The Neuroscience of Food and Mood

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ABSTRACT

Recently, evidence suggests that the gut microbiota may play a key role in development and progression of certain neurological and neuropsychiatric conditions (such as Alzheimer's disease (AD), Parkinson's disease (PD), autism spectrum disorder (ASD), depression and anxiety.The study of the gut microbiota-brain axis has become an intriguing field, attracting attention from both gastroenterologists and neurobiologists. The present study investigated the role of probiotic, *Lactobacillus rhamnosus* GG (LGG) in modulating host behaviour by the metabolic processes of toxicant and microbes' interaction.The hypothesis is to understand the role of gut microbiota in brain physiology and neuronal functioning as well as regulation of the neurobiological mechanisms like neurogenesis and neuronal plasticity supporting the relevance of actions reflecting possible causes of neuronal disorders. The hippocampus is the centre of learning and memory, and plays a pivotal role in neurodegenerative diseases, such as AD and PD. Previous studies using diet administration, antibiotics, probiotics, prebiotics, have shown that the structure and function of the hippocampus are affected by the gut microbiota. The findings of present study through laboratory experimentas well asthe literature survey showedthat the gut microbiota is an emerging key regulator of the brain's function and behaviour. An increasing number of evidenceshave shownthe importance of bidirectional communication between the intestinal bacteria and the brain. Based on recent findings, the result suggested that the interaction between diet and the gut microbiota, which might ultimately affect the mental health, represents an unprecedented stimulus for conducting new research that links food and mood.Since some specific gut bacteria are positively or negatively correlated to the structure and function of the hippocampus, it is expected that alteration of specific gut bacteria and other microbiota-based interventions could be potentially applied to prevent or treat hippocampus-based memory impairment and neuropsychiatric disorders.

Keywords: Microbiota; Probiotic; Learning and Memory; Neurogenesis; Neuronal Plasticity

Introduction

The composition of the microbiota is altered throughout the lifespan and is dependent on dietary and environmental factors, disease state, and other factors. The constituents of the microbiota, ranging from its bacterial genes to their proteins and metabolites are known as gut microbiome. Gut microbiota serve the host by protecting against environmental pollutants, pathogens, participating in the intake of dietary nutrients, assimilating certain drugs and carcinogens, and influencing the absorption and distribution of fat (Hooper et al., 2001). Environmental pollutants may be converted into metabolites by intestinal microbes that serve as biologically active molecules affecting regulatory functions in the host.

The concept of the human microbiome was first introduced to the scientific community by Joshua Lederberg, who defined it as 'the ecological community of commensal, symbiotic, and pathogenic microorganisms that literally share our body space and have been all but ignored as determinants of health and diseases (Lederberg and McCray, 2001). The constituents of the microbiota, ranging from its bacterial genes to their proteins and metabolites are known as gut microbiome. In addition, gut microbiota is now known to have a crucial role in the development and functionality of innate and adaptive immune responsesand in regulating gut motility, intestinal barrier homeostasis, nutrient absorption and fat distribution (Cryan and Dinan, 2012). Gut microbiota serve the host by protecting against pathogens, participating in the intake of dietary nutrients, assimilating certain drugs and carcinogens, and influencing the absorption and distribution of fat (Hooper et al., 2001). Disruption of the symbiotic relationship between the microbiota and the GI tract (Hawrelak et al., 2004) disturbs host functions and in some cases, it will contribute to a "leaky" gut-immune barrier (Daneman et al., 2009) which leads to malfunction and illness such as inflammatory bowel disease (IBD). There is an emerging understanding of the bi-directional crosstalk governing gut-to-brain communication in health and disease of both organs. Accordingly, not only the brain can affect gut functions, but the gut can also induce changes in the central nervous system (CNS) and there is now compelling evidence for various links between the enteric microbiota and brain function. This connection is becoming increasingly pertinent in novel therapeutic measures to target psychiatric disorders such as depression and anxiety-like disorders (Borrelli et al., 2016).

Impact of Food on Gut Microbiota

The food after digestion released into the small intestine. The small intestines secrete some digestive juices and enzymes to absorb the digestive materials to pass on to bloodstream for utilisation of the body. The intestine as well as the whole digestive tract filled with variety of microorganisms together known as microbiome. Healthy microbiome can able to balance some dissention whereas too much leads to illness. The bacteria within the digestive system are manipulative because they can influence the choice of food as per their needs, in reverse they can also be manipulated by the hosts choice of food. Hence, nutrition plays an important role in maintaining the healthy microbiome for the secretion and proliferation of different types of neurotransmitters, which leads to reduction of anxiety and depression. Probiotics are beneficial live microorganisms that colonise the intestine with beneficial gut microbiota. One study showed that *Lactobacillus rhamnosus* GG (LGG) found in yogurt increase brain activity by regulating the neuronal survival (Mahanta et al., 2020).

polycyclic aromatic hydrocarbon (PAHs). PAHs are a group of hydrocarbons that are mainly formed by the incomplete combustion of organic matter This ubiquitous compound can be found in coal tar, tobacco smoke and many foods, especially grilled meats.Benzo alpha pyrene, B[a]P is readily absorbed following inhalation, ingestion and skin exposure. In animals, approximately 30 % of absorption occurred through the GI tract directly into the duodenum upon exposure of low dose of B[a]P.B[a]P can easily cross the blood brain barrier and induce damage in brain, since brain is susceptible for oxidative stress due to high lipid content and lack of antioxidants. B[a]P metabolism led to generation of wide array of metabolites and ultimately formation of hydroxyl compounds of free radical reactive species causing cellular toxicity leading towards behaviour changes by alternation of neurotransmitter secretion in brain(Mohanty et al., 2016). B[a]P exposure induced significant shifts in the composition and relative abundance of stool and mucosa-associated bacterial communities.

Lactobacillus rhamnosus GG is a strain of *L.rhamnosus* that was isolated in 1983 from the intestinal tract of a healthy human being. This particular strain is acid and bile-stable having a great avidity for intestinal mucosal cells, and produces lactic acid. It tends to colonize in the digestive tract and balances the intestinal microflora of the host.Probiotics have been introduced as a nutrient supplement to influence the brain activity and protect it from the negative impact of hormones. These probiotics help to enhance the quality of life by modulating gut health. Till now investigations are going on to unlock the actual mechanisms on how microbiota composition affects the functioning of the brain in animal models predominantly about behavioural disorders such as anxiety, depression, etc(Figure 1). Till now researchers are going on to unveil the molecular and cellular signalling mechanisms to exactly know how microbiota alters gastrointestinal function as well as behavioural response interlinking with the brain. Although the mechanisms by which probiotics exert their beneficial effects on the host are largely unknown, probiotic administration showed amplifying results on growth performance and health of teleost fish (Llewellyn et al., 2014).

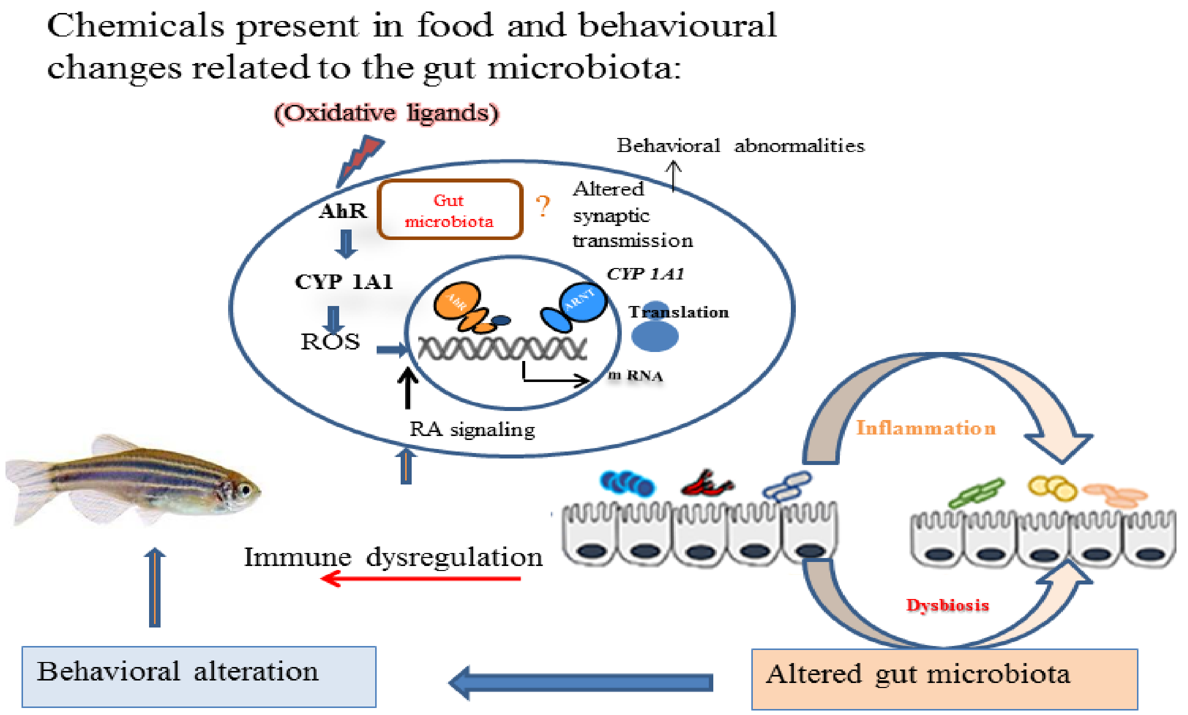

Fig. 1 Environmental pollutant present in food can enters the gut across via the gills or the gastrointestinal tract in zebrafish. Alterations in the microbiota population can result from exposure to various environmental factors, including diet, toxins, drugs, and pathogens. Of these, enteric pathogens have the greatest potential to cause microbial dysbiosis as seen in experimental animal models, where it may influence the host cellular homeostasis or the gut inflammatory mechanisms though immune dysregulation.

Role of Probiotic on gut microbiota

Probiotics may restore the composition of the gut microbiome and introduce beneficial functions to gut microbial communities, resulting in amelioration or prevention of gut inflammation and other intestinal or systemic disease phenotypes (Hemarajata and Versalovic, 2013).Recently, probiotics have come into limelight as a novel for safely keeping a healthy intestinal microbiota, and thus having impact on the gut–brain function. These are “live microorganisms” that, when ingested in adequate quantities, exert a health benefit on the host. These are widely marketed and consumed, mostly as dietary supplements. Mechanisms of probiosis include manipulation of intestinal microbial communities, suppression of pathogens, immunomodulation, stimulation of epithelial cell proliferation and differentiation and fortification of the intestinal barrier (Thomas and Versalovic, 2010). In animal models a variety of probiotics have been investigated however, not all bacterial populations show adequacy in inflecting behavior. *Bifidobacteria* and *Lactobacillus* are the main genera so far investigated for beneficial effects on health. *Lactobacillus* is a genus of Gram-positive, facultative anaerobic or microaerophilic, rod-shaped, non-sporeforming bacteria. It is the most common probiotic found in food such as yogurt and dairy products which includes fermented, unpasteurized milk and semi-hard cheese. *Lactobacillus rhamnosus,* GG is a strain of *L. rhamnosus*that was isolated in 1983 from the intestinal tract of a healthy human being.

Conclusion

In conclusion a growing number of investigations have suggested a bidirectional link between the nervous system and commensal enteric microorganisms including microbiota. Therefore, by illuminating the present scenario of Gut-Brain dysfunction the present study was carried out for restoration of proper gut function through supplementation of probiotics which will ultimately lead to amelioration of behavioural changes. Further work can be preceded by determining which bacterial populations residing in the gut microbiota are responsible for alterations in CNS and creating disorders.

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