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The effects of psychotherapy on brain function: A systematic and critical review

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ABSTRACT

Over the past two decades, the development of neuroimaging techniques has allowed the non-invasive investigation of neuroplastic changes associated with psychotherapeutic treatment. The aim of the present article is to present a systematic and critical review of longitudinal studies addressing the impact of psychotherapy on the brain published to date. After summarizing the results reported in the literature for each psychiatric disorder separately (i.e. obsessive-compulsive disorder, panic disorder, unipolar major depressive disorder, posttraumatic stress disorder, specific phobia, schizophrenia), we discuss the results focusing on three questions of interest: (i) whether neurobiological changes which follow psychotherapy occur in regions that showed significant neurofunctional alteration pre-treatment; (ii) whether these neurobiological changes are similar, or different, to those observed following pharmacological treatment; and (iii) whether neurobiological changes could be used as an objective means of monitoring the progress and outcome of psychotherapy. The evidence reviewed indicates that (i) depending on the disorder under investigation, psychotherapy results in either a normalisation of abnormal patterns of activity, the recruitment of additional areas which did not show altered activation prior to treatment, or a combination of the two; (ii) the effects of psychotherapy on brain function are comparable to those of medication for some but not all disorders; and (iii) there is preliminary evidence that neurobiological changes are associated with the progress and outcome of psychotherapy. It is hoped that a better understanding of the impact of psychotherapy on brain function will eventually inform the development of new biologically informed treatments and allow clinicians to make more effective treatment decisions.

Contents

Abbreviations: ACC, anterior cingulate cortex; BADT, brief behavioural activation treatment for depression; BEP, brief eclectic psychotherapy; CBSST, cognitive behavioural social skills training; CBT, cognitive behaviour therapy; CRT, cognitive remediation therapy; CT, computed tomography; DLPFC, dorsolateral prefrontal cortex; DSM, Diagnostic and Statistical Manual of Mental Disorder; FG, fusiform gyrus; fMRI, functional magnetic resonance imaging; IFG, inferior frontal gyrus; IPL, inferior parietal lobule; IPT, interpersonal therapy; LTC, lateral temporal cortex; MBRS, mindfulness-based stress reduction; MD, major depression; MFG, middle frontal gyrus; MPFC, medial prefrontal cortex; MRI, magnetic resonance imaging; MRSI, magnetic resonance spectroscopy imaging; MTC, medial temporal cortex; OCD, obsessive-compulsive disorder; OFC, orbitofrontal cortex; PCC, posterior cingulate cortex; PD, panic disorder; PE, prolonged exposure; PET, positron emission tomography; PFC, prefrontal cortex; PFMC, prefrontal medial cortex; PHG, parahippocampal gyrus; PTSD, posttraumatic stress disorder; SFG, superior frontal gyrus; SPECT, single photon emission tomography; SRI, serotonin reuptake inhibitor; STG, superior temporal gyrus; TAU, treatment as usual; vACC, ventral anterior cingulate cortex; VRET, virtual reality exposure therapy; Xe-CT, xenon-enhanced computed tomography.

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1. Introduction

Psychotherapy can have the most profound influence on a person's belief system, emotional state and behaviour, and it is perhaps therefore not surprising that it may also lead to significant structural and functional changes in the brain (Kandel, 1998). A better understanding of these neuroplastic changes has several potential benefits: firstly, it may provide an objective means of monitoring the progress and outcome of psychotherapy in terms of cortical reorganisation; secondly, it may provide insight into the neural basis of psychological recovery; and thirdly, it may inform the development of new biologically informed treatments.

In the 1880s, Sigmund Freud's attempt to translate psychotherapeutic concepts into the language of biology was greatly restricted by the limited neuroscientific knowledge available at the time (Freud, 1895). Over the past two decades however, the development of a number of neuroimaging techniques has, for the first time, allowed the non-invasive investigation of the neuroplastic change associated with psychotherapeutic treatment. These techniques include, amongst others, magnetic resonance imaging (MRI), positron emission tomography (PET) and single photon emission computed tomography (SPECT). Since then a growing number of neuroimaging studies have reported significant effects using a range of therapeutic approaches such as cognitive behavioural therapy (CBT), interpersonal therapy and psychodynamic approaches, alongside different clinical populations. Although several interesting reviews of these studies have been published, most of them focused on either a specific treatment approach (Porto et al., 2009) or clinical population (Frewen et al., 2008; Sharpley, 2010), whilst those that did adopt a more comprehensive approach are now relatively dated (Kumari, 2006; Linden, 2006, 2008).

The aim of the present article therefore was to present a systematic and critical review of longitudinal studies published to date, which examined the impact of psychotherapy on the brains of patients with psychiatric disorders. In order to facilitate interpretation of the results, here we focus on studies that examined groups of subjects, rather than single case studies, and which were carried out on adults rather than children. In the first section of the article, we summarize the results reported in the literature for each psychiatric disorder separately (i.e. obsessive-compulsive disorder, panic disorder, unipolar major depressive disorder, posttraumatic stress disorder, specific phobia, schizophrenia). This section includes both studies that investigated the neurobiological change associated with psychotherapy alone and also studies that compared this change with that associated with psychopharmacological treatment. In the second section, we provide a critical discussion of the results, focusing on three questions of interest that have been the focus of the existing literature: (i) are neurobiological changes which follow psychotherapy located in the same or different regions to the ones which showed altered function before treatment? (ii) are these neurobiological changes similar or different to those which follow pharmacological treatment? (iii) could neurobiological changes provide an objective means of monitoring the progress and outcome of psychotherapy? The answers to these questions will be of interest to current biological models of symptomatic remission (e.g. Hofer et al., 2011) and may inform the development and evaluation of new biologically informed treatments.

2. Methods

2.1. Search strategy

A systematic search strategy was used to identify suitable publications. This involved an online search of the PubMed and Web of Science databases, using the search terms (''psychotherapy'' OR ''psychological intervention'' OR ''psychological therapy'' OR ''psychological treatment'' OR ''CBT'' OR ''cognitive-behavioural therapy'' OR ''cognitive-behavioural therapy'' OR ''mindfulness'' OR ''interpersonal therapy'' OR ''behavioural activation treatment'' OR ''virtual reality exposure therapy'' or ''psychodynamic therapy'' OR ''acceptance and commitment therapy'' OR ''remediation therapy'' or ''cognitive remediation'' or ''social skills training'') AND (''neuroimaging'' OR ''imaging'' OR ''MRI'' OR ''Magnetic Resonance Imaging'' OR ''PET'' OR ''Positron-Emission Tomography'' OR ''SPECT'' OR ''Single-photon emission computed tomography'' OR ''NIRS'' OR ''Near-infrared spectroscopy'' OR ''spectroscopy'') conducted on 4th March 2013 with no time span specified for date of publication. A total of 1902 and 670 hits were returned for the two databases respectively.

2.2. Selection criteria

Studies were included if they met the following criteria: (a) were reported in an original paper in a peer-reviewed journal, (b) examined the impact of psychotherapy on brain function in psychiatric patients using functional neuroimaging methods which allowed the examination of specific regions; (c) employed a longitudinal design in which the same patients were scanned before and after treatment (d) reported the results at group level rather than in one or more single case studies. For the purpose of the present review, psychotherapy was defined as a clinical intervention based on psychological principles; this means that it included both computer-aided treatments (e.g. computerized cognitive behavioural therapy) and treatments delivered by a mental health professional (e.g. interpersonal psychotherapy). Studies focusing on the impact of psychotherapy in previous psychiatric patients who had already reached remission at the time of recruitment were not included. Studies using electrophysiological methods (e.g. electroencephalography) which did not allow the identification of specific regions were also excluded. After applying these selection criteria, 42 papers were selected as relevant to the present review. In a second step, the reference lists of these 42 articles were manually checked for any additional studies not identified by the computerized literature search. This second step did not reveal any additional studies, resulting in a final sample of 42 articles to be included in our review. Although there was no language restriction, all the included articles were written in English.

2.3. Variables of interest

The following variables were examined for each article included in the review: number of patients receiving psychotherapy and

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