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The presentation of gut microbiome-based personalized nutrition on the internet: simple and accessible, complex and inaccessible

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The gut microbiome is related to health and wellbeing, although the precise nature of the relationship and the involvement of and interaction with other factors is not fully understood. In this context, private companies are providing gut microbiome-based personalized nutrition services on the internet. Framed by social representation theory, we conducted an analysis of the websites of 27 companies offering direct-to-consumer personalized nutrition based on the microbiome, to understand how they communicate to prospective consumers. We found that through imagery, metaphor, and personification, companies simultaneously position the gut microbiome, and gut microbiome-based personalized nutrition, as simple and accessible and complex and inaccessible. Highly medicalized content in the main web pages is negated in often peripheral disclaimer sections.

KEYWORDS

gut microbiome, personalized nutrition, health communication, internet, health, social representation theory

1. Introduction

The relationship between diet, non-communicable diseases (e.g., Rosato et al., 2019), healthy aging, and longevity (e.g., Capurso et al., 2020), is well-established, and personalized nutrition (PN) a focus of research and enterprise. The premise of PN is that more individualized nutritional advice is more beneficial to health than generalized approaches (Ordovas et al., 2018). PN is made personal by the collection and analysis of individual data over and above lifestyle information. These data could relate to genotype, phenotype, or gut microbiome (GM). The focus of this paper is the way that companies offering GM-based PN communicate their offering. This is important because the status of the science underpinning this approach could be described as incomplete (Görman et al., 2013; Ordovas et al., 2018).

The microbiota are a vast collection of microorganisms that live on and inside human beings, estimated to be equivalent in number to human cells (Sender et al., 2016). Microbiota live all over the body, the majority in the gut. The term GM refers to the collective genomes of the microbiota present in the gut, and has been dubbed the "second genome" due to the functional potential it encodes (Herd et al., 2018). Largescale projects such as the Human Microbiome Project (Turnbaugh et al., 2007), have improved understanding of the human GM. A growing body of evidence suggests it is related to innumerable facets of human health, mental (e.g., Foster and Neufeld, 2013) and physical (e.g., Philips et al., 2020); fecal

microbial transplants have been used successfully to treat recurrent *Clostridium difficile* infections (Ser et al., 2021). There is no one-size-fits-all definition of a "healthy" GM, as "healthy" depends on an individual and their unique context (e.g., Leeming et al., 2021). As a general rule, greater microbial diversity appears to benefit the host, whilst lower diversity is associated with conditions such as type two diabetes and coeliac disease (Valdes et al., 2018). However, comparing GM composition between individuals and inferring which microbes are "beneficial" and "harmful" is difficult due to the high degree of functional redundancy present (Tian et al., 2020).

Environmental factors exert considerable influence over the GM (Rothschild et al., 2018). It is a product of and responsive to an individual's environment; how they were born, where they live, what they eat, what medicines they take, how much they exercise (e.g., Hughes, 2020). Every individual has a GM as unique as their fingerprint; even identical twins share only marginally more GM characteristics than unrelated individuals and may respond differently to the same diet (Berry et al., 2019). In contrast to the human genome, the GM is relatively malleable; compositional changes can be observed even after a brief period of dietary changes (Spector, 2017), although it is unclear how long-lasting these might be (Klimenko et al., 2018). This malleability offers a potential route to improving health and wellbeing, if changes to diet can alter the GM and reduce incidence of non-communicable disease (Mathers, 2019).

The science appears promising, but it is unclear whether current understanding of the GM is sufficient to facilitate the successful implementation of GM-based PN. First, most data come from observational studies or studies in mice (Fan and Pedersen, 2021) and many of them do not account for the compositional nature of microbiome data in their analysis (Gloor et al., 2017). Second, although technological advancements have led to the identification of numerous microbial taxa and genes, a complete understanding of the GM, its interaction with diet, and impact on human health has not yet been achieved (Thomas and Segata, 2019). Third, although environmental factors are important, so too are genetic factors, and there are still many unknowns about the interaction between the human genome, the GM, and diet (Bligh et al., 2020). Fourth, individuals' baseline GM determines the extent to which they are "responders" or "non-responders," i.e., the extent to which their GM responds to dietary intervention (Mills et al., 2019). There is also the issue of whether dietary advice is more effective if based on GM analysis over and above more easily accessible lifestyle information. The Food4Me study (Celis-Morales et al., 2017) found that personalized nutritional advice based on current diet was more effective than generic nutritional advice, but that phenotypic and genotypic information did not enhance intervention effectiveness (Livingstone et al., 2017). In sum, whether, how, and for whom analysis of an individual's GM can lead to effective PN, are questions mired in uncertainty. Nonetheless, several internet-based companies provide PN services based on analysis of a customer's GM. The focus of this paper is to examine how such companies characterize the GM, their offering, and the science behind it. We do not seek to determine whether their depictions of the science are accurate but rather, to identify the ways they position their offering and the discursive and visual resources they deploy to do so.

Though not widely researched, studies (e.g., Pineider et al., 2021) suggest lay publics do not have high levels of awareness and understanding of the GM. Even if they are aware of the GM, it is, like other abstract, scientific concepts such as nanotechnology, imperceptible. It cannot be seen, heard, or touched and so must be re-presented—or given meaning beyond the immediate senses—to be understood. Commercial companies offering GM-based PN need therefore, to communicate an inherently complex and abstract proposition in a way that will appeal to prospective consumers. Here, we employ Social Representation Theory (SRT) (Moscovici, 1961) as a lens through which to examine how they do this. SRT is a theory of social knowledge that is concerned with how scientific knowledge becomes lay knowledge, how the complex and abstract, becomes simple and concrete. One process central to SRT—objectification—is particularly important here. Objectification transforms the abstract to concrete, via the use of visuals, metaphors, symbols, and personification (Joffe, 2003). These tools help to make a phenomenon salient and accessible. Studies informed by SRT have shown how metaphors, visuals, and personification are tools of objectification that help to make the unfamiliar, familiar; for example, polar bears have come to personify—or act as a shortcut to—climate change (Smith and Joffe, 2009). Visual imagery is considered a particularly persuasive form of objectification (Joffe, 2008), as it can generate emotion and give meaning to information in a way that textual presentation cannot (Zajonc, 1998), exerting a "positioning power" over an issue (Boholm, 1998). Visual imagery is an important tool in marketing; in the context of relatively minimal product differentiation, visuals can provide that point of differentiation and to a degree, circumvent legal restrictions applying to the written word (Branthwaite, 2002).

Our intention is to examine the ways that companies offering GM-based PN communicate their offering. We are interested in the ways they set out their offering, the way they present the science, and the discursive and visual resources they deploy. Our research questions are:

1) How do companies present the GM?
2) What benefits are claimed and how are these claims given credibility?
3) How, if at all, are uncertainties about the science of GM articulated?

2. Method

To define our inclusion criteria, we adopted Adam et al.'s (2020) definition of personalized nutrition. To be included, a company offering, presented on their website in English, had to fit the criteria outlined in 1 to 4 below:

1) Individual-specific microbiome information must be provided to the company by the consumer (via stool or other relevant test).
2) An evidence-based scientific basis for claims relating to the microbiome test and benefits of performing that test must be articulated.
3) Dietary advice must be provided.

4) Benefits of making the recommended dietary changes on the individual's health/wellbeing must be articulated.

In June 2021, we conducted Google searches using the following search terms: "gut microbiome test personal nutrition"; "personalized nutrition microbiome"; "buy microbiome test," and "best microbiome test." We saved the first 10 pages of results for each search. Except for the second search ("personalized nutrition microbiome"), which yielded mainly academic articles, the crossover between searches was high. The searches also yielded academic articles, health websites, blogs, and media articles about the GM.

Of the 40 pages of search results, we identified 28 relevant sites that met the inclusion criteria. A second search in November 2021 revealed that one of the initially identified sites was no longer offering a direct-to-consumer service, leaving 27 sites, one of which was trading under a different name. We examined the relevant pages of each site, selecting text and images pertaining to the research questions. We grouped images and texts into initial codes and then broader categories, using the principles of inductive thematic analysis (Braun et al., 2019), to identify recurrent patterns of meaning. The authors met frequently to discuss the coding and categorization. To maintain the privacy of the 27 companies, we allocated each a code.

3. Results

Most companies were based in Europe or the US. We identified three types of companies. First, twelve companies exclusively offering GM testing and personalized nutritional advice, with the option of adding a consultation. Second, eight companies exclusively offering GM testing and selling a range of GM-enhancing supplements, recommended following the analysis of a customer's GM sample. Finally, seven companies offering a broad suite of tests (e.g., fertility, DNA, food intolerance) of which the GM test and associated recommendations is one.

3.1. RQ1: How do companies present the GM?

The companies undertake two communication tasks here; explaining why the GM is important and explaining what the GM is. Three claims are made about the former. First, that every individual's GM is unique to them. This is sometimes communicated by referring to fingerprints, or by highlighting the low proportion of shared gut microbes. Numbers and scale are used to explain this uniqueness: the GM is comprised of trillions of microorganisms, and whilst humans are almost identical in terms of DNA composition, they are vastly different microbially, even from close relatives.

> *Your gut microbiome is unique. Humans share 99% of the same DNA, however, the human gut microbiome is hugely variable from person to person. Through our research, we have found that even identical twins have very different gut microbiomes, with unrelated individuals sharing 30% and twins sharing 34% of the same gut microbes.* Company E

Second, that the GM is directly related to and exerts an influence—positive or negative—on health and wellbeing. A "healthy" GM protects the body and can reduce the risk of disease and enhance wellbeing, whereas an "unhealthy" GM can have deleterious effects on the body, amplify the risk of disease, and reduce wellbeing.

> *A damaged gut microbiome produces an improper imbalance of building blocks, which makes the body more susceptible to health issues. A healthy gut microbiome produces a better balance of building blocks, which protects the body.* Company F

Third, that the GM is malleable and can be "improved," which in turn, can improve health and wellbeing. In this way, the case for the companies' offerings is made clear and comprehensible: understand your individual GM and how it could be improved, improve your GM health by altering diet, and enhance overall health. A range of argumentation is used to make the link between the new ways of assessing gut health and the recommendations to improve it. The GM is presented as the hitherto undiscovered key to change that mediates diet and health. It is made clear that a "healthy" diet is not necessarily a simple matter of common sense; the companies will help to elucidate the complex interaction between an individual's unique GM and the foods that maintain good health.

> *The foods we eat change the composition of millions of bacteria lining our gut—the gut microbiome. In turn, an imbalance of good versus bad bacteria in our gut can cause a whole host of uses such as anxiety, leaky gut, obesity, or even issues with sleep.... The good news is that if you start to understand your unique microbiome composition, making small mindful adjustments to your diet can rapidly improve the balance of your microbiome and help you feel better.* Company W

Communicating why the GM is important is perhaps a more straightforward task than explaining what the GM is. This may explain why some companies focus almost exclusively on communicating what the GM *does* and offer little or no explanation of what it *is*. Typically, the more detail-heavy and scientific content is placed within blog or "science" sections that sometimes contain references to published research. Generally, the companies in the first category have more such content on their websites than companies in the other categories. The companies in the third category tend to have relatively minimal explanatory content, presumably because of their broader product offering. Outside of sections containing very scientific content, companies present the GM in rather simplified terms, with clear examples of personification, analogy, and metaphor.

Some sites personify the GM by depicting it as individual or collections of cheerful, colorful, anthropomorphized "bugs" complete with facial features, arms, and legs. These images have a

childlike quality, and this "friendly," non-threatening presentation seems designed to (re)position microbes—long associated with illness or dirtiness—as allies rather than foes. Some sites use images of vital, healthy, and happy-looking individuals, presumably to convey the positive aesthetic consequences of a healthy GM. In contrast, some sites evoke battle metaphors and describe the GM as a force, a colony, or an army. Despite the potentially hostile connotations, it is made clear that if treated appropriately, these forces will fight on the side of your body, against foes such as disease, lack of energy, or ill-health.

> *Meet your invisible army. In the ongoing fight against chronic disease, scientists have begun to turn to an army of unexpected allies—bacteria and other microorganisms.* Company C

Anchored to the idea of scale and interdependence, the GM is presented as analogous to a forest or ecosystem, sometimes with accompanying imagery of foliage or trees. It is also referred to as a forgotten organ, or a second brain. The use of the word "forgotten" in this context implies the potential for rediscovery (with the companies' help) of something vitally important. Imbuing the GM with a mystical quality, there are references to ancient wisdom, with some sites quoting ancient scholars.

> *"The intestines are the seat of health" Hippocrates.* Company M

On the one hand, evoking millennia-old wisdom seems counter to the promotion of products making use of contemporary technological advancement. On the other, there is perhaps an intuitive logic at play here; in modern times we have lost our way; adopting ancient wisdom is to revert to fundamental truths. Some sites evoke mysticism, with images of ancient rocks and landscapes and references to new worlds, forgotten systems, and the unlocking of powerful secrets. Here, it is not so much scientific advancements that are heralded, but rather, enduring popular imagination. This presentation juxtaposes the long-acknowledged importance of the gut, with cutting-edge scientific advancements and technology, the ancient and the modern.

3.2. RQ2: What benefits are claimed and how are these claims made credible?

Claims about benefits center on the potential for improving an individual's health. Some claims relate to improving singular physical conditions (e.g., IBS, fibromyalgia) and mental health issues (e.g., anxiety, brain fog). Others relate to generic and all-encompassing health benefits and addressing debilitating but diffuse sets of symptoms (e.g., immunity and fatigue).

> *A targeted approach to improving your gut microbiome. Increase energy, support weight loss, optimize health, support emotional health, improve sleep, strengthen immunity.* Company F

Some sites are populated with images of young, attractive people or of particularly vital middle-aged and older people, and these images of youth, beauty, and vitality are aspirational. Benefit claims about improving health and wellbeing are supported and made credible in several ways. First, by highlighting the specific scientific and academic credentials of the organization. This seems intended to establish a companies' ability to translate the inaccessible and unknowable into the accessible and knowable. This is achieved in two ways: by referring to specific individuals and their involvement with the company, or by conveying the companies' wider scientific credentials. For example, an individual's eminence may be detailed, their academic qualifications and publications noted, and associations with research institutions or commercial organizations outlined. Organizational credibility is achieved by emphasizing company links to research or commercial organizations, and by including detailed information about the science of the microbiome that suggests breadth of knowledge and expertise, linking to scientific articles about the GM.

> *Over the last few years, in excess of $1.7 billion was spent on gut microbiome research. We've tapped into numerous research publications to bring you the latest science-backed findings.* Company I

Second, credibility is claimed by highlighting the superiority of the companies' technological and analytic capability. This entails detailing the type of sequencing employed and its superiority over types that cannot provide the same insights. In one example, analogy is used—likening different types of technologies to those that might be found in audio-visual equipment in the home. Sometimes, information about sequencing and analysis appears presented in a deliberately abstruse fashion that would not be readily understood by the layperson. The use of lengthy, scientific words and detailed graphs and diagrams seems intended to convey6 a level of complexity that is out of the laypersons' reach but could perhaps be perceived as all the more credible for it. There is a clear contrast between the complicated, esoteric detail about sequencing and analysis and the simple, straightforward output then given to the consumer.

> *The best gut health test is one that offers a full spectrum microflora analysis and includes full HD resolution scanning of over 23,000 microbes including probiotics, viruses, phages, and fungi. Think of it like watching your favourite movie, sports team, or show on TV. Would you prefer watching it with 1080p resolution or 5K UHD? Our whole genome sequencing gut test results will show you your bacteria all the way down to the species level, so you know you're getting the best resolution.* Company H

Third, many sites display customer testimonials. Some feature testimonials from social media influencers, others display written endorsements that report improvements to health and wellbeing and satisfaction with services and products received. These endorsements are both brief and generic, and lengthy and specific. In either case, the impact on the consumer is portrayed as definitive, providing the answer to a previously unsolved problem. Finally, some companies claim credibility by displaying mainstream and niche media logos, in "as featured in" style to communicate the credibility of their product.

3.3. RQ3: How, if at all, are uncertainties articulated?

Companies do not articulate uncertainty or give caveats in the main pages of their websites. Their claims about the GM, its links to health and disease, the scientific technology underpinning a companies' test offering, and the benefits of conducting GM tests are made unequivocally. Nonetheless, 24 of the 27 companies do give a disclaimer of one kind or another. These disclaimers are often hard to find, buried within lengthy terms and conditions or at the bottom of long webpages. One company printed their disclaimer in a text virtually indistinguishable in color from the background color. There are two broad types of disclaimers. First, in contrast to the highly medicalized claims made elsewhere, is the clarification that product offerings are not "medical." Rather they are variously: general, educational, or informational; the relationship between the consumer and company does not represent a patient-doctor relationship.

> *The tests we offer are not intended to diagnose or treat disease, or to substitute for a physician's consultation.* Company L

The second type of disclaimers relate to potential analytic limitations. These are not about the ineffectiveness or inaccuracy of the analyses *per se*, but additional errors.

> *Due to the nature of the genetic sequencing technology used, it is not possible to interpret the genetic information provided without errors, although these will comprise a small percentage of the results. As such errors cannot be predicted in advance, Company B does not offer a refund or other compensation with respect to them.* Company B

These errors could arise because of the nature of the technology, because of occasional misinterpretation by analysts, because of errors made by the consumer when collecting or packaging their biological sample, or because of a paucity of research relating to the GM of a particular ethnic group.

4. Discussion

The purpose of this analysis was to explore how commercial companies offering GM-based PN present the GM, the benefits of GM-based PN, and whether they articulate uncertainty about the science. We found that companies deployed visuals, metaphors, and personification to transform the GM from an abstract to more concrete concept. Images of friendly, anthropomorphized microbes were used to convey the helpful, transformative nature of the GM and to communicate the potential of "good" microbes. Similarly, images of healthy, attractive people, were deployed to communicate the aesthetic benefits of GM-based PN. These individuals embodied—or personified—the benefits of using the companies' services. In contrast to the presentation of the GM as small and unthreatening, it was also objectified, via battle-related metaphors, as a fighting force or army. It was made analogous to a forest or ecosystem and—perhaps most interestingly in the context of the modern science and technology facilitating GM-based PN—aligned with ancient wisdom. This alignment makes the GM and its potential impact on health intuitive, logical, simple, and wise, a presentation that perhaps circumvents the need to further engage with more difficult and complex detail. The way that imagery, metaphor, and personification is used objectifies the GM as the secret key to the improvement of health.

4.1. Social representations and themata

In addition to evidence of objectification, the presence of another concept related to SRT—themata (Marková, 2003)—became apparent as we analyzed the data. The idea of themata originated in the physical sciences, conceived as the dyadic oppositions—such as reductionism/holism and complexity/simplicity—underpinning scientific thinking (Holton, 1975). Themata were incorporated into SRT (Moscovici, 1993) as dyadic oppositions underpinning lay thinking, the latent structures that underpin social representations (Marková, 2017). Themata are comprised of oppositional or antithetical poles that help people make sense of a particular object. These dyads are interdependent, like the Chinese concept of yin and yang, one pole is understood in relation to the other (Liu, 2004).

It became evident during the analysis that dyadic oppositions—or themata—underpinned the companies' presentations of the GM and GM-based PN. The GM was positioned as both benign, small, and friendly—when depicted as smiling, anthropomorphized, cartoonish characters—and vast and combative—when depicted as an enormous fighting force or army. The link between the gut and health was argued to be ancient wisdom, and knowledge that can only be accessed via the application of the most modern technological advancements. The ability of the companies' test analyses and recommendations to provide straightforward and actionable improvements to health was depicted as easy and straightforward, in contrast to the complexity alluded to when describing the technological processes. The certainty contained in the main sections of the companies' websites, where benefits were clearly outlined, contrasted with the uncertainty articulated in the disclaimers. In a parallel vein, although companies did not explicitly claim to be medical organizations, this was inferred by their claims about health benefits and the stated associations with academics, medical journals, and healthcare institutions. These contrasted with the text in the disclaimers which stated with clarity that companies were not offering a medical service. These apparent antinomies: small/vast, friendly/combative, ancient/modern, easy/complex, certain/uncertain, and medical/not medical all seem to sit within one overarching thema: accessible/inaccessible. That is, the GM and GM-based personalized nutrition are simultaneously presented as accessible—straightforward, easy, and self-evident—and inaccessible—complicated, difficult, discernible only by experts. The accessible positioning makes GM-based PN a viable and logical proposition, the latter justifies the companies' service; they can translate the complicated and difficult into the straightforward and easy.

4.2. Limitations of the study

Our search was bounded and conducted at a specific point in time and so it is possible that we did not identify all companies meeting the inclusion criteria. We are aware that companies come and go—indeed, one ceased trading in the same form in the time between our initial search and second check. In line with the principles of interpretative qualitative analysis, we acknowledge that alternative interpretations of the data could have been made by other researchers (Willig, 2013).

5. Conclusions and future directions

Our analysis demonstrates that the strategies of companies seeking to promote GM-based PN and communicate the complex science around the GM are illustrative of the process of objectification and the oppositions of themata noted by social representation theory. As set out in the introduction, the purpose of this study was not to evaluate the efficacy of the products being offered or to dissect the factual accuracy of the claims made, rather, to examine the ways GM-based PN is communicated to consumers. Nevertheless, despite the scientific evidence for GM-based PN being far from certain, uncertainty was absent in the claims made about potential benefits. In contrast, disclaimer sections contain explicit caveats, which mirrors a previously identified incongruence between wide-ranging promises made about outcomes and the content in disclaimer sections on PN websites (Ahlgren et al., 2013). PN is not governed by the kinds of regulations applied to medical products, although some critics argue that regulation should be more stringent (see Saukko, 2013, for review). Given the potential for ethical concerns around a lack of clarity and transparency in benefit claims, future studies might usefully examine consumers' understanding of the way PN is communicated by commercial companies. Further, it would be interesting to understand the extent to which the communication of uncertainty and caveat impacts consumer understandings of GM-based PN. It may be that—as in related areas—the presentation of scientific uncertainty does not necessarily fundamentally undermine confidence (Frewer et al., 2002) or negatively impact attitudes (Ratcliff et al., 2021) toward PN.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors upon request.

Author contributions

KL designed the study, conducted the analysis, and wrote the article. RD contributed to writing the article. JB supported with study design, data analysis, and edited the article. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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