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The Gut Instinct: Microbiota's Hidden Role in Psychological Well-Being

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ABSTRACT

Advances in our time in the field of neuroscience and microbiology have revealed that the gut and brain are intricately connected though a bidirectional communication system known as the gut-brain axis. This relationship highlights the significant influence of the gut microbiome on cognitive function, mood regulation and emotional wellbeing. This paper is aimed towards exploring how gut microbiota affects psychological health, particularly in relation to anxiety and depression. By examining mechanisms such as neurotransmitter production, vagal communication and immune signaling. Furthermore, the paper extends into discussion to dietary influences on gut microbiome composition, the decline in gut health over time and how improvement of our gut health can lead to improved psychological well being.

Keywords*: biology*, *neuroscience*, *mental health*, *gut*, *microbiota*, *microbiome*, *psychology*, *wellbeing*

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INTRODUCTION

The phrase “trust your gut” and “gut instinct” are often used lightly, but in reality they may hold more scientific truth than previously believed. The gut is a microbiome that consists of trillions of microorganisms, including fungi, bacteria and viruses, residing in the digestive tract (Cryan & Dinan, 2012). A microbiome is a collection of diverse microbes (microscopic organisms that are too small to see with the naked eye) that live on and inside the body (Carabotti et al., 2015). The gut microbiome plays a crucial role in the human body, considering it aids in digestion, immune function, and even mental health (Mayer et al., 2015). Some may wonder, how exactly can your gut assist in mental health?

To understand that, it is important to delve deeper into the gut-brain axis. The gut-brain axis is a bidirectional communication system that links the central nervous system to the gut (Cryan & Dinan, 2012). The linkage between the two can be seen in the vagus nerve, neurotransmitter production and immune signalling. This connection helps support the argument that gut microbiota can influence cognitive functions and emotional well-being (Dinan & Cryan, 2017). The connection between these two prompts the question: how does the gut microbiota influence mental health conditions such as anxiety and depression?”

Understanding the relationship between the two could help revolutionise psychiatric treatment by introducing microbiome - based therapies. Moreover, insights from this study can help contribute to medical research, which can help serve towards finding new approaches that manage anxiety and depression. Furthermore, prior studies have shown a clear association between mental well-being and gut health.

For example, prior research states that individuals with irritable bowel syndrome, a condition characterised by gut issues, are more likely to experience depression or anxiety (Sarkar et al., 2016). The need for this research is more relevant than ever, especially in an era where according to the World Health Organisation more than 264 million people of all ages globally suffer from depression, and anxiety disorders remain highly prevalent, affecting 284 million people worldwide (WHO, 2021). This paper explores the depth of the relationship between the gut microbe and mental health, helping one gain better understanding on how what we eat can change how we think.

LITERATURE REVIEW

The gut microbiome and its role in mental health

The gut microbiome has trillions of microorganisms that all aid in the various functions that the biome has, such as digestion, immune function and metabolic processes. In recent times, research has shown that these microbes influence the brain function through the gut-brain axis**,** a bidirectional communication network that involves the vagus nerve, neurotransmitter, and immune signalling pathways (Cryan & Dinan, 2012). This intricate network between the central nervous system and gut microbiome has emerged as a critical player in diseases and human health, majorly focusing on mental health. As illustrated in Figure 1, the network consists of neural, humeral and immune pathways. The vagus nerve is a major conduit of information as it transmits signals bidirectionally between the gut and brain (Cryan & Dinan, 2012; Forsythe et al., 2014). Moving on, the gut microbiome played a crucial role in this communication by producing a variety of neuroactive molecules, including

neurotransmitters like serotonin and dopamine, while also having metabolites such as short - chain fatty acids and hormones (Sharon et al., 2019; Carabotti et al., 2015). These molecules influence behaviour and brain functions through many different mechanisms, including modulation of the immune system and direct entry into the bloodstream (Dinan & Cryan, 2017; Mayer et al., 2015).

When the gut-brain axis is irregular, the possibility of various mental health disorders, including anxiety, bipolar disorder and depression arise, highlighting the importance of maintaining a healthy gut microbiome for brain health and overall better mental health (Foster et al., 2017; Kelly et al., 2015). Moreover, studies have also shown that individuals suffering from depression and anxiety often have reduced microbial diversity and an increased presence of pro-inflammatory bacteria that can be linkers to neuroinflammation and altered neurotransmitter levels (Clarke et al., 2013; Sarkar et al., 2016).

Neurotransmitter Production and Mental health

The gut microbiome is known to play a crucial role in the production of neurotransmitters that regulate mood, cognition, and emotional stability. Neurotransmitters in the gut are primarily produced by specialised cells within the lining of the intestine called enterochromaffin cells (Mayer et al.,2015). Several studies have highlighted the significance of specific bacterial strains in synthesising these neuroactive compounds(Dinan & Cryan, 2017). For example, Lactobacillus and bifidobacterium, two probiotics that are commonly used to treat digestive issues are known to contribute to the production of serotonin, a neurotransmitter that is referred to as the “happiness chemical” (Clarke et al., 2013). Since we know that nearly 90% of the body's serotonin is synthesised in the gut, disruptions in any microbial compositions may possibly have profound effects on emotional well-being (Sharon et al.,2019).

Beyond serotonin, these microbes also influence the production of gamma - aminobutyric acid, popularly known as GABA. GABA as a neurotransmitter is responsible for inducing calmness and relaxation in the central nervous system, low levels of GABA have priorly been associated with heightened stress responses, depression and anxiety (Dinan & Cryan, 2017). This again emphasises the guts' role in maintaining mental equilibrium.

Dysbiosis and Mental Health disorders

An imbalance in the gut microbiota is known as dysbiosis. Dysbiosis has been increasingly linked to various mental health disorders and even has connections to neurodevelopmental conditions such as schizophrenia and autism spectrum disorders (Sarkar et al., 2016). Individuals that suffer from depression and anxiety are known to exhibit reduced microbial diversity, with an alarming representation of pro-inflammatory bacteria and a depletion of beneficial microbes that support neurotransmitter synthesis (Foster et al., 2017).

One major consequence of dysbiosis is increased intestinal permeability, which is commonly referred to as “leaky gut”. The leaky gut can cause pro-inflammatory molecules, and those can enter the bloodstream and make their way to the brain that triggers neuroinflammatory responses (Kelly et al., 2015). Any sign of chronic low-grade inflammation is a hallmark of many mood disorders, including bipolar disorder (Dinan & Cryan, 2017).

Animal and Human Studies on the Gut-brain axis

There is compelling evidence that exists for the gut-brain connection that comes from both animal and human studies (Bravo et al., 2011; Tillisch et al., 2013). The research done on mice, which are raised in sterile environments without gut bacteria, has demonstrated that absence of microbiome leads to heightened anxiety-like behaviour and stress responses. It was found that the effects could be reversed with probiotic supplementation, which suggests the present of specific gut bacteria directly influences emotional resilience (Bravo et al., 2011).

The studies done on humans also reflect similar findings. Clinical trials have shown that consuming probiotic strains leads to significant reduction in depressive symptoms, anxiety and stress, adding evidence on how gut bacteria can actually influence mental well being (Tillisch et al., 2013). Additionally, MRI studies have reflected the same conclusion, showing changes in brain activity and emotional processing following probiotic supplementation (Mayer et al.,2015.

DIETARY INFLUENCES ON THE GUT MICROBIOME AND PSYCHOLOGICAL WELLBEING

A fundamental role in shaping the gut microbiome is done by an individual's diet due to its direct correlation on the availability of nutrients and substrates that microbes use for survival and growth (David et al., 2014). It has been concluded that a balanced diet rich in fermented product and plant based foods consistently result in a more resilient and diverse gut microbiota (De Filippis et al.,2016). However, diets high in saturated fats, processed foods and refined sugars tend to decrease microbial diversity and promote growth of proinflammatory bacteria (Singh et al., 2017). These imbalances in gut composition can disrupt communication along the gut brain axis which leads to higher susceptibility to mood disorders such as anxiety and depression, increased inflammation, altered neurotransmitter production(Foster & Neufeld, 2013).

Foods rich in fiber, particularly ones with prebiotics like insulin and resistant starches that are found in vegetables, fruits and whole grains, support the growth of beneficial bacteria which produce short chain fatty acids. (Silva et al.,2020) The advantage of these short-chain fatty acids is that they maintain intestinal integrity, modulated brain function through anti-inflammatory and neuroprotective mechanisms while also reducing systemic inflammation. (Dalile et al.,2019). Furthermore, fermented foods such as yogurts, kefir, sauerkraut, and kimchi contain live bacterial cultures that positively influence emotional well being by reducing cortisol levels and serotonin synthesis. (Sarkar et al. 2016).

THE MODERN DIET

In recent decades, the dietary habits worldwide have dramatically altered. Modern diets are characterized by high intake of refined sugars, artificial additives and processed foods. Showcasing a decline in fiber and plant based nutrient consumption (Monteiro et al. 2018). These eating patterns have been linked to dysbiosis which is an imbalance in the gut microbiota that results in reduced microbial diversity and growth of pro-inflammatory bacteria (Singh et al.,2017).

While this diet has severe consequences on one's physical health, these effects extend beyond. Evidence suggests that individuals who consume high levels of processed foods become more likely to experience symptoms of mood disorders and face cognitive decline (Jacka et al., 2010). However, it is important to understand

that this relation is largely correlational rather than causal. While the poor diet does not alone cause mental disorders, they contribute to inflammation, oxidative stress and disrupted neurotransmitter regulation which are known to exacerbate mental health conditions (Firth et al.2020).

The problem with processed foods is that they lack essential nutrients such as omega - 3 fatty acids, vitamins B and D, and dietary fiber. All of these support brain function and gut integrity (Sánchez-Villegas et al.,2009). The overconsumption of refined sugars have also altered insulin sensitivity and stress hormone levels, further influencing mood and energy regulation. (O'Neil et al.,2014).

Although a causation cannot be firmly established, the consistent association highlights that gut microbiome is a key mediator in the relation of highly processed diets and declined psychological well-being. The correlation underscores the importance of dietary awareness and preventative health strategies that target the brain and gut.

HEALING FROM WITHIN: HOW GUT HEALTH IMPROVEMENT CAN SUPPORT PSYCHOLOGICAL WELL-BEING

Significant promise in enhancing mood, stress management and cognitive performance has been shown by interventions aimed at improving gut health. Probiotic and prebiotic supplements which are also often referred to as *psychobiotics* have shown positive influence on emotional states through restoration of microbial balance and promotion of production of beneficial metabolites that include short-chain fatty acids and neurotransmitters (Dinan & Cryan, 2017)

Studies have shown that consumption of probiotic rich foods have reduced depressive symptoms and improved overall mood (Wallace & Milev,2017). The effects are paryl mediated through reduction of cortisol levels, modulation of systemic inflammation and improved vagus nerve signalling (Bravo et al., 2011).

Furthermore, lifestyle modifications such as regular physical activities and adequate sleep also support gut health which in turn contribute to mental well being. (Foster & Neufeld, 2013)

CONCLUSION

The research that exists in this field underscored a strong bidirectional relationship between the gut microbiota and mental health, with growing evidence that the microbiome plays a pivotal role in stress regulation, emotional stability and neurotransmitter production. As the understanding that individuals hold on gut-brain axis deeds, future interventions may pave the way for personalised mental health treatments based on an individuals' gut microbiome composition.

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