



Modern Neuroscience and Psychotherapy: Opportunities for Integration - Review

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ABSTRACT

The paper conducts a thematic literature review and analysis on neuroscientific concepts as per which psychotherapy practice has to be executed. Psychotherapy might be linked to the changes within the mentalizing and empathy networks' connectivity as per the results are found on the neural level. Several mechanisms underlying these changes are proposed: improvement of the prefrontal system's functioning by developing arousal regulation, activating oxytocin-related as an attachment system, and optimization of the predictive coding of interpersonal perception, including the receiving pathway of predictive error. The hypotheses are corroborated by the evidence provided through social, cognitive, affective and behavioral neuroscience as it regards to psychotherapy research and neuroimaging data of the psychotherapy effects.

Keywords: psychotherapy, fMRI, brain functional connectivity, mentalizing, empathy, predictive coding

1. Introduction

For almost a century, psychotherapy and neurobiology have grown virtually alone path with less than a foot of interaction between them but only accidentally. Today in that direction, there is a drift to mingling the experts of both these branches that deals with the diverse fields of social neuroscience, affective neuroscience, cognitive neuroscience, and behavioral neuroscience. This hectic and emerging transience landscape relies heavily on natural science research techniques used to gain knowledge about the mechanisms behind mental processes. Multidisciplinary research significantly grew [1], the publishing of specialized books and reviews broke new grounds [2], papers and journals dedicated to the topic appear in academic journals. The central topic of this article is the presentation of the neuroscientific theories that are considered now to explain mechanisms operable in psychotherapies. We build on the findings of resting-state brain networks that have acquired and are heavily being studied in recent years [3]. Current neurosciences are more often proponents of the anatomical connectivity of these brain networks. They are usually localized by tracking interdependencies in the timing of the deoxygenation of certain brain regions, the latter ones believed to be a reflection of the functional coupling. Learning about these networks is something attractive to the understanding of integrating mental processes, which are vital for human social health, and psychotherapy tries to improve this.

2. Mentalization and Empathy Networks: Implications for Therapeutic Practice

The network of brain which is mentalizing and empathy play a vital part in the social cognitive process of the human being. The mentalizing network that we can have across is also the root of the theory of mind and it operates within the realm of intellectual character when it involves understanding the feelings, thoughts, and intentions of others with reference to one's own internal space. While empathy network is activated when one is dealing with emotions of self and another person, it becomes inactive when one is dealing with physical information as in the case of recognizing people. The pontons that regulate these networks are the insular and cingulate cortices which are in the front part of the brain and are in charge of not only emotional orientation but interception, which is the process of signals reception and the integration of body inside information signals like those of breathing and heart beats. The models of emotion perception from reviews of Cannon in (1927)[4] and from James et al. in (1981)[4] and current models of emotions, state that emotional perception is following the perceiver's interpretation of interoceptive signals arising from the context where it occurs. Therefore, the primary distinction between the empathy and mentalizing networks lies in their approach to perceiving others' states: Empathy versus Mentalizing-Can be rephrased as empathy cooperation which is the state of being directly responsive to emotional as well as punitive perception and mentalizing which is the intellectual processing. Figure one and two display the Mentalizing and Empathy networks via the use of cs228, brain mapping program created by Yarkoni T and his colleague [5]. Theism and Empathy networks were discovered through technology, termed "intrapersonal". "The mentalizing circuit

is a network of the associative cortex located intermedially and on the inner cortex of the heart specifically the medial prefrontal cortex, posterior cingulate cortex, precuneus, ventral part of the temporoparietal junction and the temporal pole, and the cerebellar regions. But whereas empathic network involve engagement of the anterior cingulate cortex, regions of the anterior insula along with the inferior frontal gyrus and, laterally, the temporoparietal junction as well, according to some research

Figure 1. Mentalizing Network

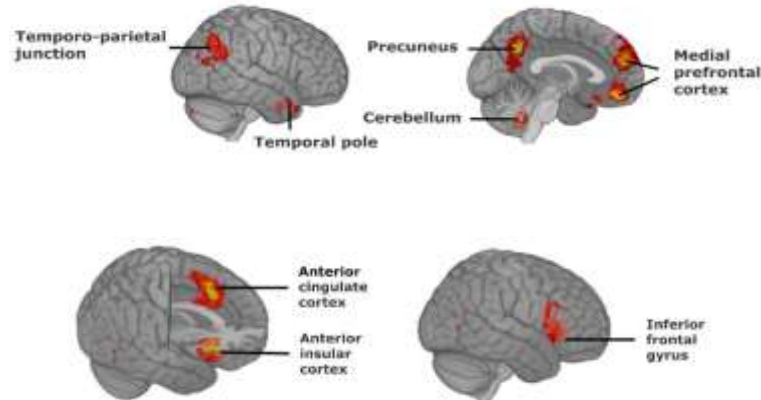


Figure 2. Empathy Network

The neural reflection system which the mentalizing and empathy networks are based on is actually the neural fundamental that psychotherapy is aimed into social processes. It is well-recognized that the bondability of the networks evolves steadily from infancy to adulthood and the most notable growth in this process happens in the first two years of human life. When accounted to the critical period, relationships with adult figures have a significant role. The process of developing the newly discovered emotions with their associations by the attachment system is the link between primary affective experience and mature information processing networks. So, the psychotherapeutic relationship may be regarded as a kind of support which will result in the development of new uniforms and the compensatory networking of the mentalizing and empathy systems. When high level networks are involved, the meaning of primary affects during the course of psychotherapy is assigned new meanings and they change just like the natural developmental path [6].

In different papers including review articles that summarize diverse findings of over multiple studies, the existence of various patterns of functional changes in regions within the mentalizing and empathy networks following psychotherapy were documented (see Fig. 1, 2) [7,8,9]. A large number of the privileged studies depend on blood flow in part of the brain which involved in cognitive and emotional tasks. A number of researchers have made comments like this on the Para limbic regions, mainly five region of the cortex, which are implied in emulating new internal models that lay a foundation for improved perception and relation with people [10, 11]. What is even more noteworthy, as the depression treatment using psychotherapy increases the activity of the right Paracontingual region, pharmacology treatment does just the opposite, by decreasing the activity of the latter region, therefore allowing to localize specific neural correlates in each of the aforementioned therapies. The Empathy Network is the psychological aspect, which is accomplished successfully by psychotherapy through the deactivation of the insular and anterior cingulate cortex in response to emotionally negative conditions. Unlike the neurobiological processes brought about by psychotherapy, which involved altering areas of the brain especially those related to visual and spatial perception, the FMRI, on the hand relate to increased functioning of mentalization and empathy networks. On the same line, the mentalization network exhibiting altered connectivity in patients with borderline personality disturbance that encompasses the middle and posterior cingulate and Para cingulate cortex showed the influence of psychodynamic therapy on them. This fall in connectivity has a clear connection with the help of psychotherapy in the capacity to identify, evaluate and emphasis express.

3. Two Systems of Arousal and Psychotherapy

The functioning of the neural network which generates higher order mentalizing behaviour aims at monitoring the physiological arousal levels. Mayes put forward a notion of a two-system aeration. Within the domain of low to moderate arousal thresholds, the prefrontal system, which is the association to self-regulated purposeful behaviour and mentalizing, is dominantly in charge of social behaviour. Nevertheless, in the advanced stages of anxiety the activity of the prefrontal region decreases whereas the subcortical system responsible for involuntary reactions, such as 'fight or flight' responses, works on full acceleration. The system operating of these systems is correlated with incremental consciousness levels, respectively, as we have presented in Fig. 3. This pattern supports the Yerkes-Dodson law, established by Yerkes and Dodson in 1908 and suggesting an optimal level of arousal for optimal task performance. In many cases, voluntary and complex tasks require higher optimal arousal than repetitive and standardized tasks since there is a need for more effort and concentration.

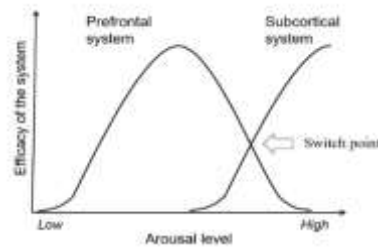


Figure 3. Two Systems of Arousal Regulation

The research of fMRI (functional magnetic resonance imaging) found that the prefrontal region performed as important source for controlling arousal state. Young [12] looked for the link between the connectivity in the central nervous system and the heart rate during the viewing of emotionally arousing movie scenes. The team recognized that their routers' heart rates correlated with the functional connectivity of the anterior cingulate and bilateral insula's core executive network that is the empathy networks. Moreover, they observed that the relationship ability among these areas and the posterior frontal region of the network is shaped like a toned-down Vile meanwhile. Thus, the results are consistent with a theory that states that arousal above a critical level is associated with a lower effectiveness of the prefrontal regulatory functions. In psychological counselling the mentalizing network tends to be subdued by arousal connected to stress coming from the attachment system. An experiment using the "Reading the Mind in the Eyes Test" measured fMRI activation associated with mentalizing before and after two types of stressors: think of such critical relationships related issue (attachment-related stress) and imagine other stressful situation which is not about relationships (non-specific stress). Outcome of this stress is more distinct in the brain than non-specific stress in inferior frontal gyrus, posterior temporal region and left tempura-parietal junction which are key areas in social cognitions. Indeed, the deficit in high-level prefrontal regulation during the emotionally intense experiences appears to be a relevant issue, which however, could be easily overcome within a setting of psychotherapy. In addition, among the data that are available, the most prescribed limited arousal optimum works on prefrontal regulation and physiological components of learning starts at a moderate arousal level. Overly abundant of catecholamine's can lead to disruption of memory reconsolidation. The result of this is that the feeling of excessive arousal which is common in emotionally heightened situations can distort our ability to absorb or process the events. This manifest that controlling arousal is very crucial to allow it to remain within the "window of tolerance" and not turn to be over arousing. P. Fonagy stated that the effect of psychotherapy lies in shifting the control point form the prefrontal system to the subcortical areas to the right, progressively increasing the range of emotions and arousal that one tolerates (Fonay & Tagett, 2006). Research on fMRI to establish the role mentalizing plays, supported by the findings that improves frontal affect regulation, is likely to provide evidence for such a hypothesis. Many studies reported that there was a strengthened connectivity between frontal-limbic structures and had a decreased activation in the limbic brain areas (cognitive-behavioural or psychodynamic type of psychotherapy for depression, anxiety disorders and borderline personality disorder) after individual psychotherapy and group psychotherapy. These changes can be noticed in resting-state fMRI studies and during emotion regulation tasks using fMRI.

4. Neurohormonal Foundations of the Attachment System and Psychotherapy

For the case of the youngsters, as we learned before, the empathy and Mentalizing networks originate through the interactions with close others, utilising the attachment system as the facilitator. One of the most significant features of this approach is shared social stress between infant and caregiver that involves coordination biological as well as behavioural processes. The 'stabilizing' part of the mature adult brain plays an irreplaceable part in the regulation of the immature brain during child development. According to psychoanalytic theories, a parent who was masterfully handling emotional tasks for a long time may eventually be incorporated as an internal object, which will then help the child learn self-regulation. It is in line with the observation of the buildup of mentalizing and empathy connections in the neural network. It has been researched that these neurotransmissions can synchronize with those of a client to the same extent as similar processes like biobehavioral synchronization take place with the therapist. They are composed of such as synchronous motions, heartbeat rate and respiration, and reaction on galvanic skin. The level of consistency measures reliability on key relational factors like therapeutic alliance and session satisfaction. Oxytocin, a neuropeptide, is regulating the attachment system soundly by its mechanisms at a hormonal standpoint. For both mothers and infants the release of oxytocin during breastfeeding occurs, and in the case of the father oxytocin, is also effective it is when holding an infant, and as oxytocin is critical this plays a great role in the physical and psychological well-being of the infant. In adults, the oxytocin level that rises when there are close relationships that are characterized by attachment and beyond the romantic. An activation of oxytocin can be proven by looking at neurophysiological data according to which amygdala activity is significantly inhibited. The amygdala is connected with a state of high caution, fervor and fear, and in depression and personality disorders, which are accompanied by hypervigilance and reactivity of the amygdala, these features are common. The relationship between hyper attentiveness and impairment on mentalizing is especially noteworthy. Studying the Asf of oxytocin reveals that it is a helpful supplement that facilitates the understanding of other people's mental states. There is more accurate belief transformation of interpersonal situations, pinpointing distortions from early traumatic experiences, into trustworthy beliefs with oxytocin administration. The article of S. Zilcha-Mano showed that as the therapy session is on the duels of oxytocin levels between clients and therapists the treatment of depression is more successful. The soothing effect of oxytocin released by the therapist in the situation where the patient experiences such emotions as sadness and anxiety dictates the link between the patient's psychological state and therapy results. Results suggest there is a stronger oxytocin level increase in therapists who experience more negative emotions from patients. Such increase creates a lower presentation of depressive symptoms.

5. The Idea of Predictive Coding in Psychotherapy

For the last decade the prediction coding framework has been used as a basis for evolution and functionality of mentalizing and empathy subsystems. The principle implies the use of brain causes as well as that they use the highly complex neural system, thus making the brain to function by constantly predicting the internal and external situations which come later. The predictions can address the context of body position, physical state or even the eyesight/mental condition, physiological conditions and the mental state. By considering the social construct of emotions which L. F. Barrett proposes, one can see that emotions are largely dependent on various interpersonal activities. Emotions are activated from the exact rendering of the event or its non-happening, an interpretation that is already in place even before the event has occurred. The mental processes here refer to the stream of consciousness concept. With the rise of e-commerce, social networking sites (Mentalizing networks and empathy) has assumed a primary important role in these process of interpersonal coding.

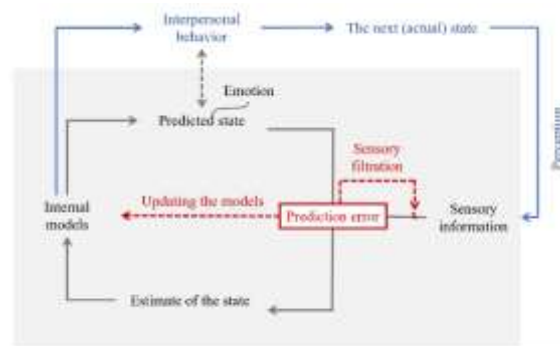


Figure 4. Predictive Model of Interpersonal Processes

Illustration of Fig. 4: Sensing mechanism of interpersonal predictability. At any point always there is a change of mental processing of emotional experiences and relations as well as an appraisal of the present situation. By using internal reference or past experience, and person makes predictions or probable consequences that carry through and once he or she decide for the specific action he or she acts. Consequently, the action engages with results which subsequently yield consequence and triggers the system to its actual state which is now different. The consequences of the act are submitted through perception verge. And, as no prediction is perfect, a prediction error—a divergence between received information from the senses and the knowledge that the brain predicts—sets in. The central role of this war in computational tools [13] is worth noting. There are primarily two ways to handle a prediction error: the brain utilizes its internal models (bottom-up mechanism consisting of assimilating the new sensory and experience over time) and filters the incoming sensory information (top-down mechanism in which the internal models perceive the world outside that is consisted of internal models creating a perception based on the information from the outside). The best illustration of the predisposition to the top-down (hermeneutic) error-handling path is neuropathology of personality disorders. The developed schemas at the initial age are adamant and determine later interpersonal prejudices, the one that lasts for the quick distortions. As per this research, the motor acts with predictive coding is relatable in it. Besides action being just the reaction to a certain situation, researches carried out by H. Friston's group [14] provided that it originates from the prediction of the future and the aim of this action is to keep the reality in line with the prediction. In motor acts, the movement searches for the sensation afferent that is matched the next possible proprioceptive sensation pattern for it is done by muscle force. Moreover, communication is another crucial process during which one aims to experience in response to their own actions and the partner's, the expected feelings. The findings of neurophysiologic studies, mostly with an electroencephalogram technique, have already supported the prediction about the change in predictive coding and its psychological implications. e. g., in major depression, and borderline personality disorder there is a reduction of the feedback-related negativity potential which could indicate problems with external feedback process. In mood depression, it is also observed that there is a general reduction of positivity amplitude and of the mismatch negativity (MMN) evoked by deviant stimuli such as a happy face presented among a number of neutral faces. The discrepancy between what is expected and what actually happens during the phenomenon is known as the mismatch negativity (MN1) and MN2 is reduced upon the presentation of happy faces. It could be an indication of the common filtering of good feelings that can be observed in a depressed person. This neural Process Correction as seen in depressed people is shown through clinical study finding of matching negativity (MMN) to happy faces and processing positivity (PFA) in reward. Nevertheless, the studies show imbalance of the predictive coding between negative and positive responses and propose its case as a factor of cognitive-behavioural therapy difficulties. Bearing in mind these considerations, it is fundamental to examine the processes that make the pathway selection from either the bottom-up or top-down type to process errors predictive. The neuroimaging studies, which are aimed mainly for functional, are very significant in this regard. Functional neuroimaging of brain areas engaged in visual imagery revealed that the phantom's images, be they imaginary or real, correlate with an equal level of clarity. Yet the most important characteristic of images which are rooted in reality lies in a more intensive activation of the primary visual cortex. Use our AI to write for you for free as many times you want. Our tool is here to help you save time and improve your writing skills. This result is exploited in psychotherapy, when it is advised to clients to consider sensory parameters of actual occurrence of momentary reality stimuli. In contrast with that, additional tools such as physical stimuli, for example holding melting ice, are involved to combat detrimental subjective feelings linked to past traumatic experience relapse. Yet, several neuroimaging studies provide evidence with regard to how the amygdala contributes o predictive error processing. According to the somat operception model in this descending error-processing pathway, it was indicated that the anatomical linkage between the amygdala and the rostral prefrontal cortex is operationally functional. The research of the mothers, whose parenting structures are out of place or overly controlling,

indicates that watching a video of their infants drives out-of-place activation of the amygdala. Moreover, this region is joined through neural connections with the areas that are involved in internally directed actions). This propensity of modifying a baby's activity might conform to a top-down error-processing channel. In contradiction, for those mothers by whom who adaptively synchronized their biobehavior with their infant's pictures of their infant's brain amygdala activity correlates with oxytocin levels. Because oxytocin makes the amygdala not working, it might lead to a more receptive and open outlook of the interpersonal characteristics, which is connected to the serotonin style error processing. The research shows how the error pathway can be som encoded, as well. We assume that the activation of the therapeutic relationship, attachment system, and whether oxytocin is released have abilities to reduce the amygdala's activation. This already makes the neural network adaptive for such operations as perception and behaviour regulation, having altered the way it responds to predictive models. This concept is in harmony with the findings of scientists documenting the successful application of psychotherapy focusing on the nature of therapeutic relationship (psychodynamic therapy, schema therapy, dialectical behaviour therapy), that are helpful in treating personality disorders. Also, finding remediation of the personality disorders by psychotherapy results in decreased hypervigilance and amygdala activity, directing, as the result, the activation of the storage error information in the brain.

6. Conclusion

The paper explains the neuroscientific perspective of psychotherapy that is interdisciplinary in nature as it names the relevant concepts to the scientific field. This explanation argues that the underlying mechanisms for emotional therapeutic changes involve neuroplasticity restructuring of mentalizing and empathy-related neural networks. The following shedding light on the engagement of mechanisms such as neuromodulator observations of the prefrontal cortex (PFC), oxytocin system modulation, as well as optimization of the predictive coding systems (PCS) are the possible mechanisms through which self-compassion leads to reorganization. Everything in this context is carried out through a including connection. The article seeks to merge neuroscientific and psychotherapeutic concepts so as to produce excitement in this area that is at the intersection of the two disciplines. These methodologies thus have the ultimate objective of increasing our knowledge of the neuroanatomy of social processes and of helping to create new psychotherapeutic techniques that integrate neuroscience clinical data.

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