

## Missing Mess and Strange Agencies in Online Images of Mind Microbiome Connections

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### Abstract

This paper examines online images of the relationship between the human microbiome and mind. It asks how these images visualize connections between vastly different scales and kinds of being, and discusses what kinds of agency they perform. An archive of 274 images was built using Google® image search and a qualitative analysis of imaging strategies resulted in five groups of images characterized by their use of *linking*, *zooming*, *texturing*, *absent elements*, or *strange agencies*. The images were overwhelmingly ‘clean’ – simple lines, plain backgrounds and pastel colours dominated – and mess, spookiness, and dirt were largely invisible. The microbes and minds shown were often de-situated, and out of context. In discussion, we argue that the strategies by which connection between scales were directly depicted, or indicated using diagrammatic tropes, elided the strangeness and ambiguity of mind-microbiome research. Images that instead broke the rules of scale by texturing microbes into human forms, using symbolic connections or missing elements, were open to more critical engagement. We suggest that *not* depicting connections might sometimes be more effective than depicting them for inviting critical engagement, though this is an unstable and context-dependent effect, deserving of further empirical investigation. We further discuss that the absence of mess might speak to its potency, and challenge us to explore its potential for engaging (and holding open) the uncomfortable affective tensions that surround questions of multispecies human agency – tensions between excitement and scepticism, intimacy and alienation, awe and disgust. The study contributes to STS literature on the importance of images in mediating relations between science and society, and to STS studies of the implications of microbiome research for how human agency is understood.

### Keywords

microbes; microbiome; scientific images; science communication; performativity

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## Introduction

Over the last decade or so scientific research on the connection between the microbiome and the mind has flourished, examining mental states and conditions ranging from autism to anxiety (e.g. [Järbrink–Sehgal and Andreasson 2020](#); [Smith and Wissel 2019](#); [Montiel–Castro et al. 2013](#); [Cryan and Dinan 2012](#); [Severance, Yolken, and Eaton 2016](#); [Liang, Wu, and Jin 2018](#)). Some of the results appear to question fundamental post-enlightenment assumptions about human agency and control, as they indicate that the microbiome may play an important factor in regulating our mental state. While these results are still very preliminary, they have escaped the laboratory and are widely reported in the media and in various blogs and internet fora. In this paper we study how these preliminary ‘facts’ are represented in popular science communication, more specifically in online images of mind-microbiome relations. We examine how images show connections between vastly different scales, and discuss what kinds of agency are performed via these connections.

Before outlining the methods of the empirical study that lies at the heart of this paper, we will expand on our motivations – why are mind-microbiome connections so interesting, why study their popular communication, and why focus on online images? To do so we will present a brief outline of mind-microbiome research, alongside discussing relevant concepts and findings from literature in science and technology studies (STS), cultural studies of science, and science communication. We will then explain our approach to popular images as performative, situated in earlier STS usage of this concept.

## Meanings of Microbiome Research

In order to understand why popular discourse on microbe-mind connections is important to study, a brief introduction to the field of microbiome research is needed. ‘Microbiome’ refers to the combined genetic material of our microbiota – of the bacteria, vira, fungi, and archaea that live *on* and *in* us. However, in this paper we follow popular usage, and use ‘microbiome’ to refer to both the genetic material and its bearers (see [Marchesi and Ravel 2015](#) for discussion of terminology in the field). The microbiome is crucial to many bodily functions, as well as being implicated in disease and dysfunction. Scientific studies have implicated the microbiome in states and conditions ranging from autoimmune disease to cancer, augmenting older notions of a ‘probiotic diet’ and ‘good dirt’ with findings about the impact of particular microbiota compositions, and the influence of environments on those compositions (e.g. [Lynch and Pedersen 2016](#)). In other words, the microbiome-mind connection is from a scientific perspective highly situated and shaped by context. Early enthusiasm about visions of new medical futures ([Sekirov and Finlay 2006](#); [Brody 2017](#)) have been accompanied by a healthy critical examination of the status and promises of microbiome research ([Bik 2016](#)).

Early scientific studies focusing on the connection between the microbiome and mental states and conditions were greeted as potentially paradigm shifting for the understanding and treatment of diseases categorized as being ‘psychosomatic’, but also as lacking rigour and being primarily correlational (e.g. [Lynch, Parke, and O’Malley 2019](#)); as generating huge amounts of genetic data with insufficient interrogation of what that data might mean ([Hanage 2014](#)). The early scientific studies were also criticized for being based almost exclusively in animal models, whose translational difficulties are amplified when dealing with subjective experience ([Hooks, Kongsman, and O’Malley 2018](#)). What does a depressed mouse look like, and in what ways might its experience relate to ours ([Rose and Abi-Rached 2013, 82–109](#))? In

recent years, these initial correlational studies have been supplemented by causal studies in both mice and humans, better understanding of mechanisms, and early clinical trials ([Willyard 2021](#); [Foster 2020](#)). However, results are still tentative and contested, and the translational potential of the science into clinical treatments, monetizable products and diets remains unclear ([Lynch, Parke, and O'Malley 2019](#); [Kelly et al. 2016](#); [Bested, Logan, and Selhub 2013](#)).

Despite the early stages of the science and its internal critique, results have been widely reported in popular media. Perhaps in part because they invoke fundamental issues around the status of the individual human in understandings of health ([Formosinho, Bencard and Whiteley 2022](#); [Sariola and Gilbert 2020](#)). More generally, mind-microbiome research seems to add a novel layer to the ancient dilemma about the relation between body and psyche ([Lucas 2018](#); [Rees, Bosch, and Douglas 2018](#)). It seems to offer a more expansive notion of 'body' than that found in attempts to locate the mind within the brain, incorporating the gut and other physiological interfaces between body and world, along with multiple species that move across these interfaces. This does not promise an escape from dualism, but rather poses interesting challenges to the boundaries around the entities to be related ([Friis 2023](#); [Rees, Bosch, and Douglas 2018](#); though see [Parke et al. 2018](#) for a more critical take on whether the microbiome shifts philosophical notions of 'self'). In this way, the research has also evoked discussions about free will and human agency. Here are two examples: a 2016 headline from *Scientific American* asks: 'Does our microbiome control us, or do we control it?' ([Fine Maron 2016](#)); and Carl Zimmer titled their *New York Times* article in 2014 'Our microbiome might be looking out for itself' ([Zimmer 2014](#)). These discussions are part of a long history of engagements with an apparent competition between the mental and biological; just like previous headlines have asked whether our genes ([Nelkin and Lindee 2004](#)) or brains ([Whiteley 2012](#)) in fact 'control us'.

We decided to look at popular images to explore how they depict these new findings and the potential implications for how we understand ourselves. We chose images in part because we consider they play a key role in shaping discourse around emerging science, as outlined in the next section. But imaging also had to grapple directly with a key issue for all communication of mind-microbiome research – depicting connections between vastly different scales and forms of being; between human and microbe, mental and metabolic states, and within a small 2-dimensional frame. We asked: what strategies have been used to depict these connections and how are those strategies implicated in enacting how agency is distributed between humans, microbes or other actors.

### Performative Images in STS and Science Communication

Many have argued that shifts in popular imagery and metaphor can both indicate and follow shifts of thought in science (e.g. [Haraway 2004](#); [Keller 2020](#)). This makes popular images particularly interesting in relation to the development of new and unsettled, yet highly reported, scientific fields such as microbiome research. In studying popular images of mind-microbiome connections, we are in particular inspired by Sarah Davies' ([2022](#)) view on what an STS gaze on science communication can offer. First of all, we consider scientific facts as constructed and flexible to local interpretation and the images we study form part of that construction. Following that, and also underlying an STS approach to science communication, we ask 'what do these images do?'—treating them as performative rather than asking if they are effective or truthful in communicating a stable scientific fact ([ibid., 308](#)). From this perspective, science communication shapes the

world in specific ways ([ibid.](#), 310), impacting the world it describes via looping effects (e.g. [Hacking 1986](#), [1996](#)). Here, we study graphic strategies used for depicting the relations between microbial and human scale, and discuss the implications of those strategies for the distribution of agency between the humans and microbes in the range of images that we go on to examine. The study of audience reception or reactions to the images could be a topic for a future study but is beyond the scope of this research.<sup>1</sup>

Below, we further unfold our use of the concept of ‘performativity’, alongside our understanding of ‘agency’. Studying the performativity of specific phenomena in relation to (scientific) disciplines is a relatively recent development in the sociology of knowledge and STS. In the following, we will point to a few of those whom we are inspired by in our use of the concept. One of the most notable is Michel Callon’s studies of how ‘market behaviour’ is ‘formed’ by economic theory, rather than economic theory objectively and passively describing the markets – this is the ‘performativity’ of economic theory (e.g. [Callon 2009](#); [Callon 1998](#)). We are inspired by Callon’s focus on how knowledge forms shape practice rather than just being innocent descriptions of a phenomenon. In the same way, we believe that the graphic strategies for dealing with differences of scale are not innocent, as they also contribute to forming the distribution of agency between different actors in the images.

Particularly in relation to performativity and scientific images, we draw on Manuela Perrotta’s ([2012](#)) typology of STS studies of scientific images, which identifies three different strands of literature. The first strand is preoccupied with the practice of constructing scientific images within networks of technical instruments, style and aesthetic conventions, as well as preferences of the scientist, and so on (e.g. [Latour 1999](#); [Turrini 2012](#); [Burri 2012](#)). The second strand is also interested in the images as part of fact-construction, but rather than looking at image constructions in practice, studies broadly show the wider ways in which technoscientific images are deployed as ‘evidence’ – both in scientific settings and elsewhere (e.g. [Yu 2017](#); [Brumfiel 2006](#); [O’Neill and Nicholson-Cole 2009](#); [Rodriguez and Asoro 2012](#); [Kennedy 2020](#)). We see our study as contributing to the third strand, which Perrotta describes as preoccupied with studying the relations between ‘*images and imaginations*’ ([Perrotta 2012](#), 170). This strand focuses on images that communicate about science, to ask – how the images foster people’s imagination and perceptions of scientific phenomena, not least those phenomena invisible to the human eye such as the microbiome. This strand of literature has been especially vibrant around nano-technology (e.g. [Nerlich 2008](#); [Hanson 2012](#); [Ridder-Vignone and Lynch 2012](#)), but also in relation to gene technologies (e.g. [Nelkin and Lindee 2004](#)) and reproductive technologies (e.g. [Lie 2012](#), [2015](#), [2023](#)). These studies all have in common their interest in what kind of imaginations about ‘being human’ the images support or exclude, in context, resonating with our performative approach.

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<sup>1</sup>This is not an art-historical or visual anthropology analysis, and we do not approach the image archive through the analytic methods of those disciplines, though this could be an interesting approach. Rather, we aim to highlight the relevance of pop culture images in an STS context that doesn’t have an established tradition for how to handle them, drawing on tools that we find useful from our interdisciplinary perspective and which resonate with an STS frame.

We extend the third strand to a new focus on mind–microbiome relations, and aim to demonstrate the relevance of popular science communication images, alongside the more studied domain of images produced within science (though we recognize that the boundaries between ‘science’ and ‘non-science’ are slippery). In relation to our image archive, we show how the images take part in renegotiating what humans are, especially in terms of agency and control. In considering the performativity of *graphic* strategies, our study is related to Penelope Ironstone’s (2019) study of microbiome TED-talks. Ironstone argues that *rhetorical* strategies conjure up the idea of an at once neoliberal biological citizen with great potentials for agency and responsibility for their own health, *and* a human almost overwhelmed by their own multitudes of microbes. Similarly, we ask what ideas about agency are conjured up in graphical strategies for depicting relations across scales, and what the implications are for their performative capacities to enable and restrict critical discussion about the distribution of agency.

Moving to our other key concept, namely ‘agency’, our understanding is grounded in classical sociology of knowledge and STS literature. Here, agency is considered an effect of networks; as the power to effect the course of action rather than an isolated cause of action (e.g. Law 1994; Latour 2005). As Michel Callon and John Law suggest:

... agents are effects generated in configurations of different materials. Which also, however, take the form of attributions. Attributions which localize agency as singularity—usually singularity in the form of human bodies (1995, 502).

As agency is always an effect of network relations, we say that agency is ‘attributed’ to a range of agents (microbes, humans, guts, brains, others) in the images. The images are of course part of much wider networks in which meaning is made, but our analysis focuses on their graphic strategies. We also see the graphic strategies as themselves having ‘agency’, as they (more or less intentionally) delimit how relations between microbe and mind are depicted. This sense of agency is closely related to performativity as described above. We consider the graphic strategies as effects of other networks of agency (both located materially and digitally) and consisting of: (e.g.,) algorithms, stock photo availability, trends in infographic design, taste of the cartoonist, available scientific info, etc.; but again do not ‘open’ the black box of these networks (Latour 1999, 304). Rather we look at their immediate effects on how agency is depicted – as in *who* or *what* is portrayed as a ‘course of action’.

## Methods

### Building an Image Archive

The study is based on an archive of 274 unique images, sourced primarily through UK Google® image search<sup>2</sup> conducted in English but from Denmark, in January–March 2021. This exact time period was chosen in part for pragmatic reasons, but also as lying within a longer period where both scientific evidence and cultural meanings were unsettled, after the first phase of the Human Microbiome Project ([n.d.](#)) concluded in 2016 ([Lloyd-Price et al. 2017](#)), and initial ‘wow effects’ had given way to discussion of implications and applications (as well as limitations) of the developing field. The primary search terms were ‘microbiome’ and ‘microbe’, which we combined with keywords related to mind–microbiome and gut–brain axis research, resulting in the following Boolean conjunctions entered into the search engine—

- microbiome AND mind
- microbiome AND mood
- microbiome AND mental illness
- microbe AND ADHD.

We were curious about whether the images implicating health were specific to *mental* health, so added search terms relating to general health and other conditions and states such as—

- ... AND cancer
- ... AND obesity
- ... AND pregnancy
- ... AND Crohn’s disease.

Notably, this did not generate new image types. Images were only included if the article or webpage where they appeared dealt with the mind–microbiome connection in some way.<sup>3</sup>

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<sup>2</sup> The search engine was set on ‘private mode’ to prevent cookies and other preferences influencing the searches. We also secured the rights to publish all images shown in this paper: Some of the images were publicly available, others we bought the rights to (notably many are owned by stock photo platforms and appear as illustrations in numerous online articles and blog posts) and for others not publicly available for fair use, we were given permissions with appropriate accreditation. Dates given in the main text and in the figure captions show the image creation date if known, otherwise the current date is taken from the source’s webpage. Some of the source articles have been updated or replaced with similar content subsequent to our initial 2021 search process if the original articles had been taken down by the time we came to prepare the figures. For some images, dates are not available.

<sup>3</sup> We decided to exclude images from professional scientific journal webpages, graphs and experimental diagrams, as well as those (very few) images from professional art media and product photography and/or advertisements – aiming to delimit (albeit with fuzzy edges) a field of widespread, popular imaging. We are aware that the boundaries between scientific and public communication are slippery and looping. For instance, scientific diagrams appear on blogs and graphic designers’ illustrations end up in *Nature*.

Such online images are often mundane and simple and may not seem to call for much attention or deep interpretation. Yet, they are also ubiquitous, travelling across different genres and sites, and can be the first visual encounter people have when their interest in a topic is piqued – ‘just Google it’ – or when they read a social media post whose author has ‘just Googled it’ to find an accompanying image. The mundanity of these online images can hold potential for curiosity, challenge, manipulation, and resistance ([Whiteley 2012](#)), and as such, we aimed to take them seriously as a key place or ‘site’ where unsettled relationships to scientific understandings are negotiated. They both reflect our collective capacity to imagine mind-microbiome relations and in turn reinforce or change those capacities by depicting them anew. As such, these images can also provide a window into the more affective currents lying behind popular cultural engagement with mind-microbiome research – and more widely for social studies of the microbe.

We are aware of the amplifying influence of search engine metrics that impoverish online content and favour mainstream and commercially viable content.<sup>4</sup> We consider these mechanisms – and their effects in search results – as part of the construction of what is possible to imagine about microbe-mind relations. We also chose Google® search to gather a large sample of images, as our purpose was to elucidate the range of graphic strategies used in popular images for depicting microbe-mind relations, rather than to conduct a deeper analysis of images in context and image-text relations. We are aware that the audiences for these images will generally encounter the images in context, in association with text, and as single images rather than in a collated group as we present in figures 2–6.

The resulting archive material ranges from minimalistic outlines of brain and intestines connected by arrows to symbolic landscapes, anthropomorphic microbes, and microscope images. A survey of the source webpages of the images found that most were, in one way or another, reporting on ‘new findings’ in the field of microbiome research. Many of these featured in the established press; big newspapers and magazines such as *The New York Times* or *The Atlantic*. Others were in popular scientific media such as *Scientific American* or *Science News* ([www.sciencenews.org](http://www.sciencenews.org)). There were also many blog entries; for or by patients, and commercial blogs by health practitioners working in Complementary and Alternative Medicine fields (CAMS). In the analysis we do not, however, distinguish *a priori* between different outlets. From our perspective they constitute a field of different voices that articulate possible visions for living with the notion that microbes influence our mental states. We therefore posed the same analytic questions to all of the images in the archive, in order to understand the ecology of visual articulations they present, in a space where traditionally distinct forms of media flow through search engines and social media.

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<sup>4</sup> We included visualizations from the first five rows of results from each Google® search, and then looked at the images Google® suggested when clicking on each of the five rows. Images from these further suggestions were included as long as they were (a) not already part of the archive, and (b) still clearly related to the original search term. If the same image was used in different contexts, all instances were entered into the archive, noting duplicates (n.b., these are not included in the total counts for each imaging strategy). However, if different search terms found the same image in the same context, it was only included once.

### **Making Analysis**

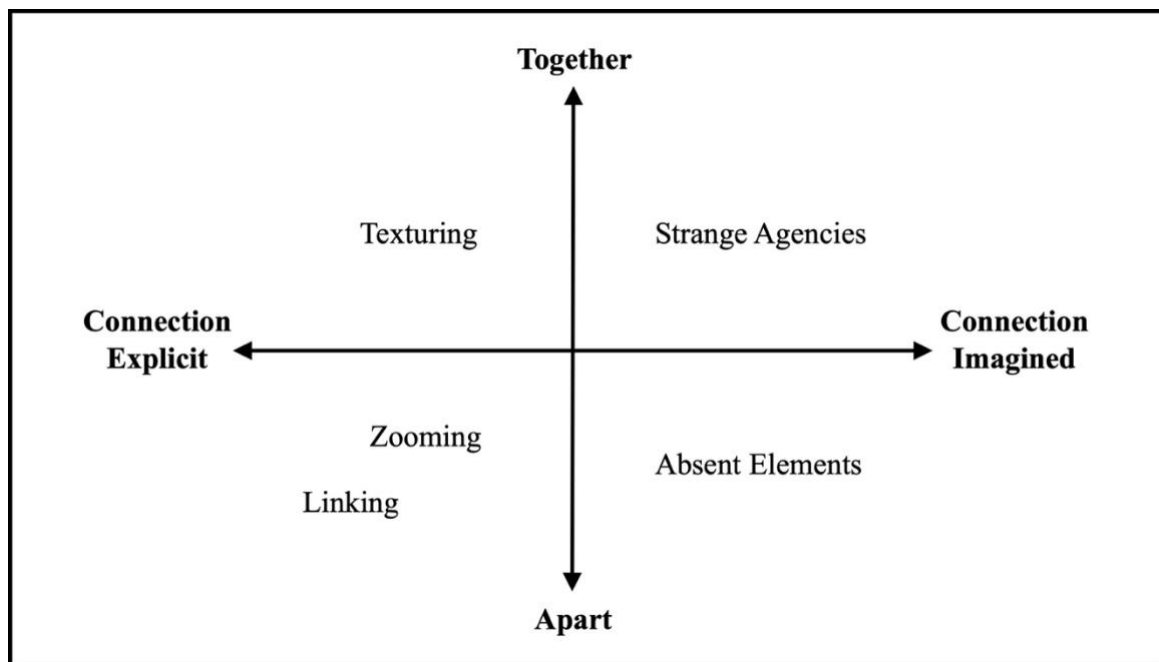
As outlined above, the starting point for this analysis was how a seemingly impossible visual challenge is solved in online images of mind–microbiome relations – how connections between two vastly different scales are depicted. In the analysis reported below we stick close to the images themselves, finding ‘clusters’ of graphic strategies for depicting connections across scales, with attention to how agency is performed, then grounding a discussion about what this might enable or restrict in terms of critical engagement with the distribution of agency and control. The aforementioned questions were asked of a subset of one hundred images, generating four groups in total: three that used either ‘layering’, ‘collage’, or ‘linking’ to connect mind and microbes, and one that had either mind or microbe as an ‘absent element’. The analysis was then expanded and refined on the whole image archive, resulting in the five imaging strategies outlined below. In the pilot analysis of one hundred images, strategies for depicting agency were spread across the categories and often involved anthropomorphized elements or collage techniques. In the full analysis, this developed into a fifth cluster ‘strange agencies’ which occupied a distinct position in the two–dimensional space we present in [figure 1](#), reflecting the importance of this cluster in addressing our research questions.

### **Analysis: Five Imaging Strategies for Depicting Microbe–Mind Relations**

Based on the analytical work described above, we identified five distinct graphic strategies for depicting microbe–mind relations, described in [figure 1](#): The two axes describe (1) whether the graphic strategy is to place mind and microbe spatially together or apart, and (2) whether the connection is explicitly visualised or left to the imagination. Within this framework, the four image groupings could be clearly delineated and fell one into each of the four quadrants formed by the two axes of the diagram shown in [figure 1](#), except for one grouping that split in two.<sup>5</sup>

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<sup>5</sup> These should not be read as geometric or quantitative; rather the diagram is an analytical construct that allow us to discuss the graphic strategies’ performance both in relation to each other and as a whole. (Source Authors’ own).



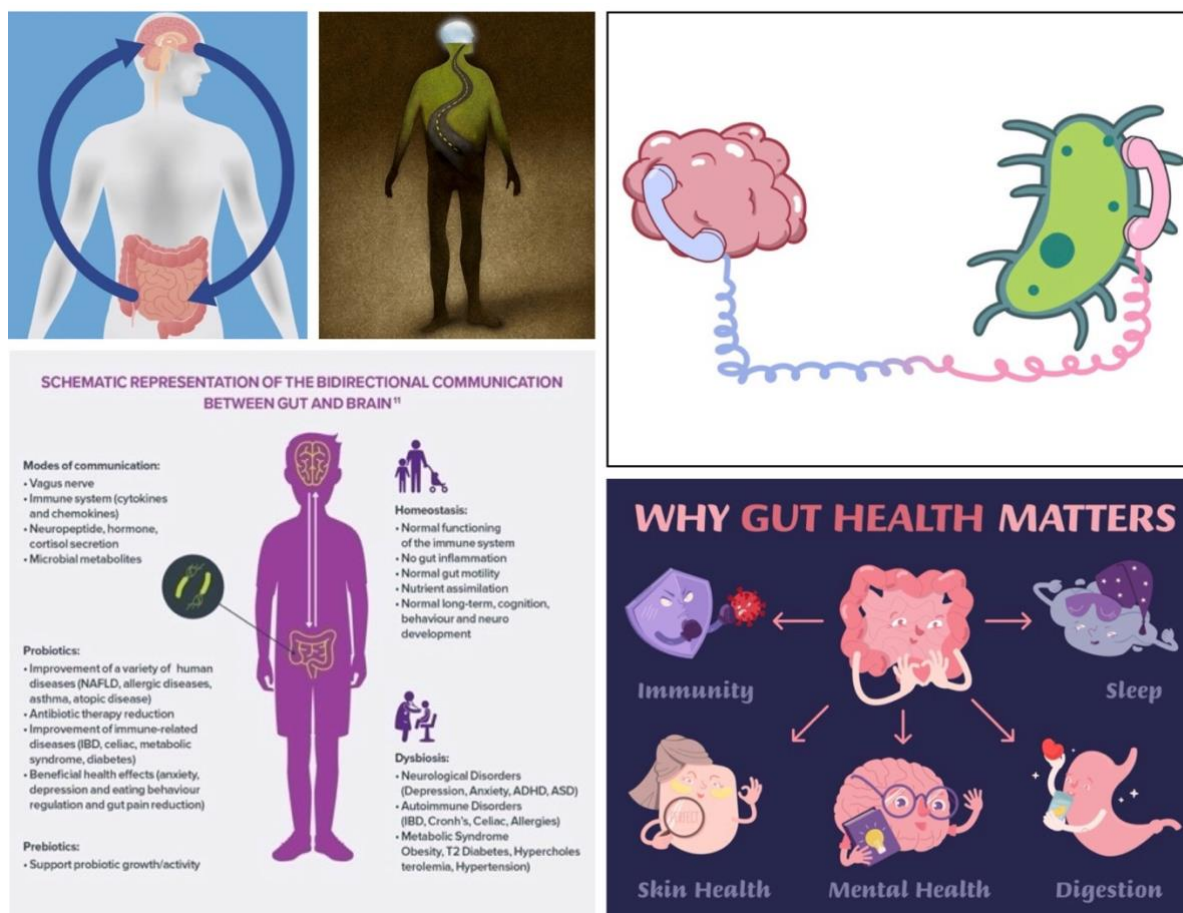
**Figure 1.** Five imaging strategies situated on two axes: The x axis indicates whether the connection between mind and microbe is made explicit or left to the imagination, and the y axis indicates whether human and microbe are graphically portrayed as together or apart (Source Authors' own).

The strategies 'linking' and 'zooming' both sit in the lower left quadrant of [figure 1](#): both portray humans and microbes as *separated*, and then use different graphic techniques to reconnect them. 'Linking' draws arrows or other forms of visual connectors between the elements, whilst 'zooming' uses the visual language of a microscope or camera to connect across scales. The strategy 'texturing' sits in the upper-left quadrant. Similarly to 'linking' and 'zooming', 'texturing' portrays the connection between humans and microbes very literally, but without spatially separating them: rather, humans and microbes are layered on top of each other. In the lower-right quadrant, the 'absent elements' strategy is characterized by leaving one or more things out, showing e.g., just microbes, just humans, or even metaphorical images such as a landscape or scientific actors such as a mouse. As such, mind and microbe are only implicitly connected. Finally, the strategy 'strange agency' sits in the upper-right quadrant. Here, symbolic modes of visualizing connection through agentic action dominate, for instance showing a garden in the gut or small humans working in a factory-like body. Here, the connection between microbes and humans is not described literally, but in contrast to 'absent elements', the two are portrayed together.

Next, we will describe each graphic strategy in more detail using illustrative images from our archive. We have chosen the images as poignant examples of the strategies, but they are not meant to be canonical – in our analysis, it is not the singular image but the strategies that matter. When describing the images and what they show, we attempt to be concrete, especially when choosing verbs that describe forms of agency, as the valence of these words is often powerful and significant for the topic of our analysis. However, we also wish to write our image captions in a way that echoes the rich network of associations such images lie within.

**Imaging Strategy 1: Linking**

The linking category is the second largest within our data set, consisting of 80 unique images. Here the key strategy is to show the gut and/or microbes as distinct and disparate entities, separated from the also distinct brain, and then link them graphically. The most dominant technique is two-way arrows between intestines and brain (figure 2i), indicating some kind of causal or communicative interaction that flows in both directions. Sometimes the intestines and the brain are portrayed on a human silhouette (ibid.), but mostly they hang in mid-air, freed from other connections. Usually plain arrows are used, but in a few images the spinal cord is used to connect the two, hinting at the concept of the ‘gut-brain axis’, even if the spinal cord is by no means solely responsible for these interactions (ibid., iv). In most of the images, the intestines and brain are presented as distinct and on a clear background as in the examples above, but sometimes microbes are ‘sprinkled’ over and around the forms.



**Figure 2.** ‘Linking’ strategy for depicting connection between mind and microbiome. Sources from top left to bottom right:

- (i) Chombosan on iStock by Getty Images, 2016
- (ii) Dave Cutler, 2015
- (iii) Steven. Adobe Stock, 2020
- (iv) Biocodex Microbiota Institute, 2017
- (v) Anna Bergbauer on [www.dreamstime.com](http://www.dreamstime.com), last accessed, 2025.

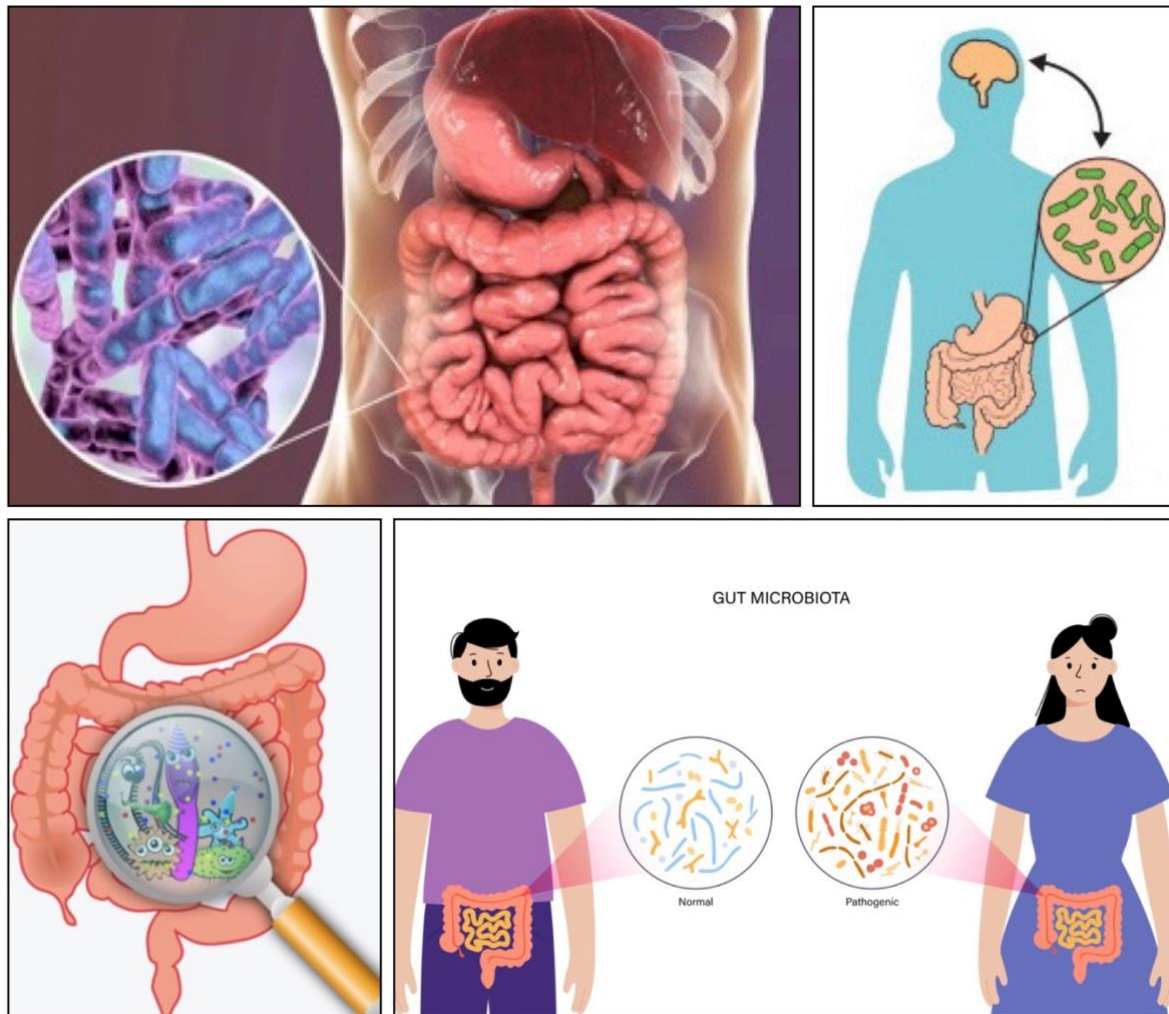
There are also several less commonly used linking techniques. One schematic technique is to place the gut in the middle and the different organs or functions it affects in an outer ring, including the brain ([figure 2, v](#)). These were mostly used in overview articles, which often mentioned mind-microbiome connections as part of a broader survey of microbiome research. Some images deploy more symbolic or imaginative ideas of connection. For instance, instead of arrows we might see a telephone cord or an electric switch between brain and intestines ([ibid., iii](#)) or a body as a factory with production lines as the connecting elements, or the connection between brain and gut as a road traversing a landscape ([ibid., ii](#)). Across these diverse ways of drawing connection there is a large variation of style, but with a few exceptions all are very 'clean' in their graphic language, not overly detailed, and with plain backgrounds.

This strategy is also an answer to the challenge of scale: brain and intestines are two 'meso scale' organs of roughly the same size that can be separated in space and then graphically reconnected. But where, then, are the microbes? For most of these images, even if the accompanying text is about the role of the microbiome in mind and mental health, microbes are often represented by the intestines or the gut, and rarely connected with an arrow to the brain. Microbes do figure in some of the images, sometimes scattered across the image or within the guts, or presented within a symbolic petri dish, but are not the primary entity to be connected to the brain. Notably, this strategy also foregrounds the human; it doesn't challenge the iconic medical images we are accustomed to, and delegates microbes to a content rather than a protagonist.

### **Imaging Strategy 2: Zooming**

'Zooming' is a smaller category, containing 22 unique images. Similarly to 'linking', 'zooming' separates the different elements whose connections it seeks to portray, and then graphically links them. But these images deploy techniques that mimic the view into a microscope, echoing conventions of biological illustration. Typically, a circle or rectangle containing enlarged microbes with arrows connecting the outer edges of the circle to a point within a human form; a classic visual indicator of zoom. The microbes are thus contained and delimited, but connected explicitly to a specific part of the body that is supposedly being enlarged to reveal its microscopic inhabitants. This strategy thus explicitly addresses differences of scale, by attempting to show what is under the surface or invisible to the human eye (e.g., [figure 3, i](#)). Microbes are separated from the body, but via a visual strategy that implies co-location and difference of scale.





**Figure 3.** 'Zooming' strategy for depicting connections between mind and microbiome. Sources from top left to bottom right:

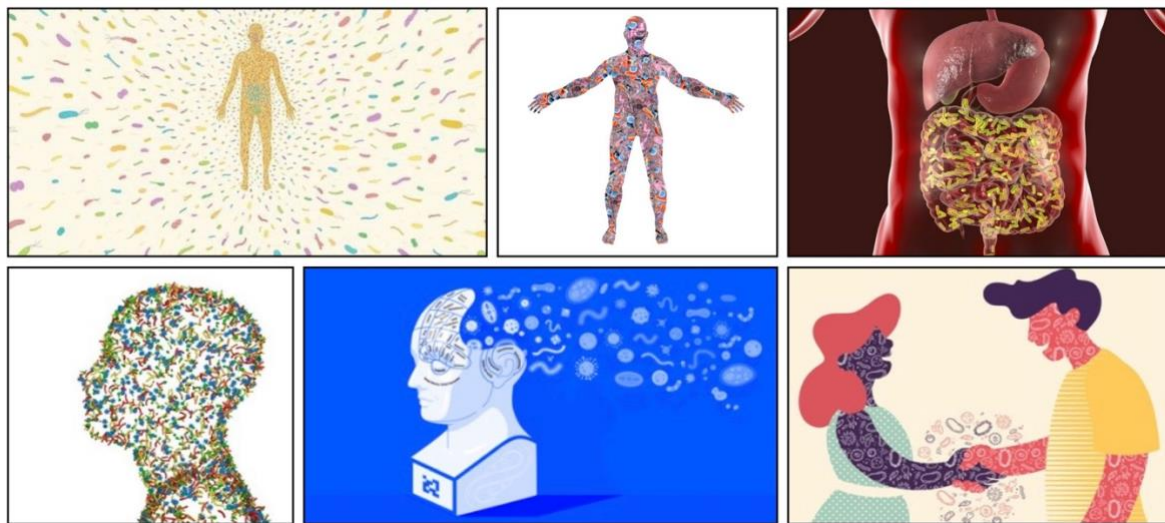
- (i) Kateryna Kon on [www.dreamstime.com](http://www.dreamstime.com), last accessed 2025
- (ii) Genetic Literacy Project, 2015
- (iii) Pexels on Anyrgb, 2019
- (iv) Pikovit44 on [www.freepik.com](http://www.freepik.com), 2021.

The images assembled in this strategy are stylistically diverse. Some overlap strongly with 'linking', combining the strategy of connecting distinct brain and intestine elements with a microscopic zoom into the microbes ([ibid., ii](#)). Others favoured more complex graphics that engage the mechanisms involved, typically deploying the recognizable visual language of a PowerPoint® presentation or biology textbook. But there were also some stylistic outliers. One shows two humans with distinct different facial expressions – one happy and one sad. The 'microscope' then reveals the different microbial ecologies under their skin, distinguished via different colour schemes ([ibid., iv](#)). Another similarly introduces a more lively sense of microbial agency – magnifying anthropomorphic microbes having a party in the gut ([ibid., iii](#)).

Both ‘linking’ and ‘zooming’ delimit the different entities they seek to connect – microbes, mind, and gut – and both seem to focus on two of the three elements. ‘Zooming’ is often focused on the microbes and intestines, leaving out the brain, and leaving the human expression to imply the ‘mind’ element of the connection. ‘Linking’ is typically focused on the brain and intestines, leaving out the microbes, with the intestines or a disconnected textural element indicating the microbe element of the connection.

### Imaging Strategy 3: Texturing

Now we move to ‘texturing’, containing 56 unique images and sitting in the upper left quadrant of [figure 1](#). Here connection is explicitly indicated, as in ‘zooming’ and ‘linking’, but the elements are spatially together rather than separated. This strategy involves covering, filling, overlapping, or composing human forms with microbes. Creating a microbial ‘texture’ that (partly) constitutes the person. These images typically invoke ideas of microbes being everywhere, rather than focusing on the specific bodily location of particular microbes connected to particular states or conditions. ‘Texturing’ solves the problem of disparate scale by showing the world as composed of two layers, one on a human scale and one on a microbial scale. Of course, the scales are still mismatched, but the connections between them are indicated by coincidence within a human form, rather than drawn in the two-dimensional plane of the page.



**Figure 4.** ‘Texturing’ strategy for depicting connections between mind and microbiome. Sources from top left to bottom right:

- (i) The American Museum of Natural History, 2016
- (ii) Kateryna Kon, on Shutterstock, 2017
- (iii) Kateryna Kon, on Science Photo Library, accessed 2025
- (iv) Vrx123 on Adobe Stock, 2019
- (v) Atlas Biomed, accessed 2025
- (vi) Sara López Gilabert, 2019.

This texturing is achieved in several ways. Some images texture either the intestines or brain with microbes ([figure 4, iii](#)), but many use microbes to make up the entire human form ([ibid., ii](#)). In most images, microbes

are colourful and graphically clean, acting almost as pixels, and the human form is on a plain background. There were a few outliers evoking a more medical or biological style (e.g. [ibid., iii](#)) but these were rare – as were images with a more symbolic or abstract frame such as microbes dissolving out of a ceramic phrenology bust ([ibid., v](#)). In many of the images the microbes compose and bound the human – but in others they ‘overspill’ the body and enter the surroundings. Here transitions in the density of the texture indicate porous boundaries between body and world ([ibid., i and v](#)), or between people in physical contact ([ibid., vi](#)).

Contrary to ‘zooming’ and ‘linking’, images using ‘texturing’ rarely show the brain and only sometimes the intestine; what is portrayed here seems to be a more basic connection between humans and microbes, and sometimes also involving the environment. This is not a localized, causal connection between two organs, or between a particular entity and a particular state – rather it suggests a constitutive relation.

#### Imaging Strategy 4: Absent Elements

The strategy ‘absent elements’ contains 93 unique images. Here the problem of scale is solved by showing either microbes, or mind, and sometimes neither, rendering the problem of how to visualize connections between scales irrelevant. The connection is thus left to the imagination rather than made explicit, and the elements are apart rather than together, placing ‘absent elements’ in the lower right quadrant of [figure 1](#). These images are unsurprisingly diverse, and contain more photographs and scientific images than the other categories.



**Figure 5.** ‘Absent elements’ strategy for depicting connections between mind and microbiome. Sources from top left to bottom right:

- (i) National Institutes of Health, 2021
- (ii) Decade3d on Adobe Stock, 2018
- (iii) Dennis Lan/USC Dornsife College of Letters, Arts and Sciences, 2019
- (iv) Matias Del Carmine, last accessed 2025
- (v) Kuttelvaserova Stuchelova on Shutterstock, 2014.

There are several dominant kinds of images in this category. First, images of microbes – some built on or designed to look like electron microscope images, with microbes typically coloured blue on a black background ([figure 5.i](#)), and others are more artistic or cartoon in style ([ibid., iii](#)). In the latter, the location and role of the microbes is often ambiguous, inviting the viewer to interpret the image rather than treat it as a direct illustration of a biological entity. Another large group of images shows humans in various emotional states. These are both photos, often of children, and drawings, but usually of generic adults; ([ibid., iv](#)), and typically show a single person from the shoulders up with a distinct emotional expression. The drawings often use symbols to underline the feelings, for instance rain in conjunction with a sad facial expression ([ibid.](#)). If these ‘solo images’ are encountered in the context of the accompanying text about mind-microbiome connections, the ‘absent elements’ and their connection is evoked but not imaged, and thus, left to the viewer’s imagination.

The rest of the images in this category are a mixed bag and vary considerably. Some are images from the gut, often calling on medical imaging tropes – for example, resembling an X-ray, old anatomy drawing, or body scan (e.g., [figure 5.ii](#)), while others evoke the experience or phenomena at stake in the accompanying text, such as hands preoccupied with a task or covered in dirt, or an image of a crowd at a railway station. One humorous image shows a mouse mimicking human body language associated with negative emotion ([ibid., v](#)) – humour rarely appears in the archive, and when it does it is typically associated with strange agency (see final category below). Across these images, there are often loose associations with the mental phenomenon at stake, but the images are not at all precise about the entities to be connected or the form of their connection. In this way, they reinforce not the invisibility of microbes, but the invisibility of connection itself.

### Imaging Strategy 5: Strange Agencies

In our pilot analysis based on 100 images, we found strategies for directly depicting agency scattered across the other clusters. In the full analysis it became clear that a subset of those images could be clustered as a fifth distinct strategy. ‘Strange agencies’ comprises 35 unique images, which are overtly playful in their agencies depicted. This is the dominant visual strategy for showing connection among this set. These images portray someone or something acting in relation to a human element – for instance, tiny human figures gardening in the intestines, or microbes painting the brain ([figure 6.ii and vi](#)). The problem of scale is here solved by rejecting any attempt at biological realism. With some similarity to ‘texturing’, but moving even further away from depicting the relation between microbe and mind in a biological sense, in favour of more symbolic depictions. We thus place them in the upper right quadrant of [figure 1](#): the connection is left to the imagination – indeed, it is presented as *imaginary* and as such, the elements are present *together*, even if those elements are often highly symbolic or anthropomorphized. This is the least stable analytic category under our scheme, but it usefully amplifies the limits of the two axes.



**Figure 6.** The composite figure shows a variety of forms of ‘strange agency’ as a strategy for depicting connections between mind and microbiome. Sources from top left to bottom right:

- (i) Stuart Bradford, 2013
- (ii) [www.HealthXL.com](http://www.HealthXL.com), last accessed 2025 (no longer available)
- (iii) Katie Horwich for BBC News, 2019
- (iv) PrettyVectors on iStock by Getty Images, 2019
- (v) Antoine Doré for the Wall Street Journal, 2020
- (vi) Benjamin Arthur for NPR, 2013
- (vii) Mitch Blunt, 2019.

This strategy is perhaps the most diverse of the five, in terms of content, tone, and style – ranging from cartoon-like or corporate to artistic collage or dreamlike illustration (see [figure 6](#) for examples), but there are still a few dominant techniques to indicate connection. One is to anthropomorphize microbes, e.g., making them into small human-like figures gardening in the intestines ([ibid., ii](#)) or into cartoonlike versions of microbes doing various tasks – as in image vi, where they paint a brain. Another technique used in several images is to portray the inner body as a luscious landscape or garden ([ibid., ii and vii](#)), depicting microbes as flowers and trees ([ibid., vii](#)), reminiscent of the ecological metaphors discussed by Funke Iyabo Sangodeyi (2014) and Brigitte Nerlich and Iina Hellsten (2009). These images are usually very detailed, with some similarities to ‘texturing’ but in a highly symbolic language.

A third technique is to draw humans and microbes together in an alternate, dreamlike reality ([figure 6, iv and v](#)). Human figures use magnifying glasses to look at intestines suspended in the sky, or they hunt stars that resemble microbes. Here, it’s difficult to discern what exactly is microbe and what is human, as they are intertwined in actions not possible in this world. The final technique we touch upon in this category is that of collage. While collage is relatively infrequent, it was an original spark for this study – combining different materials and textures in non-harmonious ways suggested to us something interesting about how to talk about microbe-mind relations. Here connections across scale and forms of being are indicated by ‘cut and paste’ – disparate items simply stuck together, such that incongruity and mismatch are the medium as well as the message. Microbes fly through a colourful void with tiny black and white photos of noses, ears or eyes pasted onto their ends ([ibid., i](#)), or humanlike figures with unnaturally big brains and intestines plastered onto the body seem to be in a sort of mysterious chain dance ([ibid., iii](#)). The ‘strange agencies’

category was generally more elaborate, often incorporating more layers of depth and perspective, and with more gestures towards humour and satire.

### Discussion and Implications

In approaching the image archive, we began by asking how connections between microbes and mind were depicted, and how the enormous scale differences involved could be placed in the same image. In this discussion, we summarize what we found, drawing some threads across the categories. We then discuss how the strategies for overcoming these challenges result in specific understandings of the nature of these relations and thus enable and delimit specific discussions about human agency and control. We conclude with some more speculative consideration of what this might then imply for critical engagement with this relatively hyped research field ([Marcon, Turvey, and Caulfield 2021](#)) – but emphasize that this is not a study of audience reception. This fits within the strand of STS image studies identified by Perrotta ([2012](#)) as investigating ‘images and imaginations’ fostered by images that communicate about science – indeed, what is imaged versus left to the imagination was a key theme in our analysis. Woven throughout, we make some suggestions for future imaging approaches, from our situated position as researcher-practitioners.

So how is connection across scales handled, and which agencies are foregrounded or questioned? In the ‘linking’ category, brain and intestines are typically separated and discrete, and then explicitly reconnected via arrows, proximity, or symbolic connectors such as roads or telephone wires. Here, the scale of the human body is foregrounded, whilst in the ‘zooming’ category, microscope dissections of microbes are brought to the fore – yet in both, the human largely appears to remain in control. The visual language, scale, and tone simply encompasses microbes into an existing schema where the human is the frame, and microbes are linked as a subsidiary element, not imbued with agency ([figure 6](#)) or allowed to stand alone ([figure 5, i and iii](#)). In the ‘texturing’ set of images, microbes are treated as an alternate layer of reality rather than as a separate element or bodily content. They are a component stuff from which humans are at least partly made. Here, discrepant scales are not dealt with by separating and reconnecting their members, but as alternate domains that can be suggestively overlaid. Often, microbes describe and bound the human form, usually in clean colours against a plain background: with (non-art historical) “pointillist painting” rather than a disconcerting revelation, though sometimes the microbial texture more provocatively overflows the body ([figure 4, i, v, and vi](#)). Across these first three categories – comprising the bulk of the archive – agency is curiously muted. Human and microbial forms often appear static, pinned down, with action left to the symbolism of arrows and the flagella of microbial flows.

Another feature of all three categories is that they tend to portray individuals – either as a torso, a face, a single set of intestines or one brain and without any form of background or context. We would argue, with others who have looked at gendered and racial implications of microbiome research and its communication, that this reinforces current dominant social discourses (e.g. [Kenney and Müller 2017](#); [Wolf-Meyer 2017](#); [De Wolfe et al. 2021](#)). In our study, the discourse they reinforce is the idea of the (most often) white individual with a private relation to its own body and mind, and clear boundaries to its surroundings, which then further reinforces discourses about humans as having individualized responsibility for their own health. Adding to previous expectations of making ‘good personal choices’ about diet and exercise, humans must now also tend to their own microbiomes. This is in contrast to discussions of microbial health as a

common matter of concern, which in theory could also have been the outcome of preliminary scientific findings that suggest porous boundaries between body and environment, emphasizing the very limitations of an individualized, de-situated lens on health.

In 'absent elements' the connection between mind and microbe is left to the accompanying text – the imaging challenge is refused. Associations with a mental phenomenon are often depicted through a photograph or illustration (e.g., [figure 5iv](#)) of an emotional facial expression, but the images do not specify what is connected or how. Rather, they seem to reinforce the invisibility of connection itself, which arguably opens more for discussion than 'linking' with arrows that implies discrete and settled connections. However, by not depicting connection at all, opportunities for grappling with strangeness and ambiguity are potentially missed. It depends on whether the viewer reacts to the image as a simple illustration of one term in the equation, or as highlighting how impossible it is to illustrate the equation at all. These groupings may explain why adding other 'non-mental health' conditions to our search terms did not add new clusters of strategies – many of these images would function for multiple conditions. In fact, mental illness receded from view as our analysis proceeded – most images focused on more general considerations about human-microbe relations. In addition to the challenge of depicting specific mental illnesses, we might speculate that the early stages of the science meant that there were few findings about specific human diagnoses to depict.

Finally, in 'strange agencies' connection is visualized more through its implications than its mechanics. Anthropomorphized microbes ([figure 6 vi](#)), flourishing gut-plants ([ibid., vii](#)), or microbe-sized humans ([ibid., ii, iv, and v](#)) act imaginatively through impossible worlds. Here, agency buzzes mostly on the microbial side – once biological realism<sup>6</sup> is abandoned, action can occur between human and microbe. Though we should note, these actions are usually still defined in human terms – eating, watching, painting, gardening – rather than inspired by microbial behaviour. We could ask: is this a missed opportunity for exploring the implications of mind-microbiome research for how we think about human identity, or is it a valuable way of reassuring and welcoming viewers into some rather strange territory? The microbes have been granted agency and a level of control, but this performance of agency is mostly friendly, if a little peculiar. The microbes seem to be weird, but safe, guardians or gardeners of the gut and mind. In the first four clusters microbes are largely de-situated, de-contextualized. This elides the critical importance of both inner and outer environment, and the specific composition of the microbial population, for any of its effects. In strange agencies, situatedness is occasionally invoked but very generically – gardens, homes, studios in cartoon form, with none of the environmental challenges many people face and which impact their microbiome.

To place all elements – microscopic life; human scale organ systems; and mental subjectivity – within the same two-dimensional image requires schematic, imaginative or symbolic strategies to link across scales. Of course, 'mind' always has to be visually displaced onto symbol or allusion in order to be

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<sup>6</sup>We note a resonance with 'magical realism' in literature and the arts, but this lies outside the scope of the present analysis.

depicted – as evident in the fact that ‘linking’ replaces ‘mind’ with ‘brain’ ([figure 2](#)), and that the few images directly evocative of mental illness show facial expressions in isolation ([figure 5, iv](#)). We should perhaps ask, is *showing* a connection the best way of inviting discussion about it? In our archive, images where connections are implicit or left to the imagination seem to be the ones that leave most room for questions about the distribution of agency and open up for microbiome research itself as an uncertain endeavour. But this is an unstable effect – some omissions seem to provoke curiosity about what is included, whilst others seem to elide the missing element ([Kennedy 2020](#)). We would suggest that *evident absence* and *scalar mismatch* are qualities that might facilitate critical engagement here – making it obvious that something is left out, and somehow indicating the impossibility of visualizing the relations of these discrepant scales. Both qualities refuse the ‘smoothness’ of connecting disparate elements in the same plane, providing avenues for resistance to the subsuming of microbiome science into existing conceptions of human agency and mental health.

As outlined in the introduction, critical discussions surrounding mind–microbiome research, both in relation to how we understand the basis of subjectivity, and in relation to the individual vs. communal/environmental origins of mental distress, are grounded in a challenging of boundaries and the location of agency. If microbes are simply placed as another element of the body on a mind–body axis (as in linking and zooming), we risk simply expanding a dualistic frame down into the gut. To escape this ontological gravity, we would argue that images deploying *agentic play* and *dissolution* can help – collages with weirdly acting brains and microbes ([figure 6, iii and v](#)), surreally emotional mice ([figure 5, v](#)), and forms overflowing their boundaries ([figure 4, i, v, and vi](#)). In these images, connection is active rather than technical. Perhaps, then, connection is better left to the imagination, and agency is best depicted imaginatively – at least if your purpose is to provoke discussion about how agency is distributed (or mixed) between human, microbe, biology and the environment, which are all ambiguous concepts.

Stylistically, all categories tend to be simple, clean, and often evocative of scientific diagrams, medical clipart, editorial illustrations, or microscopy. Even in the more unstable collaged and anthropomorphized images, pastel colours dominate. Dirt, mess, and disease are washed away. Soil, blood, faeces, mucus or ‘disturbing’ or troublesome behaviour hardly ever appear. Cuteness or humour are favoured over spookiness and anxiety. The appearance(s) of mental distress are sanitized in the form of symbolically cloudy weather or stylized emotional facial expressions. Humans tend to be in outline or archetype, as a medically normative body. In the archive, ‘mess’ is present primarily in incongruity – particularly in ‘strange agencies’ but also where other categories deploy conflicting elements or allow the otherwise clean microbial to overflow its apparent bounds. This overlaps with the places we come closest to the features that David Yaden et al. ([2019](#)) describe as comprising awe – a sense of the *vastness* of the microbial microscopic, and the *diminishment* of a self and feelings of *connection*. Yet, reactions of awe in science communication are also unstable in terms of their criticality – they can provoke either curious engagement or a kind of affective stasis ([Daston 2014](#)).

We would therefore argue that in order to critically engage the implications of mind–microbiome and wider microbiome research, we need to be able to hold both the repulsion and attraction of these entities and the discourses they support about agency. Not seeing the entanglements of microbiome and human experience as either utopic, or as insignificant – instead seeing them as situated and ambiguous. Indeed, as

Jessica Houf (2021) argues with respect to faecal microbiota transplants, we need to resist the co-option of disgust ‘to reconstitute a false vision of human subjectivity—the coherent, contained and exceptional human subject situated above the natural world’ (ibid., 407). In critiquing these images, we should remember their source and purpose: circulating on the mainstream internet, often to illustrate news headlines, blogs, and ‘clickbait’ content, they are primarily motivated to attract rather than repel (though repulsion can of course itself attract).

Following Ironstone’s study of microbiome TED talks (2019), we also found contradictory visions of human agency. Human figures are often dissolved, broken into parts, consumed, controlled, or in stasis. But they are also often at the same time reified and foregrounded, with microbes struggling to exceed a role as context, texture, or comedic controller. Accompanying our speculation about absence perhaps being productive, and connection perhaps being best left to the imagination, we might here suggest that ambiguous agency is an appropriate place to land: to settle in the unsettled. The question of where human agency lies when one shifts mind into body and beyond is an ancient one – and often resolved via an absorption of the biological disturbance into a reinstated sovereign boundary. With microbiome research, we see this neutralizing effect, but also images that keep boundaries more open. Images that express the perhaps inevitable, and definitely not novel, necessity of holding contradictory agencies together.

Most STS studies of scientific images were of those produced within science – for instance as a way to support a fact’s credibility. In conclusion, we suggest that STS should devote more attention to popular images, and that science communication studies could gain from a more STS-inspired lens on what these images *do*. Much research on science communication evaluates its subjects in relation to accuracy and truth, driven by concerns about hype and misinformation. In this paper we enact a belief that we should consider popular engagement with science as a field for critical engagement with the ambiguous, unstable meanings of research, beyond accuracy and into the territories of strange and incongruous relations between the psychological, social and biological. In doing so, questions of situatedness take new shape as attentions to what is included and left out in an image; what kinds of context and connection are shown, hidden, and implied. We note here that our analysis of the situatedness of the images – and of the situatedness of microbes they depict – is limited by our focus on the images alone, without accompanying text or online context. A methodological irony perhaps, but one that allows for a close attention to the graphic strategies that shape how these images perform within their wider contexts.

Shifting from theory to practice, along with many science communication scholars and a growing number of STS scholars engaging in artistic and public collaborations, what should we then do? We suggest reframing our initial ‘imaging challenge’ about connecting across scales and forms of being as a new challenge: to find new ways of depicting impossible connections and the uncomfortable affective tensions they carry: between excitement and scepticism; between intimacy and alienation; between awe and disgust. To develop strategies of ‘agentic play’ and ‘dissolution’ that allow human experiences of subjectivity to hold a place alongside phenomena that disturb them. Looking for the unresolved and messy in popular culture, and then resisting impulses to clean it up – rather than producing even better strategies for keeping resolution at bay.

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