

PSYCHOLOGICAL TREATMENTS AND BRAIN BIOLOGY

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SUMMARY

This is a summary and transcription of a talk given to ISPS Slovenia in Bled in 2006. It assesses the research evidence for a biological basis for psychological treatments.

Key words: *psychological interventions – neuroplasticity – memory – depression – phobias - obsessive compulsive disorder*

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Introduction

This talk will attempt to answer the question ‘Is there biological basis for psychological treatments?’ It will attempt to identify biological substrates for psychological treatments, and to assess the research evidence. There are three major forms of psychotherapies/psychological treatments; Behavioral, Cognitive and Psychodynamic. They reflect on interventions at different levels of psychological organisation. Behavioural psychotherapy focuses on dysfunction in simple forms of learning and memory (operant and associative conditioning) and related motor behaviour. The brain structures which it involves are the amygdala, basal ganglia and the hippocampus.

Cognitive psychotherapy focuses on patterns of information processing thinking patterns in particular disorder. It addresses negative cognitions that play a role in the development and maintenance of the psychopathological state patient learns to evaluate and modify such thinking patterns. The brain areas which it involves include neocortex, specifically the frontal cortex.

Psychodynamic psychotherapy focuses on interpersonal representation of a set of expectations about self, others, and their relationship that organizes related affect, thought, and behaviour and the neuropsychological underpinnings of interpersonal representations. The brain areas probably involved include Neurocircuitry incorporating, lateralized cerebral hemispheres and subcortical areas.

Biological treatments include Medications, ECT, Light therapy, and repetitive Transcranial magnetic stimulation (rTMS).

They work by modifying gene expression, neurotransmitter modulation, neuronal firing, and modification of neural circuitories, causing pervasive changes and thence causing behavioural and symptom changes. If Biological treatments work by affecting the Brain’s structure and functioning, then psychological treatments should surely work in similar way in order to produce change. How else could they work?

The Memory model of psychotherapy shows that there are two distinct memory systems. PET and EEG studies have shown that these two types of memory are separate brain functions and rely on different sets of neural structures and physiologic properties which result in distinct patterns of neural activity.

Explicit memory is a conscious recollection of facts and events. It involves temporal lobe structures, such as the hippocampus. Implicit memory is a heterogeneous collection of abilities and experience which alters behavior non-consciously without providing access to any memory content. It is thought to involve the Basal ganglia as is suggested by the observable influence on emotional behaviors related to early attachment experiences.

The distinction between the two memory systems is significant both in the course of development over the life cycle and in the context of memory modulation through psychotherapy. Evidence exists to support the hypothesis that the human infant (neurodevelopmental stage) is equipped with a functional memory system at birth and that. That this memory is more capable of implicit learning than explicit learning (Amini 1996).

The Implicit memory system processes information regarding affect and forms large amounts of complex information extracts and stores rules.

These rules are learned implicitly, which causes self-perpetuating bias for interpreting later experience whether appropriate or not, and which guides behaviour which is not available for conscious processing and reflection.

"In psychotherapy, these patterns of implicit rules are revealed and reflected upon, and change occurs through the learning of new patterns explicitly repeated until the new habit-based manner is engrained in the implicit memory system".

Effective and successful psychotherapy should lead to long-lasting change in behavior, cognition, and emotions. When using the memory model to describe the changes listed above, there is a need to postulate plasticity or adaptability of the brain.

The Biological basis of Memory & Plasticity may be summarized as follows:

Cajal has suggested that information can be stored by modifying the connections between communicating nerve cells in order to form associations.

Hebb has observed that modifications only takes place between the connected cells, if both neurons were simultaneously active.

Information is encoded by strengthening the connections between neurons that are simultaneously activated "Neurons that fire together will wire together"; this is known as Hebb's rule, and it leads to 'Hebb - like synaptic plasticity'.

Elementary forms of synaptic plasticity include:

- 1) Long-term potentiation (LTP) mediated by N-methyl-D-aspartate (NMDA) receptor activation;
- 2) LTP mediated by voltage-dependent calcium channel activation;
- 3) Long-term depression (LTD) mediated by the NMDA receptor.

Evidence from experimental work links modification of synapses to macroscopic brain behavior. This occurs in the hippocampal formation, a part of the limbic system, implicated in memory formation. This modification of synapses leads to hippocampal long-term potentiation to cause memory formation.

Evidence for Cortical plasticity includes changes in Cortical maps, which may be:

1. Shown by controlled experiments altering sensory input.
2. Following neuronal damage neighbouring areas take over.
3. Rehabilitation following CVA.

Cortical maps are dynamic and are remodelled as result of important experiences through out life. One interesting study describing this was that of Structural MRIs of the brains of 16 London taxi drivers with extensive navigation experience compared with those of control subjects who did not drive taxis. The Posterior hippocampi of taxi drivers were significantly larger relative to those of control subjects.

This was reported in the popular press as follows; "The scientists also found part of the hippocampus grew larger as the taxi drivers spent more time in the job". She (Maguire) said "The hippocampus has changed its structure to accommodate their huge amount of navigating experience."

David Cohen, one of the taxi drivers commented 'I never noticed part of my brain growing - it makes you wonder what happened to the rest of it.' (Maguire 2000).

The Posterior hippocampus stores a spatial representation of the environment and can expand regionally to accommodate elaboration of this representation in people with a high dependence on navigational skills. The volume of gray matter in the right hippocampus was found to correlate significantly with the amount of time spent learning to be and practicing as a licensed London taxi driver.

Thus, it was stated that 'Local plastic change in the structure of the healthy adult human brain in response to environmental demands'.

Aydin et al. (2005) described MR spectroscopy of auditory cortex 10 musicians and showed that, Long-term, professional musical activity caused significant changes in the neurometabolite concentrations, possibly reflecting use-dependent adaptation in the brains of musicians.

Psychotherapy facilitates changes in the permanent storage of information acquired throughout the individual's life. The mechanisms involved in neuronal learning and memory, such as LTP and LTD, are used and reused in the moulding of personality and behavior based on experience (Post 1998).

Attachment memories may be implicit. Attachment research suggests that early patterns of responsiveness exhibited by attachment figures has consequences during neural development. Affective self-regulation appears to be minimal at birth and enhanced by exposure to experiences of appropriate attachment relationships. Inability to self-regulate leads to inability to self-soothe or to modulate anger. In personality disorders, the consequence of early attachment failure possibly results in exaggerated and prolonged reliance on external sources of regulation. Rosenblum et al showed that exposure of monkeys in early life to an inadequate attachment figure engendered permanent vulnerability to anxious and depressed states and to poor social functioning.

Psychotherapy is a form of attachment relationship. A physiological process capable of regulating neurophysiology and altering underlying neural structure. When patients participate in psychotherapy, they first of all activate the implicit memory system and then engage the mechanism whereby implicitly stored material can be modified (Amini 1996).

The neurotransmitter systems in the brain include Pyramidal neurons, which utilise: glutamate as a neurotransmitter. This neurotransmitter is excitatory, and interneurons, which utilise gamma-amino-butiric acid (GABA) as a neurotransmitter, and are inhibitory. There are also modulatory pathways from the brainstem, which utilise dopamine, serotonin, and noradrenaline as neurotransmitters and from the basal forebrain, which utilises acetylcholine as a neurotransmitter.

Dopamine is a neurotransmitter in the basal ganglia, involved in movement regulation and cognition. The substantia nigra and the limbic system is involved with motivation and reward. The mesencephalon or prefrontal cortex is involved with working memory.

Serotonin in the limbic system is involved with mood, appetite, sexuality, and in the raphe nuclei and brainstem is involved in the sleep-wake cycle. Noradrenaline in the limbic system is involved with mood and motivation, while in the Locus Coeruleus, prefrontal cortex, and brainstem is involved with attention, arousal.

Acetylcholine in the hippocampus is involved with memory. In the Nucleus basalis (Meynert), the brainstem – attention, arousal, sleep-wake cycle. Neurotransmitters attach to receptors in the post synaptic cell. If these are metabotropic receptors, they give rise to second messengers,

which lead to gene expression, which then leads to altered synaptic functions, affecting learning and memory. Thus, biological parameters may give rise to learning and memory.

Methods

Measuring brain activity during psychological processes in humans can be carried out using several techniques. EEG (electroencephalography) mapping measures the electrical activity of many neurons with electrodes placed on the scalp. It can demonstrate activity related to the presentation of stimuli, or event-related potentials. It can be used for source analysis or frequency analysis.

Positron emission tomography (PET) utilises the administration of positron emitting substances into the vein. It demonstrates increased cerebral blood flow in active regions by measuring increasing level of positron emitting substances in the active region.

Single photon emission computer tomography (SPECT) depends on the detection of gamma photons. Functional magnetic resonance imaging (fMRI) utilises a magnetic field and radio-frequency stimulation. The signal emitted by oxygenated and non-oxygenated haemoglobin is different. The ratio of these haemoglobin types is changed in the active regions, and this shows on an MRI scan. Transcranial magnetic stimulation (TMS) utilises reversible inhibition or excitation of brain areas using magnetic fields.

Results

A number of studies have demonstrated the effects of Psychotherapy on biological parameters. Baxter et al. (1992) Used PET scans to look at changes in cerebral metabolic rates for glucose in OCD patients receiving behavior therapy and those fluoxetine. They found a similar decrease in the head of the right caudate nucleus in the two treatment groups.

Schwartz et al. (1996) Used PET scans to look at changes in cerebral metabolic rates for glucose in 9 OCD patients receiving 10 weeks of therapy (structured exposure and response prevention, that is, behavioral and cognitive treatment). They found that responders had significant bilateral decreases in caudate glucose metabolic rates greater than those seen in poor responders to treatment.

Brody (1998) Used PET scans to look at changes in cerebral metabolic rates of OCD patients and their response to Behaviour therapy

(BT) and Fluoxetine found that the treatment response appeared to be different between BT and Fluoxetine depending upon differing patterns of metabolism.

Brody (2001) Used PET scans to look at changes in cerebral metabolic abnormalities pre and post treatment, comparing Paroxetine vs interpersonal therapy in 24 patients with Unipolar major depressive disorder (MDD), they had 16 controls. They found that, pretreatment, In Prefrontal cortex (also in caudate and thalamus) MDD patients had a higher normalized metabolism compared to controls, while in the temporal lobe MDD had lower normalized metabolism compared to controls.

Post treatment, In the Prefrontal cortex, Both interpersonal therapy (right) and Paroxetine (bilaterally) caused decreased normalized metabolism, and In the temporal lobe increased normalized metabolism, but Paroxetine caused greater reduction in HDRS (61.5% vs 38%).

Furmark (2002) Used PET scans to look at cerebral blood flow (rCBF) in 18 patients following 9 week treatment of social phobia (public speaking task). They compared Citalopram vs CBT vs "wait and see". They found improvement in symptoms in the Citalopram and CBT groups but NOT in the "wait and see" groups. There were four responders in each of the Citalopram and, CBT groups and one in the "wait and see" group. In these there was a decreased rCBF response to public speaking in the amygdala, hippocampus, periamygdaloid, rhinal, and parahippocampal cortices... a Common site of action for Citalopram and CBT.

Paquette (2003) used fMRI scans to look at regional brain activity in 12 patients with spider phobia. They assessed patients pre and post effective CBT, and used thirteen control patients. They found that in phobic patients, transient fear correlated with Significant activation of right DLPFC, parahippocampal gyrus and visual associative cortical areas bilaterally.

"In phobic subjects before CBT, the activation of metacognitive strategies aimed at self-regulating the fear triggered by the spider film excerpts, whereas the parahippocampal activation might be related to an automatic reactivation of the contextual fear memory that led to the development of avoidance behavior and the maintenance of spider phobia".

In normal control subjects there was significant activation of left middle occipital gyrus and the right inferior temporal gyrus.

In phobic patients after successful CBT, there was no significant activation of DLPFC or the parahippocampal gyrus.

They concluded that successful CBT can modify dysfunctional neural circuitry in anxiety disorders

Viinamaki (1998) Used SPECT imaging before and after 1 year of dynamic psychotherapy in 1 patient with bipolar personality disorder and depression. They found that Serotonin uptake was normalised, suggesting that dynamic psychotherapy can affect serotonin metabolism, but the study has a number of methodological problems (such as a relatively small n=1), and has not yet been replicated.

Conclusions

Understanding of Memory and Brain Plasticity is useful in providing biological explanations of psychological treatments. Modern investigative techniques can offer some explanation of how psychological treatments might be working. However, current knowledge is small compare to what is known about "biological treatments", but it is expanding.

Some studies suggest that the some differentiation can be made as to the suitability of particular patient to particular form of treatment.

It is time to assign the idea of psychological therapies for "psychological disorders" and biological therapies for biological disorders to the history books!

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