Medical Hypotheses xxx (2013) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Medical Hypotheses

journal homepage: www.elsevier.com/locate/mehy

Brainspotting: Recruiting the midbrain for accessing and healing sensorimotor memories of traumatic activation

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ARTICLE INFO

Article history:
Received 4 March 2013
Accepted 8 March 2013
Available online xxxx

ABSTRACT

Brainspotting is a psychotherapy based in the observation that the body activation experienced when describing a traumatic event has a resonating spot in the visual field. Holding the attention on that Brainspot allows processing of the traumatic event to flow until the body activation has cleared. This is facilitated by a therapist focused on the client and monitoring with attunement. We set out testable hypotheses for this clinical innovation in the treatment of the residues of traumatic experiences. The primary hypothesis is that focusing on the Brainspot engages a retinocollicular pathway to the medial pulvinar, the anterior and posterior cingulate cortices, and the intraparietal sulcus, which has connectivity with the insula. While the linkage of memory, emotion, and body sensation may require the parietal and frontal interconnections – and resolution in the prefrontal cortex – we suggest that the capacity for healing of the altered feeling about the self is occurring in the midbrain at the level of the superior colliculi and the periaqueductal gray.

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Introduction: Brainspotting as a therapy for posttraumatic disorders

Brainspotting (BSP) is a development in psychotherapy which was discovered by David Grand [1] in the course of a Natural Flow EMDR session in which slow eye movements are used [2]. When his client's eye movements wobbled and froze David Grand also stopped spontaneously and waited with what happened. The client then processed traumatic material which had not been accessible previously. He followed up this observation in other clients and discovered a similar pattern of processing.

If the traumatic episode being targeted had a prominent visual focus – an attacker's weapon or hate-filled face, for example – it is easy to see how one location in the visual field might become linked with maximum body activation during recall. What is more difficult to explain is the finding that traumatic episodes without a dominant visual feature nevertheless have a location in the visual field, or Brainspot, that is felt to precisely match the somatic disturbance emerging during the retelling of the trauma narrative. It is the activation in the body during remembering and recounting the traumatic event that resonates with the Brainspot. An emotional experience which felt like a kick in the gut or a breaking of the heart may have no external visual correlate but it still has a Brainspot.

This is an original and important way into the body residues of adverse experiences which allows them to process to a healing resolution. We try to explain why interoceptive distress has a location resonant with it – and towards which the gaze elicits additional activation. The spot can be selected by the client's subjective appraisal (the Inside Window method) or by the observation of turbulence in the flow of the eye movements at a particular point of a slow sweep (the Outside Window method). The Brainspot may also be selected when the client's gaze is settled on a particular point while talking about activating material (Gazespotting) [3].

We hypothesize that the orientation to highly emotional, complex information that does not require eye movements towards a stimulus nevertheless involves the basic orienting response in the midbrain tectum. Just as social pain is based on evolutionary advances in systems required for physical pain [4] orientation to social information is based in brain networks originally employed for responding to visual stimuli. We hypothesize that adaptive orientation to information of a distressing nature involves a nested hierarchy [5] based in the superior colliculi and their subcortical loops through the basal ganglia but involving higher levels in the thalamic pulvinar; the amygdala and hippocampus; the sensory cortices; and the anterior and posterior cingulate cortices. Vogt and Laureys [6] describe six stages for the cortical sequence of orientation, including head and eye movement, through the cingulate cortex. Also involved are the frontal and parietal eye fields in the neocortex. The

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http://dx.doi.org/10.1016/j.mehy.2013.03.005

Please cite this article in press as: Corrigan F, Grand D. Brainspotting: Recruiting the midbrain for accessing and healing sensorimotor memories of traumatic activation. Med Hypotheses (2013), http://dx.doi.org/10.1016/j.mehy.2013.03.005

intraparietal sulcus is one of the links between the midbrain orienting and the cortical orientation behaviors and it has connections with the insular cortex for linking with body feelings.

"Outside Window" definition of a Brainspot

When a client discusses an area of emotional difficulty in sufficient depth to allow focus on the body feeling associated with it, the therapist asks the client to track a pointer which is slowly moved in a horizontal line in front of the eyes. The therapist can then find the Brainspot by observing a disruption of the client's gaze. As this may be an eyeblink it is useful to look at recent findings on brain activity in relation to spontaneous blinking. Nakano et al. [7] observed that eyeblinks were associated with fMRI deactivations in the frontal eye fields and the superior parietal lobe, components of the dorsal attention network. The brain areas that control shifts of gaze also control shifts of attention: these are the superior colliculi in the midbrain and the frontal eye fields in the cortex [8]. Suppression of activity in the superior colliculi was induced by blinking whereas there were activations in the anterior and posterior cingulate and insular cortices with spontaneous blinking. These brain areas are also important components of the interoceptive response to emotional memories as is described below. It could be argued that the disruption of focused attention during blinking is allowing assimilation of the emotional and somatic experience by facilitating the emotional and memory functions of the cingulate and insular cortices. When blinking is observed in the Outside Window technique it is picking up the momentary heightening of the internal experience that follows the spontaneous tendency to focus the gaze on what is salient.

Non-visual gaze patterns and memory: looking in while looking out

The spontaneous activation of eye movements and gaze fixations during mental activity with no visual component has been extensively studied by Ehrlichman and colleagues [9]. The movement of the eyes during "search" of long-term memory is followed by a gaze fixation when the information is "located". This is seen as analogous to the search for a salient stimulus in the environment and is based in the same brain structures. Saccadic activity and gaze fixation are connected with memory through medial temporal regions and basal ganglia output to the superior colliculus. Focus on a memory sufficient to induce a sustained activation of the medial temporal lobe inhibits the striatum, with which there is a competitive interaction, and releases gaze fixation neurons in the superior colliculus.

Setting the frame

As in Sensorimotor Psychotherapy [10], Somatic Experiencing [11], Lifespan Integration [12] and, it could be argued, EMDR [13] the Brainspotting frame is based in the body feelings evoked by discussion of the traumatic memory. These are accessed through mindful attention to what is happening inside during the recounting to the therapist of the nature of the presenting problem. The activation is studied carefully and working memory involvement with it is enhanced by it being rated on a 0–10 scale.

Focused mindfulness

The client's attention to the internal process recruits medial prefrontal regions for observing emotions, memories, body sensations and cognitions. Sustained observation of the information files which have been opened by the Brainspotting set-up allows healing change to occur. The Brainspot provides the bookmark or tag on the appropriate information file. The mindful therapist helps to maintain this internal focus by checking on the nature and severity of the activation in the body and allowing it to unfold from within. The presenting complaint is repeatedly referred to until there is no body activation associated with its Brainspot – squeezing the lemon until not a further drop can be extracted. Healing is not imposed by technique but is liberated. When time permits the process is allowed to proceed to completion and the change in state becomes the focus of attention. The resolution of the trauma is accepted with care and patience to give it as much time as possible to rewrite the neural pathways which were previously entrenched in maladaptive and dysfunctional loops.

Dual attunement

Brainspotting's difference from other forms of talking therapy lies in its unique ability to predictably access the brain stem components of the trauma memory during the setting of the frame. Other body-based therapies are effective at a similar level but the ease with which they access the midbrain is dependent on a number of factors not necessarily integral to the treatment modality. The gaze fixation used in Brainspotting (BSP) immediately involves the superior colliculi in the midbrain and this neurobiological aspect of the dual attunement model is specific to BSP. It involves the procedural exploration of the relevant eye positions through Outside Window, Inside Window and Gazespotting. In other words, the BSP therapist is attuning to the client's neurobiology by noticing at which eye positions the client manifests increased, sustained reflexive activity (Outside Window), locating with the client the eye positions where the client "feels it the most" (Inside Window), and noticing the eye positions the client spontaneously identifies by where they gaze when talking about their emotional material (Gazespotting). When one of these three Brainspots is determined, the client is guided to maintain the gaze on the spot or pointer and mindfully observe the internal experience over time (focused mindfulness). The therapist is attuned to the client's neurobiological connectedness with the emotional material accessed through the Brainspot at a primarily brainstem level.

The therapist's gaze has an effect on the client's cortical and subcortical structures. The response of the right anterior insula to being gazed at in a non-threatening way [14] may help to maintain the client's focus on the body feelings attached to the Brainspot. Even if the gaze is not strictly mutual – when the therapist is watching the client focus on the Brainspot – the client's awareness of the therapist's gaze should accentuate the insular response to the framing. Also, increased duration of direct gaze stimulates the anterior cingulate and ventromedial prefrontal cortices of the person being looked at [15]. So when the direct gaze of the therapist is maintained on the face of the client who is focused on the Brainspot there is augmentation of the medial prefrontal activation achieved in the client through mindful attention to processing. Being gazed at while fixated visually on the Brainspot is amplifying the circuits framed via the insula and amplifying the medial prefrontal attention on emerging material. This promotes organization and integration through coalescence of hitherto separated information files.

The other aspect of the dual attunement is less specific to Brainspotting. This is the relational attunement of attending to and tracking the client's experience, listening to the verbal and non-verbal communications. The relational attunement includes the somatic and unconscious interactions between the client and therapist. This promotes the focused mindfulness on all the brain systems activated while the sustained gaze holds the brain stem bookmark. All the higher level processes are changed as they are being held under the focused influence of the neural bookmark. We anticipate that

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the relational attunement will involve a separate nested hierarchy based in the midbrain periaqueductal gray (PAG) but with an upper level in the ventromedial prefrontal cortex.

Orienting and adaptive orientation

A Brainspot is a stored oculomotor orientation to a traumatic experience which has failed to integrate. When it is accessed in treatment there is potential for greater healing of the emotional residues of the unassimilated event. The concept of orienting – an oculomotor response to a particular stimulus/event in external space – has been expanded in relation to trauma by Levine [11] and Ogden et al. [10]. To avoid confusion with the basic orienting response we will refer to the full sequence described by Ogden et al. [10]: arousal; activity arrest; sensory alertness; muscular adjustments; scanning; locating in space; identifying; evaluating; taking action; and reorganizing – as adaptive orientation. When the full sequence fails to complete at the time of the trauma some components are left unresolved and liable to recur when triggered. There is a truncation of the adaptive orientation which has significant clinical effects. The resulting negatively valenced memory is stored with physiological activation that has not been discharged. Accessing the Brainspot in a careful, mindful, way allows the activation to be processed to completion.

External stimuli are detected in sensory systems and can elicit motor reactions, affective reactions and memories within a millisecond time scale. It may be the first or most intense orienting of the eyes in response to the external stimuli which creates the Brainspot for subsequent elaboration of emotions, thoughts, and behavioral impulses to cluster around. Alternatively there may be no oculomotor link with any event but the gaze associated with the trauma memory has acquired a particular direction through top-down cortical influences. A shock which comes from more cortical processing of incoming information, for example news about a sudden death, carries a signature orientation as the inner eye turns to the meaning of the message.

Orienting to an external threat or traumatic event starts in the superior colliculi (SC) in the midbrain. The SC have direct input from the retina but also from the frontal eye fields (FEF), the supplementary eye fields, and the lateral intraparietal area (LIP) or the intraparietal sulcus (IPS). The superior colliculi detect luminance change in the external world and (with the assistance of the basal ganglia and the cerebellum) direct movements towards or away from the stimulus – depending on physical characteristics and/or associations. The superior colliculi are first responders for orienting but that does not necessarily carry an emotional charge: an affective response is one of the consequences only of particular types of activation of the SC – looming, snake- or spider-like movements (Redgrave, personal communication).

The intraparietal sulcus (IPS) has the connections with the memory areas of the posterior cingulate cortex which lead us to favor the IPS-SC axis for the integrative effect of Brainspotting. Brainspotting combines the activated emotional memory, its impact on the self and the oculomotor orienting which has become associated with that memory.

Interoceptive loops

During the set-up of the frame in Brainspotting, the client is asked to describe the presenting problem and then to notice the level of activation in the body. This is similar to the practice in sensorimotor psychotherapy [10] in which the body's response during the description of the problem becomes the starting point for therapeutic intervention. In both Brainspotting and sensorimotor psychotherapy (SP) there is no need to get all the narrative details, or to elicit all the associated negative cognitions, if there is sufficient body activation to open the information file which needs to be resolved. In SP the therapist is actively engaged in mirroring movements, making contact statements, and helping the client to find the action which leads to resolution, perhaps through completion of a truncated defence response. In Brainspotting there is no need to explore impulses to action, only to observe them with the associated sensations as the information processing moves to resolution. The development of Brainspotting was influenced by the somatic experiencing work of Peter Levine [11] in which the energetic residues of traumatic experiences are accessed and discharged. All these approaches are based in the clinical observation that there is a natural process which, if liberated, will lead to healing. In Brainspotting the therapist is engaged in mindful, empathic presence while the client's healing process moves towards completion during the period of gaze fixation.

Awareness of the somatic sensations, emotions, and impulses to action accompanying the trauma narrative 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 [16]. In the thalamus there is a divergence with projections to the anterior cingulate cortex providing a drive, while projections to the insula give rise to the emotional feeling. The feeling becomes more differentiated as the information is passed through the insula from posterior to anterior and then contributes to the core of "the sentient self" [17]. Sensory and visceral information integrated in the sensory network of the orbitomedial prefrontal cortex moves on to the medial or visceromotor network from where there are projections to the emotion-generating areas of the hypothalamus and periaqueductal gray (PAG) [18]. These structures influence the autonomic nervous system nuclei in the brain stem to produce changes in the body which are informed to the cortex through the spinothalamic tracts. This interoceptive loop has the anterior insula as the point of visceral and emotional awareness. The question, "What do you feel in your body when you are telling me about that trauma?" necessarily involves activation of the insula.

The point of interaction of this interoceptive loop with episodic autobiographical memory circuits through hippocampal and posterior cingulate areas is in the ventromedial prefrontal cortex [19]. This visceromotor region [20] is implicated in the clinical action of the alternating bilateral stimulation used in EMDR [21]. The Brainspotting protocol includes auditory alternating bilateral stimulation and an empathic therapist to accentuate the insula-VMPFC limb of the interoceptive loop which projects to the hypothalamus, midbrain and ventral striatum. There are also projections from the insula to the hippocampus and the temporal pole but interconnectedness with the basolateral amygdala [22] is most likely to be relevant to somatic components of emotional memory. The insula also has connectivity with the intraparietal sulcus [23] providing the circuitry for linking gaze with the body sensations.

There is a large sensory projection to the midbrain PAG [24] which may carry information about the visceral components of emotional reactions to traumatic experiences and the kind of deep pain associated with loss. The PAG is also involved in generating these affective responses [4]. The PAG and the colliculi are extensively interconnected so it is possible that the Brainspot is lining up for treatment the precise feeling registered in the midbrain PAG – even if an attenuated version reaches the insula via the spinothalamic tracts.

Orienting and gaze fixation

Objects which make a sudden appearance attract attention and induce a saccade, a rapid movement of the eyes towards them [25].

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This orienting saccade can be followed by a gaze fixation on the visual axis from the retinal fovea through the optical focal point towards the object being looked at [26]. Fixation neurons in the colliculi become more active when they reach their fixation point [27] and microsaccades prevent loss of vision through habituation [28]. This allows maximal intake of information about the object which may constitute a sudden threat. Both saccadic eye movements and visual fixation are initiated in the superior colliculi (SC) [29]. The SC receive projections directly from the retina and project to brain stem nuclei and to the spine, in direct tectospinal tracts, for initiating movements of the head and the eyes and a shift of gaze. They contribute to three-dimensional orienting movements of the head and eyes [30]. The SC contain a map that is topographically organized according to retinal coordinates and this is aligned during development with a sensory map carrying spatial information and an oculomotor map for accurate location of gaze [31]. The superficial layers of the SC project to deep layers where multimodal sensory integration is translated into motor output [32].This superficial to deep connectivity is also seen in post-mortem studies of human brain [33]. The SC are responsible for orienting to olfactory stimuli as well as visual, auditory and somatosensory stimuli [34].

In the cortex of the cat, the posterior cingulate gyrus is active during visual stimulation and during saccadic eye movements [35]. In the monkey, the posterior cingulate neurons which are active during gaze fixation may be carrying information about the angle of the eye in the orbit for spatial orientation [36]. The position of the eye in the orbit and in relation to the head in space is being monitored rather than controlled by the posterior cingulate cortex [36]. Cortical areas with both oculomotor activity and direct links to the posterior cingulate cortex include the intraparietal sulcus. A network surrounding the IPS and including the precuneus, posterior cingulate, retrosplenial and parahippocampal cortices [37] mediates control of eye movements in response to salience in the visual field and volition. Gaze fixation therefore activates the intraparietal sulcus and the posterior cingulate cortex.

Subcortical loops through the superior colliculi

Sensory input to the superior colliculi activates, via the thalamus, the striatum which projects back to the SC through the substantia nigra. The substantia nigra pars reticulata maintains an inhibitory control over the superior colliculi. In contrast, cortical areas project directly to the striatum and loop back to cortex via the substantia nigra and the thalamus. It is conceivable that complex events can have many different segregated loops associated with them. Whether they become integrated or remain separate, may dispose to a conflict among cognitive, emotional, and somatic components of a remembered experience. The selection of which loop is disinhibited to allow action is based in the basal ganglia but can be influenced at all the major relay points of the loop by activity within the basolateral amygdala in the case of a triggered fear response.

Cortical projections to the colliculi: corticotectal systems

In the macaque monkey, there are two distinct corticotectal systems [38]. One system is based in the visual information sent from the retina to the superficial layers of the superior colliculi and mainly involves areas of visual cortex. The visuomotor component, in contrast, projects to the deep layers of the superior colliculi from areas of frontal and parietal cortex and mediates gaze fixation, saccades and the coordination of head and eye movements during orienting. In the human, the intraparietal sulcus (IPS), the equivalent of the monkey lateral intraparietal area (LIP), can inhibit the SC when there is a conflict between the eyes being drawn to a particular stimulus and a need to direct the gaze elsewhere [25]. Voluntary or intentional saccades in humans are heavily dependent on the intraparietal sulcus [39]. A topographical representation of salience within the IPS implicates this parietal area in the response to the direction: "Tell me what point in your visual field matches best with the feeling in your body when your eyes follow the pointer". One of the remarkable findings of Brainspotting is the definite subjective feeling about what location resonates with a particular activation. There is often an objective increase in distress at a particular point.

Thalamic nuclei between the superior colliculi and the cingulate cortex

There are retinal projections directly into nuclei of the thalamus: we focus here on those with greater limbic connectivity. The superior colliculi are connected with the medial pulvinar and with the intralaminar nuclei. The medial pulvinar receives afferents from the deep layers of the superior colliculi and projects to areas of anterior and posterior cingulate cortex. There are also afferents to the intralaminar nuclei from the intermediate and deep layers of the SC, especially from somatosensory neurons [40]. The intralaminar nuclei are involved in orienting and in sensorimotor integration; and their inputs from the brainstem reticular formation and the cholinergic mesopontine tegmentum contribute to activation of the thalamocortical mantle. The intralaminar nuclei connect with all parts of the cingulate cortex whereas the medial pulvinar has specific projections to anterior areas 32 and 25 and posterior cingulate areas 23 (ventral), 29 and 30 [41]. The intralaminar nuclei receive projections from anterior cingulate cortex, area 24, whereas the medial pulvinar receives from posterior cingulate, area 23 [40]. Thus, the medial pulvinar is interconnected with anterior cingulate areas involved in emotion processing and with the posterior cingulate area in which multisensory information is coded for self-relevance. The medial pulvinar also influences prefrontal cortex, superior and inferior parietal lobules, insular cortex and parahippocampal gyrus. It has a distinct projection to the IPS.

A nested hierarchy based in the tectum?

The deep layers of the superior colliculi have inputs from other sensory modalities and their cortical representations. Functional MRI studies of crossmodal integration in humans suggest that the superior colliculi constitute the most significant region for this function while the intraparietal sulcus has a weaker integrative capacity [42]. When the connectivity of the superior colliculi in monkeys is studied by microstimulation of the colliculi during functional MRI several areas of visual cortex are activated in addition to the frontal and parietal eye fields. However, there were also changes in the somatosensory cortex, the primary auditory cortex, the primary motor cortex, the anterior cingulate cortex, and the posterior cingulate cortex [43]. The anterior cingulate cortex is part of the interoceptive loop and the posterior cingulate cortex contributes to self-related memories with an emotional component – and both receive projections from the medial pulvinar. Stimulation of the superior colliculi is being followed by activity in areas of the brain involved in autobiographical memory and in focused attention on these.

The anterior part of the intraparietal sulcus is part of a dorsal fronto-parietal network for the assessment of salience [44] and may direct attention even in the absence of eye movements (covert orienting). The posterior part of the intraparietal sulcus may be more involved with eye movements during overt orienting. In

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Brainspotting linking eye position with what is salient in the attentional field requires anterior and posterior subregions of the intraparietal sulcus.

The posterior cingulate gyrus: linking sensation and memory

Posterior cingulate area 23 has reciprocal connections with the retrosplenial cortex for long-term memory and it transfers information about head and eye movements to the caudal cingulate motor area [6]. After a saccade the coding of the position of the eye in the orbit is dependent on posterior parietal inputs to posterior cingulate cortex. The machinery for linking gaze fixation with memory circuits is therefore available in these parieto-cingulate interactions.

Vogt and Laureys [6] propose a six-stage processing model. Stage 1 involves the ventral posterior cingulate cortex (PCC) in extracting self-relevant information from the multisensory inputs, in part through connections with the subgenual anterior cingulate cortex. Stage 2 relates these inputs to memories through the retrosplenial cortex. In stage 3 inputs to dorsal PCC from ventral PCC and parietal cortex provide information about the orientation of the body – and the self – in space. The caudal cingulate motor area is active in stage 4 to orient the head and body via projections to the spinal cord. Stage 5 involves intentional behaviors. Stage 6 turns the information received and processed into appropriate autonomic and behavioral outputs through projections to the midbrain and hypothalamus. These six stages cover many of the features of adaptive orientation which are disrupted by trauma.

Memory-related imagery

Bringing a troubling memory to mind activates autobiographical memory circuits which have been established through the emotional impact of the events. The basolateral amygdala has inputs to many areas significant in recording emotionally-charged life events such as the ventromedial prefrontal cortex, the posterior cingulate cortex, and the hippocampal and parahippocampal areas. It is also reciprocally connected with the insula [22]. In Brainspotting, as in sensorimotor psychotherapy, the processing is done primarily in the body rather than in the thoughts or feelings.

The mind's eye in which traumatic events and losses can be "seen" is dependent on the precuneus, a medial parietal structure, which has inputs from the visual cortex. The precuneus is activated during the visual imagery associated with a memory [45]. In the macaque monkey, the precuneus is connected with other parts of the posteromedial cortex, especially posterior cingulate cortical areas [46]. There are no significant direct projections from the precuneus to the tectum. However the precuneus has connectivity with the angular gyrus and, through that, with the intraparietal sulcus [23].

The precuneus can be divided into three parts: posterior visual, central associative, and anterior sensorimotor regions [47]. The posterior visual part may have a transition zone to the regions involved in memory. Otherwise the precuneus needs to have coactivations created during the set-up of the Brainspot to include the emotional charge. It is possible that the gaze fixation on the Brainspot reduces the precuneus involvement as processing proceeds through interoceptive channels. Visual imagery is not necessarily prominent during resolution of the traumatic event.

Interoception and gaze

The missing step in the argument so far is for establishing neural pathways for connecting the awareness of the body feeling and the spot in the visual field. The awareness of emotions and their associated body sensations while recounting a traumatic episode is dependent on the anterior insula yet there does not appear to be any significant connection between the insula and the superior colliculi. In contrast the intraparietal sulcus has an anterior region (hlP1) which is functionally connected with the insula [23]. This part of the intraparietal sulcus is closely connected with the angular gyrus which, in turn, is linked with medial prefrontal cortex, hippocampus and parahippocampal gyrus, precuneus, occipital poles, anterior and posterior cingulate cortices. It is clear that these parietal areas have the connectivity necessary to link body sensations, emotional awareness, and autobiographical memory – and gaze direction.

Healing the deep wounds of the midbrain self

Economically-driven symptom-reduction approaches to psychotherapy work with verbal techniques and checklists at a level that has little impact on the core feelings about the self. Although still to be formally evaluated, clinical experience suggests that Brainspotting is effective at a deeper level of the psyche – one that has its neural correlates in the midbrain. Damasio [48] has argued for the primacy of the nucleus of the solitary tract (NTS) and the parabrachial nucleus (PBN) for fundamental feelings of pain and pleasure. These nuclei receive full information about the internal state of the body and are connected with each other and with the PAG. Sensory input is interpreted by the superior colliculi but the body sensations are transmitted via these two nuclei – the NTS and the PBN. The colliculi integrate information in a way which allows effective action through their outputs to brain stem, spinal cord, thalamus and cortex. Damasio [48] proposes that the beginnings of mind and the beginnings of self may be found in the SC.

An alternative view is that the SC is a simple orienting machine that can inform relevant areas of the brain of the occurrence of a biologically significant external event and, with connections to and from the cerebellum, can solve the spatial-to-temporal transformation problem: retinal topography is spatial; control of the metrics of orienting is temporal (Redgrave, May 2012, personal communication).

Panksepp [49] differs in emphasizing the motor coordinates underlying self-representation. He places these in an area between the somatosensory fields of the superior colliculi and the visceral integrating and emotion-generating capacities of the PAG. The urge to act is considered to be more important for the definition of the self than the impact of sensory experience. "*I act and feel therefore I am*" (49, p203). Interms of the SC the basic urge to action would be orientation towards or away from. The self would become defined through orienting responses to sensory stimuli rather than simply through the experience of the sensations. *I orient towards or away from-therefore I feel who and what I am*. Fundamental healing of deep wounds to the self will only occur when the treatment acts at the midbrain level. We have alluded to the possibility that much of the emotional response to an event is generated in the PAG and the feedback about the visceral changes is directly to the PAG from the spinal cord. The PAG and the SC are extensively interconnected making it possible that much of the healing is happening at this level – even although conscious awareness of changes is registering at upper cortical levels.

The self is elaborated through layers of advancing complexity in the subcortical-cortical midline systems [50,51] but the most profound valence will be established at the level of the emotion-generating, autonomic-regulating, orienting midbrain. When consciousness is divided into anoetic, noetic, and autonoetic forms [52] it is assumed that in the human it is the autonoetic, self-knowing across time, mind which needs to be engaged in therapy. If the

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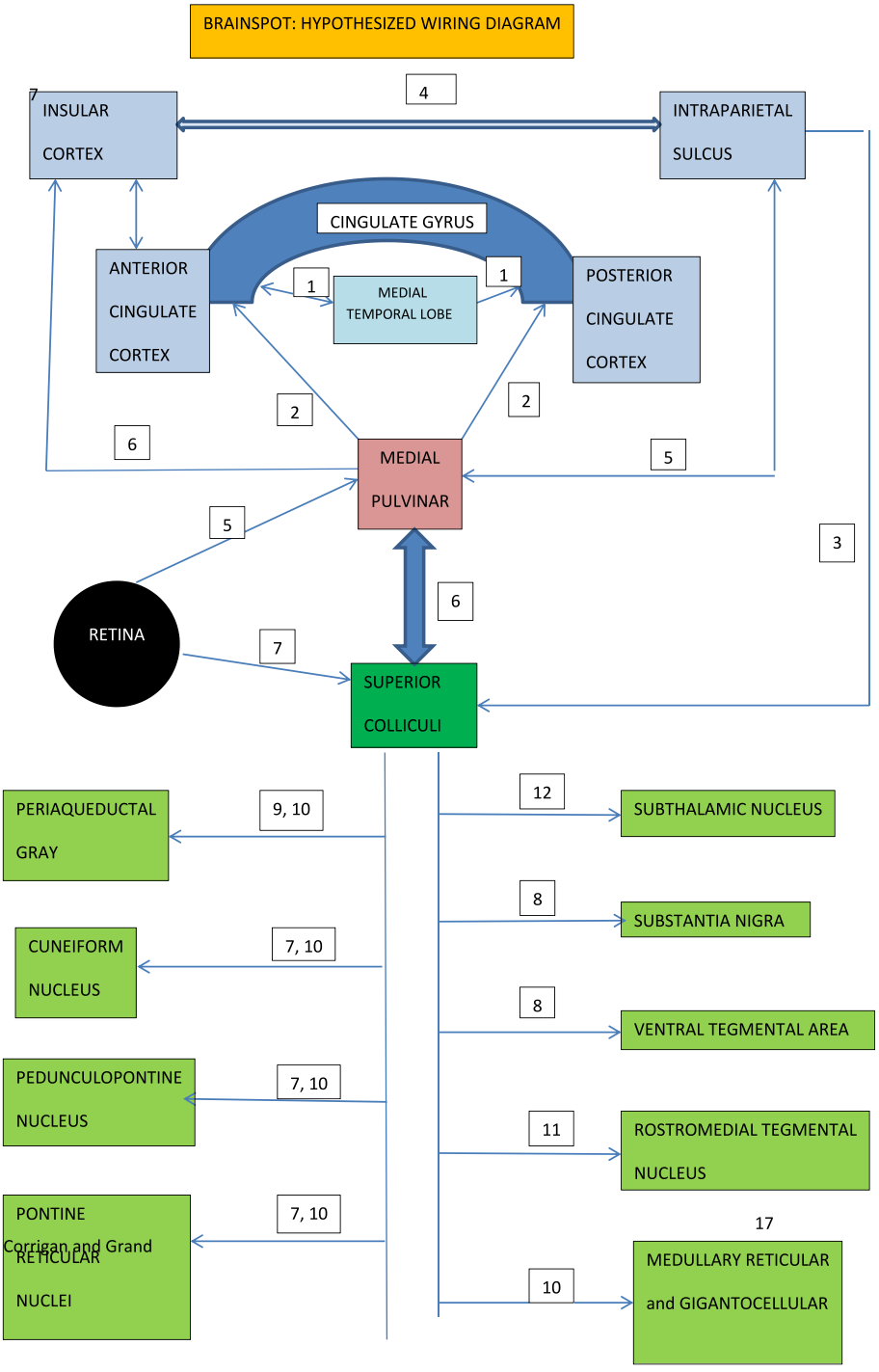
anoetic consciousness does not just include a simple awareness of external stimuli but memories of the action impulses, autonomic adaptations and emotional responses to events, then treatment needs to include those areas to be maximally effective. The neural correlates of the self extend from the midbrain through the midline subcortical structures such as the nucleus accumbens, through the medial prefrontal cortices, to the posteromedial cortices. Therapeutic interventions may be made at any of these levels but lasting and fundamental healing will follow mesencephalic resolution. Brainspotting's strength is its ability to start with events in autonoetic consciousness at the cortical level and integrate with techniques that allow healing to happen from the most basic level of the self at the nidus of the tectal hierarchy, at the fundament of the brain's midline self systems.

Brainspotting: a neurobiological hypothesis



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Conflict of interest

None declared.

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Please cite this article in press as: Corrigan F, Grand D. Brainspotting: Recruiting the midbrain for accessing and healing sensorimotor memories of traumatic activation. Med Hypotheses (2013), http://dx.doi.org/10.1016/j.mehy.2013.03.005

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