Oh my gut!

Role of gut bacteria in the production of neurochemical compounds influencing mood and behaviour in humans

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Background

Who has never had butterflies in the stomach before an exam, or before a performance? 100 million neurons in our gut are constantly communicating with our brain through release of neurotransmitters. These are biochemical messengers that carry out signaling, having relevant effects in physiological processes and mental aspects. These neurochemicals come from three main sources: neurons in the brain; enterochromaffin (EC) cells, which are specialized neurons within the intestinal wall; and gut microbiota. Neuroactive compounds arising from this third source are becoming a fascinating field for the scientific community. Thus, the aim in research is to go further into that field in order to elucidate the implication of microbiota in this "gut feeling" from our "second brain".

A little about the link between gut microbiota and the neuroendocrine and immune systems

Our intestinal microbiota colonizes the gastrointestinal tract soon after birth. This colonization seems to have a definite impact on setting proper modulation of both the immune system and the hypothalamus-pituitary-adrenal (HPA) axis. In physiological terms, gut bacteria signal to EC cells or directly to afferent nerve terminals in the lamina propria. By either of these two pathways, signals will be ultimately relayed to the vagus nerve to finally reach the nucleus of the solitary tract and ultimately to stress- and emotion-related areas (figure 1).

Who's in?

10^{14} is the number of bacteria naturally inhabiting in our gut, which represents 1 or 2 kg out of the total body mass. Many of them are able to produce neuroactive compounds.

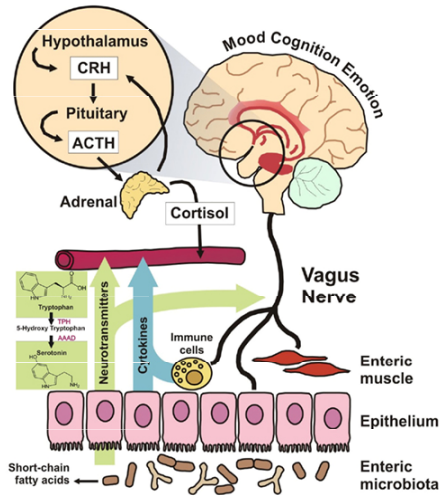


Figure 1. Connection network between gut microbiota, neuroendocrine and immune systems. Modified from Grenham et al., 2011

Objectives

The aim of the present work is to state what recent findings reveal about neurochemical compounds secreted by gut bacteria that influence in mood and behaviour. The following points will be elucidated:

- Introduction about the connection between microbiota and the brain
- Presentation of the main neurotransmitters produced by intestinal microbiota
- Highlighting of the application of "psychobiotics"

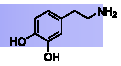
Methods

Bibliographic research has been carried out compiling information from scientific articles, books and science journals, most available in PUBMED or NCBI. The following key words have been taken into account during the research: gut bacteria, mood, behaviour, microbiota-gut-brain axis, neurochemical compounds, psychobiotics.

What do they produce?

Neurochemical products manufactured by enteric bacteria are homologous to those naturally found in human, having also in common their synthesis pathways, suggesting that communication between these two phylogenetic domains seemingly distant in the evolutionary tree can "and does" occur. Some of these neurotransmitters are presented henceforth.

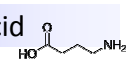
Catecholamines



Escherichia Bacillus Serratia Clostridium → Glucuroconjugated catecholamines (Beta-glucuronidase) → Free catecholamines: Noradrenaline, Dopamine

Lower activation of sympathetic nervous system and lower levels of stress and anxiety-like behaviour

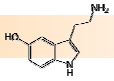
γ-aminobutiric acid



Lactobacillus brevis Lactobacillus rhamnosus Bifidobacterium dentium Bacteroides fragilis Dorea longicatena → Monosodium glutamate (Glutamate decarboxylase) → GABA

Decrease in depression and anxiety behaviours. Positive effects in motivation and pleasure in the nucleus accumbens and other limbic areas.

Serotonin

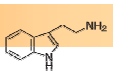


Escherichia Streptococcus Clostridium sporogenes Enterococcus → Tryptophan (Tryptophan hidroxylase) → Serotonin

Anaerobic fermentative bacteria → release Short chain fatty acids → induce Serotonin secretion from EC cells

Sleep modulation. Increase in pleasure and peacefulness.

Tryptamine



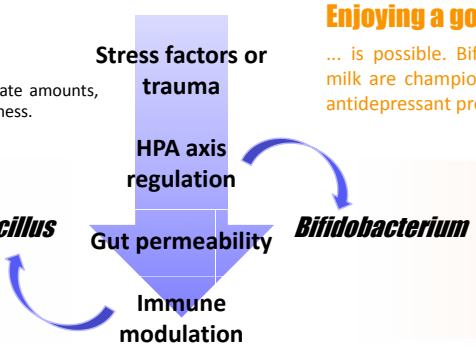
Clostridium sporogenes Ruminococcus gnavus → Tryptophan (Tryptophan decarboxylase) → Tryptamine

Induction of release of serotonin and norepinephrine by EC cells. Reinforce response of cells to serotonin.

Psychobiotics: feeling better

A psychobiotic is a live organism that, when ingested in adequate amounts, produces a health benefit in patients suffering from psychiatric illness.

Setting immune modulation in the baby
Treatment with *Lactobacillus rhamnosus* and *Lactobacillus helveticus* leads to reversion of gut permeability and stress-induced abnormalities. Immune host defences are thus strengthened (IgA synthesis within the mucosa, balanced response of T helper cells).



Setting HPA axis regulation in the baby
Hyper-activation of HPA axis can be returned to normal function by restoring *Bifidobacterium infantis* by faecal transplant at early stages of postnatal development. This bacterium will take advantage of the plasticity of the developing neuroendocrine system to set a proper HPA axis to face future stressful situations.

Enjoying a good mood...

... is possible. Bifidobacterium and Lactobacillus found in fermented milk are champions in tryptophan production, which is known for its antidepressant properties... So let's eat yoghourts!

Conclusions

In view of all the literature compiled in this bibliographic review, further studies are called to definitely unravel the recent matter about the influence of gut microbiota in mood and behaviour. Application of such knowledge could, and actually does, provide simple solutions to complex mental disorders as an alternative to medical drugs which are often accompanied by harmful side effects. In conclusion, it is all about perceive and appreciate signals coming from the gut, because down there, in our "second brain", there is a micro-world involved in every single shade of our behaviour.

References

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