glucose utilization in the central lateral and paracentral rostral ILN [67] (see Fig. 1).

The paleospinothalamic tract has collateral projections to the reticular formation, the tectum, and the PAG. When double-labeling is used to identify collateral projections to the intralaminar nuclei and the PAG, neurons projecting to the intralaminar nuclei and to the PAG were found in layers 1, 5, 7 and 10 of the spinal cord, but predominantly in layer 7 and area 10 [68]. This is further evidence of there being wiring available for the complex processing of affectively-loaded stimuli in spinal cord, brainstem and thalamic structures which have retained the evolutionarily-older pathways.

The self and the interactions of the superior colliculi with the PAG

Panksepp [69, p. 200] “proposed that the foundation for the self is concentrated in centromedial mesencephalic tissues where all basic emotional circuits converge to generate instinctual survival-promoting behaviours and gut-level affective experiences which may constitute the primordial form of consciousness in mind/brain evolution.” This midbrain area contains “a basic neuropsychic homunculus, grounded in action urges, from which a variety of core emotional *states of being* could emerge.” Self-representation “has to be built upon stable motor coordinates, such as the somatic motor map nestled between the visceral integrations of the PAG ventrally and the somatosensory fields of the SC dorsally”. We consider the basic action urge to be orientation towards or away from a stimulus. An internal sensation would draw our attention towards it in a way which ties in the visual field and the body awareness. The apparatus for this is in the superimposition of the superficial layers of the SC with the intermediate and deep layers. Panksepp, again [69, p. 204–205]: “In the evolution of consciousness, integrated action tendencies, perhaps still reflected in our emotional urges, came before any thought could be generated about how to act.” The PAG and the intermediate and deep layers of the SC project to the intralaminar thalamic nuclei with the paleospinothalamic tract where an early integration of affectively-loaded visceral sensation, orientation to an affective stimulus, and affective response may be channelled into basal ganglia and cortical substrates for complex motor and cognitive programmes.

Autonomic functioning, emotional and physical pain, and the intralaminar nuclei

The parabrachial nuclei participate in autonomic function as they interact with reflex mechanisms based in the medulla and also with higher regulatory centres [70]. With the nucleus of the solitary tract the parabrachial nucleus is positioned for the most basic feelings of pleasure as well as pain [35]. These nuclei receive the sensations from the body which are then given emotional and orienting responses through the PAG and the deep layers of the SC. The parabrachial nucleus in the pons receives inputs from Lamina I of the spinal cord, the source of the lateral spinothalamic tract for viscerosensory information which projects to the ventromedial posterior nucleus of the thalamus [71]. It also conveys information from Lamina I to the amygdala and hypothalamus [72]. Additionally, the PBN has an important pain-awareness or nociceptive transfer of information from the deeper layers of the spinal cord, laminae 5/6, to the intralaminar thalamus. These pain-responsive neurons are found in the paracentral and the parafascicular nuclei [72], have wide receptive fields, and continue to discharge for some time after the removal of the painful stimulus. Their projections to areas of prefrontal cortex involved in the emotional response to pain suggest an involvement in the most unpleasant aspects of nociception which could include the deep painful hurt of emotional distress.

The central lateral nucleus, one of the rostral intralaminar group, receives spinothalamic inputs important for motivational and affective responses to pain [16]. Many of its neurons respond only to the viscera and mediate the attentional, emotional, motor, hormonal, and autonomic consequences of noxious stimuli [73]. Cortical projections from the central lateral nucleus include somatosensory areas. The more discriminated pain sensations travel to somatosensory cortex via the ventral posterior medial and lateral (VPL and VPM) nuclei [73,47] and the posterior part of the ventromedial nucleus (VMpo [43]).

Healing at the midbrain origins of the truncated adaptive orientation

That which cannot be looked at can continue to trouble indirectly through unpleasant sensations, disturbing emotions, and even dispiriting cognitions and self-appraisals. To fully see what is there, to rob it of its power to paralyse gaze before it focuses on that which is intolerable, requires a deep level of attunement between patient and therapist and a liberation of an endogenous healing process. The self is redefined by the altered orientation: what I orient towards or away from is fundamentally changed and with that shift in perspective is the new feeling of who and what I am. The adaptive orientation can occur from the spinal cord to the neocortex and is only complete when all organised layers of the brain, with their templates laid down through the course of evolution, have been harmonised. The memory fragment which provided the access to the stored traumatic material has been integrated into a smoothly functioning system [74]. The self is reorganised from its base in the deep layers of the spinal cord through the brainstem, thalamus, striatum, cingulate cortex and neocortex. Orientation is completed at all levels of the MindBrain and healing that is deep and powerful ensues. Brainspotting provides the setting in which such healing can occur and is therefore an ideal laboratory for neurophenomenological enquiry.

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