REVIEWS

Neuroimaging of Love: fMRI Meta-Analysis Evidence toward New Perspectives in Sexual Medicine

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ABSTRACT

Introduction. Brain imaging is becoming a powerful tool in the study of human cerebral functions related to close personal relationships. Outside of subcortical structures traditionally thought to be involved in reward-related systems, a wide range of neuroimaging studies in relationship science indicate a prominent role for different cortical networks and cognitive factors. Thus, the field needs a better anatomical/network/whole-brain model to help translate scientific knowledge from lab bench to clinical models and ultimately to the patients suffering from disorders associated with love and couple relationships.

Aim. The aim of the present review is to provide a review across wide range of functional magnetic resonance imaging (fMRI) studies to critically identify the cortical networks associated with passionate love, and to compare and contrast it with other types of love (such as maternal love and unconditional love for persons with intellectual disabilities).

Methods. Retrospective review of pertinent neuroimaging literature.

Main Outcome Measures. Review of published literature on fMRI studies of love illustrating brain regions associated with different forms of love.

Results. Although all fMRI studies of love point to the subcortical dopaminergic reward-related brain systems (involving dopamine and oxytocin receptors) for motivating individuals in pair-bonding, the present meta-analysis newly demonstrated that different types of love involve distinct cerebral networks, including those for higher cognitive functions such as social cognition and bodily self-representation.

Conclusions. These metaresults provide the first stages of a global neuroanatomical model of cortical networks involved in emotions related to different aspects of love. Developing this model in future studies should be helpful for advancing clinical approaches helpful in sexual medicine and couple therapy. **Ortigue S, Bianchi-Demicheli F, Patel N, Frum C, and Lewis JW. Neuroimaging of love: fMRI meta-analysis evidence toward new perspectives in sexual medicine. J Sex Med 2010;7:3541–3552.**

Key Words. Neuroimaging; fMRI; Love; Sexual Medicine; Self-Expansion Model; Meta-analysis

Introduction

Although it seems obvious that psychological and emotional factors play a role in the etiology and maintenance of sexual problems [1,2], little is known about the ways in which love, sexual function, and sexual dysfunctions interact [1–3]. Since the 1960s, there is, nevertheless, a growing interest in love in the framework of sexual medicine [4–9]. In the last decade, the development of neuroimaging techniques, such as functional magnetic resonance imaging (fMRI) helped in better understanding the role of the brain, as a central organ in sexual function [4,10–15]. Rare, however, are the fMRI studies on love [4,16–21]. A review of these fMRI studies could critically be helpful in

Table 1 Functional MRI studies of love

Authors	Year	Love	Number of participants	Stimuli
Aron et al.	2005	Passionate	7 men, 10 women	Faces
Bartels and Zeki	2000	Passionate	6 men, 11 women	Faces
Ortigue et al.	2007	Passionate	36 women	Names
Bartels and Zeki	2004	Maternal	20 women	Pictures
Noriuchi et al.	2008	Maternal	13 women	Video clips
Beauregard et al.	2009	Unconditional	8 men, 9 women	Pictures

improving one's knowledge on the neural bases of love (in comparison with the neural bases of sexual function) by extending one's knowledge of the psychology of love in the context of close relationships, and comparing this knowledge with previous fMRI studies on different phases of human sexual response. In the present article, we will review these fMRI studies of love.

What Does fMRI Measure?

fMRI measures the change in blood flow and oxygenation (hemodynamic response) that is produced in the brain in response to the presentation of a broad variety of stimuli (e.g., faces, name of sexual partner). Functional neuroimaging studies of love present changes in blood flow and metabolism associated with the presentation of partner-related stimuli (e.g., face of a beloved partner; or name of the beloved partner). These stimuli can be visual, auditory, or tactile. To date, however, mostly visual partner-related stimuli (i.e., faces, names, pictures, video-clips; Table 1) have been used in fMRI studies of love. In fMRI studies of love, changes in blood flow and oxygenation in the brain are always analyzed in comparison with another (neutral) stimulus. For instance, a psychologist or a physician, who is interested in discovering the brain activity that is generated in response to faces of a significant/beloved partner, will analyze the brain responses that are generated in responses to the visual presentation of the face of that significant/beloved partner minus the brain responses that are generated in response to the visual presentation of neutral faces (e.g., faces of neutral strangers). By comparing/subtracting these two types of brain responses, the investigator is able to unravel the brain responses that are specific to the face of a beloved partner.

What Does fMRI Bring to Sexual Medicine?

In recent years, researchers have devoted increasing attention to neurobiological substrates and neurological processes of sexual function and close relationships [4,15]. For instance, a growing body of fMRI studies enables the visualization of brain networks that are recruited during human sexual response, such as sexual arousal, sexual desire, and orgasm [14,22–36]. Combining knowledge from fMRI studies with standard approach in sexual medicine may be helpful to better understand the psychological mechanisms that occur in couple relationships. This approach fits well with a new trend in medicine called translational neuroscience. Translational neuroscience aims to translate scientific knowledge from the lab bench to the clinical practice. The understanding and the integration of fMRI knowledge into daily clinical practice might help better target drug therapies on the brain networks that may be affected [14]. In sexual medicine, translational neuroscience is important in order to better help patients with sexual disorders, and couple relationship issues. Because several reviews about the brain networks involved during human sexual responses have been done recently [13,14,37], we are not going to review them in the present article. Rather, the present article will focus on an important topic that is often neglected in sexual medicine, i.e., love.

Why Does Love Matter in Sexual Medicine?

Even if it is, of course, clear that being in love is not a prerequisite to have a sexual intercourse, to desire someone else, or to have a satisfactory sexual life [4,36], studies show a positive relationship between love, desire, and orgasm [7,9,38]. This is in line with a recent growing body of studies in the field that investigated not only the potential risks associated with sexual activities, but examined also the potential physical and mental health benefits [5–7]. This fascinating field of research allows the integration of the scientifically essential differentiation of specific sexual behaviors, notably penile–vaginal intercourse (PVI [6]). As highlighted by Komisaruk and Whipple, "love and sexual activity, while different from each other, share a common element in that they both involve giving and receiving intimate stimulation" [9]. In line with this growing field of research, a large number of