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The potential for anthropomorphism in communicating science: Inspiration from Japan

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Abstract

Anthropomorphism—the attribution of human characteristics to non-human animals or inanimate objects—is commonplace in many cultures around the world, but is particularly prominent and pervasive in Japan. Talking furniture on children's TV, vegetable mascots for city governments, an animated letter 'e' to promote online tax returns—there seems to be no limit to what can be anthropomorphized, and no corner of the culture where it is considered out of place. This of course includes efforts to communicate science, where we can find test tube narrators, angry viruses, friendly chemical elements, and a whole lot more. Scientists, on the other hand, are less enthusiastic about anthropomorphism in scientific discussions and tend to consider it to be inaccurate and unscientific. In science, thinking or communicating in anthropomorphic terms is generally derided. Where, then, does this leave the talking microbes and smiling proteins of Japanese science communication? While the literature has quite a lot to say about anthropomorphism, there is nothing specifically about its use for science communication. This paper draws on examples from Japan to consider the potential roles of anthropomorphism in the communication of science and related issues.

Key words

Anthropomorphism, science communication, visual communication, affect

Drawing inspiration from Japanese science communication and popular media, this paper reconsiders the potential roles of anthropomorphism—the attribution of human characters to non-human animals or even inanimate objects—in the communication of science. Certainly, Japan is not unique in its use of anthropomorphic characters, either for communicating science or for general communications. Anthropomorphism is common to many, if not all cultures around the world. However, it was the juxtaposition of Japanese popular culture with the author's Western scientific background that highlighted an apparent difference in perspectives and attitudes towards anthropomorphism, and led to the considerations in this paper. A different cultural perspective can sometimes prompt us to question our established ways of doing things and perhaps lead us to new approaches. The following discussion is an exploration of what might be learned from the Japanese example of the use of anthropomorphism in science communication.

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1. Anthropomorphism in Japanese culture

Japanese culture has embraced anthropomorphism with exceptional vigour. Anyone with even a passing interest in Japanese popular culture will have noticed how industrious the Japanese are at producing endearing characters. Even the most mundane objects are routinely transformed into walking, talking, thinking, feeling entities, and this is ubiquitous across every aspect of the culture, from ancient fables to modern manga. Anthropomorphism has a long history in Japan. Japanese ancient folklore is rife with a colourful array of human-like animals and spooky animated bogeymen. A well-known example of this is the *Chouju-jinbutsu-giga*, a culturally important set of picture scrolls dating from the 12th or 13th century, which are filled with frogs, rabbits, and monkeys wrestling, bathing, swimming, and participating in Buddhist ceremonies. Another clear example from folklore is the large group of mythical ghost-like monsters called the *Tsukumogami*, or 'Tool Gods'. *Tsukumogami* are all manner of ordinary household items, which after 100 years of service have acquired souls and become animated. They include troublemaking one-eyed straw sandals (*Bake-zori*), one-legged jumping umbrellas (*Hone-karakasa*), creepy paper lanterns with ghoulish faces (*Chochin-obake*), and much more sinister futons that strangle people in their sleep (*Boroboroton*). Some scholars of Japanese culture point to Japanese spiritual foundations—the animism of Shintoism, which proclaims that all things have a soul or spirit, and Buddhism, which does not distinguish between the animate and inanimate—and suggest that these influences created an environment in Japanese culture that enables an easy acceptance of anthropomorphism even today (Asquith, 1981; Occhi, 2012).

Of course, anthropomorphism is not constrained to the past, and contemporary children's media are packed with talking animals and other objects. Although this is the case in many other countries as well (for example, the USA's Disney and Sesame Street, the UK's Thomas the Tank Engine), there seems to be a broader potential for what can be anthropomorphized into characters for Japanese children's television shows, cartoons, and picture books. One popular Japanese television show includes such characters as singing shoes, a chuckling maracas fairy, dancing potatoes, a flying toothbrush, and even a toilet king, while another features the capers of a whole village of talking chairs.[1] These are by no means exceptional examples, but rather quite typical.

However, anthropomorphized characters are not restricted to children's stories. They appear in all manner of roles right across Japanese society. Many companies have their own mascot character, which in simple cases may be modelled on an animal (for example *Jetta*, the charismatic red panda for economy airline Jetstar[2]), or in other cases on an entirely inanimate object, such as *Domo-kun*, the friendly television-shaped monster of national broadcaster NHK. Many prefectures and municipalities also have mascot characters to promote local products or characteristics of the region. These characters are often called *Yurukyara*, a term that connotes affection for their endearing goofiness. *Yurukyara* range from historical figures,[3] animals, fruit and agricultural products[4] to more unlikely candidates, such as geographical features[5] or even fruit–animal combinations.[6] *Yurukyara* are extremely popular with the public and number in the thousands. They regularly appear on TV news, variety shows, and other media and compete in an annual '*Yurukyara* Grand Prix' event to decide the most (and least) popular characters. In addition to promoting companies and regional specialties, anthropomorphic characters are also employed for public relations by government departments[7] and are common in government public education campaigns.[8] In addition, there are

countless unsung anthropomorphized characters scattered throughout advertising and promotions, events and festivals, tourist maps, instructional and guidance materials, children's textbooks, souvenir shops, warning signs, and more.

All this illustrates that anthropomorphism is a significant feature of historical Japanese culture and is ubiquitous in the current sociocultural landscape. Given the pervasiveness of anthropomorphism in Japanese culture and communication, one might speculate that individuals raised in this environment would be comfortable with and accepting of anthropomorphized characters, even those that may be more jarring for people from other cultures. Walking, talking characters based on animals, furniture, mountains, or even abstract concepts such as human rights are not seen as implausible, or even as curiosities, but as a given—a natural part of the cultural environment.

2. Anthropomorphism in Japanese science communication

Since this culture of anthropomorphism pervades every aspect of Japanese society, it should not be surprising that it is also common in science education and science communication. Here, I will focus on examples of visual or illustrated instances of anthropomorphism, rather than anthropomorphic terms or suggestions of human-like behaviour in narratives and text. This is because visual examples are more readily identifiable and because I feel that it is the use of visual anthropomorphism that to some extent separates Japanese science communication from that of other countries. Examples of anthropomorphized characters and narrators are not uncommon among Western science communication materials aimed at children.[9] However, in Japan, while anthropomorphized science is more common in materials for younger children, it also appears in explanations of science topics for adults, for example in health communications[10] and informational television shows.[11] Furthermore, Japanese examples are likely to anthropomorphize not only narrators or explainers but also entities that form part of the explanation itself. For example, an explanation of influenza transmission may include anthropomorphized virus particles, represented with evil, grinning faces and pitchforks, gleefully attacking their victims. Or diabetes might be explained using anthropomorphized sugar and insulin molecules, illustrated as rudimentary shapes with arms, legs, and faces, moving around the body and struggling to cope under poor health conditions. The emphasis here appears to be on conveying a broadscale awareness of the cause and mechanism of disease rather than a detailed understanding. This approach of integrated anthropomorphism is also quite common in children's science texts and supplementary learning materials,[12] in which explanations of cloud formation, air pressure, and chemical reactions feature air molecules, water vapour, Bunsen burners, and test tubes, all with smiling faces and an apparent life of their own. Even the periodic table of the elements has been entirely anthropomorphized (several times) with each element adopting an individual persona.[13]

Comics are also a rich part of Japanese pop culture. The Japanese are adept at using the comic format to turn even the most humdrum topic into an interesting adventure. Constructing a comic requires the development of characters and a narrative, and that process provides ample opportunity for anthropomorphism. It seems that almost every subject area imaginable has been transformed into comic format at some point in Japan, and of course science topics are no exception. Some recent examples, noteworthy both for their popularity and the extent of their anthropomorphism, are *Moyashimon—Tales of Agriculture*,[14] and *Cells at Work* (*Hataraku Saibou*).[15] *Moyashimon* is the story of an agricultural university student who can see and talk to micro-organisms. Through his activities and

misadventures at school, the comic introduces a range of micro-organisms and their roles in medicine, disease, and fermented food production. The anthropomorphized micro-organism characters are shaped to vaguely resemble the species that they represent, but with the addition of arms, legs, and faces and the ability to talk and express emotions. *Cells at Work* portrays a range of human body cells (such as red blood cells, white blood cells, platelets, and immune system cells) as youthful employees, and through their actions explains the functions of those cells in maintaining the body and in response to injury and disease. While the antagonists in this story (for example, disease-causing viruses and bacteria) are sometimes alien-like in form, the protagonist body cells are represented in an entirely human form. There is nothing about their physical appearance to suggest they represent cells, and, at a cursory glance, one would not see this comic as anything but a story involving human characters. The characters of course talk to each other, but also cooperate, fight, suffer, rejoice, bleed, and cry. It is interesting to note that, although *Moyashimon* and *Cells at Work* contain what might be deemed educational content, they are not necessarily motivated by educational or science communication goals, but rather are highly successful commercial projects. It is impossible to determine the extent to which anthropomorphism has contributed to the success of these comics, since that factor cannot be considered separately from the plot, narrative, illustration style, and many other elements that make up a comic, but it would seem that anthropomorphism, even to the extent that it appears in these publications, certainly does not detract from their popularity.

Anthropomorphized comics have also been used for genuine science communication projects with educational goals. *Nymphs of the Plant Hormones* (*Shokubutsu Horumon Gijinka*)[16] is a project aimed at raising awareness and understanding of plant hormones. A range of hormones are personified as female high school students, complete with profiles, nicknames, and key features, and through those characters and their interactions the comic introduces the functions and characteristics of various plant hormones. As in *Cells at Work*, these characters are human (rather than merely having human-like attributes) and portray the characteristics of hormones through their names, personalities, and behaviour rather than their physical appearances. *Higgstan*[17] is a series of four-frame comics that explain concepts and research endeavours in particle physics. The main characters of the comics are child-like characters that represent research institutes, such as the Japan Proton Accelerator Research Complex and the Super-Kamiokande neutrino detector. Those characters act as explainers, but the explanations also feature anthropomorphized electrons, atomic particles, quarks, dark matter, gamma rays, and more, which are generally illustrated as basic shapes with faces, sometimes with hats or sunglasses, or holding signs.

While anthropomorphized science instruction and science communication also exist in other cultures,[18] from personal observation and a Western perspective, anthropomorphism in Japanese science communication is conspicuous for its prevalence, diversity, and widespread acceptance (as it is in all areas of the culture). In many cases, this anthropomorphism would be likely to raise eyebrows among Western scientists and science communicators. However, the commonplace nature of anthropomorphized explanations of science suggests that this is popular with audiences in Japan, or at least is perceived by authors as popular or easy to understand.

3. Anthropomorphism from a (Western) science and science education perspective

Despite this enthusiastic anthropomorphization of scientific explanations in Japan, the world of science has traditionally taken a

different view. In science, anthropomorphism is bad, and that has long been the dominant position. The argument is that atoms, molecules, cells, and so on do not 'feel' or 'want' anything—their behaviour is driven by causative relationships rather than human-like motivations. Therefore, thinking in anthropomorphic terms is simply not scientifically accurate and might lead to flawed conceptualizations of the true nature of phenomena. It may seem that considering chemical bonding in terms of atoms 'wanting' an additional electron is just a harmless figure of speech, and in many cases it probably is, but some scientists worry that this has the potential to influence the direction of scientific research *per se*. For example, in a criticism of widespread anthropomorphic thinking in the field of microbiology and a warning of the dangers to scientific progress, Davies (2010) described how teleological thinking associated with anthropomorphism restricted science's understanding of antibiotics. He claimed that descriptions of antibiotics having 'militaristic' functions in a 'war' against invaders impeded or discouraged alternative conceptions of other possible functions of those molecules, and consequently delayed the current awareness that antibiotics may have a range of roles in transcription modulation, regulating, and signalling. The fundamental error in interpreting natural processes and relationships in terms of human motivations is evident for physics and chemistry, as well as areas of molecular biology as described above. However, in other areas of biology, particularly animal behaviour studies, there is an ongoing debate over whether it is necessarily incorrect to interpret higher order actions of non-human animals in terms of the emotions, desires, fears, and so on that we would ascribe to human behaviours (Wemelsfelder et al., 2001; Wynne, 2004; Watanabe, 2007). For the sake of managing the complexity of this discussion, however, I will restrict the scope of consideration here to processes and phenomena that are more objectively devoid of human-like motivations.

Since anthropomorphism is unscientific, it has also been considered unsuitable for science training and education. For decades, anthropomorphic analogies in science education have been thought to be an impediment to learning, primarily through their association with teleological explanations for the causes of phenomena, which involve desires and human motivations (Dorion, 2011), the likes of which are described at the beginning of this section. Intuitive anthropomorphic reasoning has been seen as characteristic of the early stages of childhood development (Dorion, 2011) and therefore as a childish means of explanation. This has led to widespread normative appeals to eliminate anthropomorphic explanations from science education and a traditional stance of avoiding the promotion of anthropomorphism (Dorion, 2011). However, although this has been the predominant view for some time, it has not been unanimous, and several authors have suggested that anthropomorphic explanations may have useful roles to play in science education. For example, Watts and Bentley (1993) pointed out that anthropomorphic thinking is common in the causal explanations of both children and adults. They argued that this is not something that children simply grow out of, but rather should be approached as a starting point for building correct ways of thinking, in the same way that other kinds of misconceptions are acknowledged and countered in a constructivist classroom. Taber and Watts (1996) recommended acknowledging the widespread use of anthropomorphic language among both students and scientists, arguing that some of that language is not problematic, since it is understood to be a convenient means of explanation or communication and not to be taken literally. They went on to offer an approach to classify such language into that which is useful for communication and understanding, and that which may mask misconceptions. Pinchas and Anat (1991) claimed that anthropomorphic and teleological explanations have useful

heuristic value for students. Explanations in terms of purposes and intentions that align with what we know about our own behaviour are more intuitive and help students to 'organize facts and better understand natural phenomena and processes'. Dorion (2011) continued in this direction to explain that anthropomorphic explanations, which are already common among science students, may play a variety of roles in the development of students' understanding of scientific concepts by allowing them to work with and build on as yet incomplete conceptualizations of learning goals. He went on to suggest that working with anthropomorphism may offer teachers an opportunity to bolster a tactic that students already use to develop their understanding. Zohar and Ginossar (1998) also proposed an end to the 'taboo' on teleology and anthropomorphism in biology, citing the lack of a correlation with students' development of anthropomorphic or teleological reasoning (despite widespread exposure to such depictions), along with the apparent heuristic advantages.

A growing number of such voices coincide with a recent apparent softening on anthropomorphism in science education. The American Association for the Advancement of Science publishes *Benchmarks for science literacy* (AAAS, 2009) which serve as a guideline for school science education in the United States. The 1993 benchmarks recommended that by second grade children should be made aware that 'stories sometimes give plants and animals attributes they really do not have.' However, this has been deleted from the most recent benchmarks published in 2009. Instead, the current version states that, while 'the anthropomorphism embedded in most animal stories causes some worry', developing an interest in reading is more important than 'rigidly correct impressions'. The benchmarks suggest that anthropomorphism can be ignored in the classroom, or students can be guided towards noticing differences in how animals are portrayed (realistically or anthropomorphized) in different books.

In sum, science considers anthropomorphic and teleological thinking to be inaccurate and potentially harmful to the progress of science. Although science education traditionally shuns anthropomorphism for those same reasons, there has been some debate over whether this is the most appropriate approach to handling anthropomorphism in the science classroom.

4. Potential influences of anthropomorphism

Although science communication often plays an educational role, it is also often concerned with attitude and behaviour change, and is thus a different animal from science education. Science has a clear stance on anthropomorphism, while the science education community has debated and continues to debate its own position. It is interesting, then, that the impacts of anthropomorphism specifically on the public communication of science appear to have been largely overlooked in the literature. There is no clear stance on anthropomorphism from the field of science communication, nor discussion on its potential roles and risks. However, there are some reports from cognitive psychology and science education that provide hints of what those impacts might be.

To understand why people anthropomorphize, Epley et al. (2008) examined and provided evidence for two motivational factors, which they named *effectance motivation* and *sociality motivation*.

Effectance motivation is rooted in the idea that the human tendency to anthropomorphize agents is an example of induction, or the process of reasoning about an unknown or unfamiliar entity based on what is known about a more familiar, related entity. In other words, anthropomorphism can be seen as a process of applying a familiar 'human' framework to interpret an unfamiliar concept. This is essentially the heuristic value for students

proposed by several authors and discussed in the previous section. People employ anthropomorphism as one means of gaining a sense of efficacy and satisfying a basic psychological need for an understandable, predictable environment. Epley et al. (2008) were able to show that people with a strong need for this sense of efficacy and understanding were more likely to view an animal in anthropomorphic terms when they had less understanding of the animal's behaviour (the animal's behaviour was less predictable). It seems that when presented with a knowledge gap, motivated individuals might employ an anthropomorphic explanation to help them close that gap. It is reasonable to suggest, then, that when grappling with an unfamiliar scientific concept, the more familiar framework of an anthropomorphized explanation might offer a more readily understandable explanation, which at least some individuals will be tempted to accept. For example, an anthropomorphic explanation for why trees produce fruit (for example, to entice birds to disperse the trees' seeds) may facilitate a digestible and acceptable, albeit scientifically imprecise, understanding. In fact, there is some support for this in the literature. For example, Stoos and Haftel (2017) found that students involved in structured anthropomorphic storytelling as part of a microbiology course performed better on exams than students in a regular class. Marketing research has also shown that a highly anthropomorphized portrayal of an influenza drug fighting influenza virus led viewers to a stronger perception that they understood how the drug worked (actual comprehension was not assessed). This in turn led to an enhanced perception of the drug's efficacy (Laksmidewi et al., 2017).

In science communication settings, then, a story of an 'angry' virus invading a 'hapless' cell to 'wilfully' inflict damage and chaos, followed by the counter-attack and triumph of the body's 'brave and noble' defences may set up an immediately accessible and understandable framework for explaining influenza infection and immune response, compared to a more scientifically acceptable explanation of random encounters and a complex chain of chemically triggered reactions. In this case, the decision of whether or not to use anthropomorphized characters would depend on the objectives of the communication and the relative necessity of detailed and precise scientific understanding. Of course this must also be weighed against the risk of harmful misunderstandings and misinterpretations originating from teleological explanations.

Sociality motivation, the second motivational factor described by Epley et al. (2008), stems from the need to be socially connected. Being social animals, humans have a psychological need to connect with other humans. This need is so strong that, in the absence of other human contact, individuals will construct a proxy in the form of anthropomorphized animals or objects. Epley et al. (2008) demonstrated this by revealing a higher tendency to anthropomorphize pets among individuals with a strong need for social connection (that is, with fewer human social contacts). It might also be expected that these individuals are not only more likely to anthropomorphize their surroundings, but also to respond differently when they are presented with anthropomorphic depictions. Tam (2015) demonstrated precisely this when he found that anthropomorphism in conservation messages led to a greater influence on conservation behaviour among people with a strong need for social connection. That study was interesting not only for identifying that certain groups respond more predictably to anthropomorphism, but also for demonstrating that anthropomorphism can contribute to communication objectives (in this case behaviour change) through its influence on affect or attitudes.

Other apparent influences of anthropomorphism on attitudes and non-cognitive factors are also described in the literature. Chartrand,

Fitzsimons and Fitzsimons (2008) noted previous research demonstrating that the perceived attributes or expectations of people around us can lead to behavioural change and considered whether anthropomorphic images might also command such influence. They found that showing people pictures of animals primed them with stereotypical anthropomorphic characteristics of those animals. This then led to unconscious changes in behaviour intentions that conformed with the stereotypes. Specifically, people primed with images or thoughts of dogs indicated elevated intentions of loyal behaviour (an attribute typically associated with dogs in the sample group) in a subsequent unrelated task. Those primed with cats (typically considered not to be loyal) indicated decreased intentions of loyalty. This study demonstrated that attitudes associated with an anthropomorphized character may be transferred to the object being anthropomorphized. Similarly, in a study investigating viewers' interpretation of anthropomorphized software interfaces, realistic human representations of the interface agent (compared with 2D representations and stylized caricatures) were interpreted as more capable and intelligent (King and Ohya, 1996). This suggests that not only attitudes but also a viewer's assumptions or expectations associated with an anthropomorphic representation are applied to the anthropomorphized object itself. It is not difficult to imagine how these types of effects might be important in the communication of science topics. Consider, for example, a health communication message aimed at encouraging people to take steps to avoid influenza infection. If this message portrays a virus particle as a grinning, evil-looking antagonist, and that stimulates a sense of fear or apprehension towards viruses, this might be more likely to bring about the behaviour change that the message is aiming for, and justify the reduction in strict scientific accuracy.

Some recent studies on the affective impacts of visual design in science instructional materials explore how 'emotional design'—the manipulation of the visual design of educational resources to trigger affective responses—can influence motivation and learning outcomes (Mayer, 2014). Anthropomorphism is one aspect of emotional design, and researchers found that, in a multimedia explanation of the immune system, depicting antigens and immune system cells with faces led to increased positive emotions, comprehension, and ability to apply the learning goals to new situations (Um et al., 2012; Plass et al., 2014). The suggestion here is that the anthropomorphic design has a positive influence on viewers' emotional state, leading to improved comprehension and transfer via elevated motivation.

This section draws from diverse segments of the literature, but together they suggest that anthropomorphism can offer a familiar framework for dealing with new or challenging topics, as well as affective and attitudinal influences that may be important for motivating comprehension and for encouraging attitude and behaviour change.

5. Conclusions and recommendations

What can we conclude about the use of anthropomorphism in science communication? On the one hand, describing phenomena in anthropomorphic terms is not scientifically precise, and there are valid reasons for concern about anthropomorphism in scientific contexts. However, some areas of the literature suggest that anthropomorphism might not necessarily lead to erroneous conceptions and teleological reasoning, as predicted by the traditional view—the perceived threats to accurate learning that are the basis for shunning anthropomorphism in science education. Rather, anthropomorphic frameworks may offer a familiar and approachable format for more understandable explanations of often complex and unfamiliar science. These anthropomorphic heuristics might help

students eventually develop accurate understandings and offer additional tools for engaging learners. Science communicators must consider, then, what degree of detailed scientific precision is required for a particular communication, how much priority is to be placed on ease of understanding and approachability, and the audience's 'anthropomorphic literacy' or the extent to which they understand the metaphorical function of anthropomorphism. For example, when encouraging an audience to take basic steps to avoid influenza transmission, is the scientific imprecision of a virus's evil grin outweighed by the familiar and understandable metaphor for danger and anomaly? Do the highly figurative portrayals of something like *Cells at Work* present broad themes of cell biology in an immediately recognizable and memorable way that justifies the sacrifice of specific details and the risk of teleological misunderstandings? Perhaps. Therefore, it is important that we carefully consider the value of anthropomorphism for the specific objectives of science communication.

In addition to conveying accurate information, science communication efforts are often concerned with emotional, attitudinal, and behavioural outcomes, and anthropomorphism has been shown to influence each of these. The literature describes how anthropomorphism can induce positive emotions, influence value judgements and attitudes, and subsequently impact on behaviour. With this in mind, take a frivolous example of an explainer in a science communication context portrayed as a friendly anthropomorphic magnifying glass. Despite the superficial absurdity of the character, could it have important impacts on viewers' interest and motivation, or even induce behaviours such as scrutiny and attention to detail that may be stereotypically associated with magnifying glasses? This is a deliberately provocative example, but it demonstrates how it would be useful to understand these interactions in more detail.

Responses to anthropomorphism are likely to vary. At a minimum, we would expect differences between individuals according to their psychological need for efficacy and social interaction, but there are likely to be a range of other contributing variables as well. We might also expect broader trends between cultures with different general levels of acceptance and adoption of anthropomorphism. For example, an individual raised in the anthropomorphically rich culture of Japan would be expected to have different acceptance, interpretations and understandings of anthropomorphized science than a counterpart from another country, so there is unlikely to be a one-size-fits-all approach that is the best option in all situations. Rather, the impacts of anthropomorphism in science communication are likely to be highly nuanced, and universal norms or recommendations may not be possible. Despite this, there seems to be a broad range of potential impacts of anthropomorphism in science communication settings. Some of them may be useful, but of course they must be reconciled with the need for scientific accuracy, and the decision of whether or not to anthropomorphize will ultimately be determined by the goals and constraints of a particular setting. Unfortunately, we currently have a very limited understanding of what those impacts might be and how they might contribute to science communication goals.

Fortunately, in Japan, there exists a rich variety of anthropomorphic science communications from which there may be much to learn. It is not clear whether Japanese science communicators have embraced anthropomorphism in a conscious effort to employ the potential impacts discussed here. However, they clearly do not appear to be concerned about potential negative impacts. Unfortunately, there are few means to determine the success of their approach. The commonplace nature of anthropomorphism in science communication suggests that there is a perception that this is a useful tool. However, there

appears to be little in the way of evaluation. Scholars of literature and cultural studies have appraised *Moyashimon* and *Cells at Work* for their educational value (both scientific and sociopolitical) (see Berndt, 2017; Greene, 2018). However, there are no data assessing the influence that these and other such publications have had on readers' understanding and awareness of or interest in the scientific topics described within them; nor is there any estimate of the degree of misconceptions they may have spawned. There is certainly no measure of the independent impact of the anthropomorphism that they contain. However, it is highly likely that the comics, along with their anthropomorphism, have had some kind of influence, both at the level of an individual fan and, given their widespread popularity, at the population level as well. In the absence of any other measure of the impact of anthropomorphism, it is tempting to look at population-wide standardized tests of science literacy. Japan typically does very well on the PISA (Programme for International Student Assessment) international competency test, consistently ranking in the top three for science among countries in the Organisation for Economic Co-operation and Development (Tasaki, 2017). However, it would be preposterous to attempt to attribute this to the use of anthropomorphic science explanations. At best, it is an indication that, within the overall context of a Japanese student's education, the presence of anthropomorphism in science explanations does not seem to have a significant negative impact (in so far as the PISA test is a true measure of science comprehension). Furthermore, this is only a consideration of comprehension and disregards other important objectives of science communication, such as attitude and behaviour change.

What are needed are controlled empirical assessments of the influence of anthropomorphized characters in descriptions of science content on comprehension, interest, attitude and affect. This is an area in need of further research and with the potential for highly rewarding and useful outcomes. Certainly, in light of what is happening in Japan, it would seem prudent to gain a better understanding of the influence of anthropomorphism and how it might be useful for the specific purposes of science communication before summarily dismissing it as childish nonsense.

Notes

1 National broadcaster NHK's *Inai Inai Baa* and *Miitsuketa*. See http://www.nhk.or.jp/kids/.

2 Another interesting example is the telecommunications company Softbank's talking dog, which is also inexplicably the father of an otherwise human household.

3 For example, the Ibaraki Prefectural Government's *Hustle Komon* is inspired by a TV dramatization of the exploits of famous *daimyo*, Tokugawa Mitsukuni.

4 For example, *Sashibanosa-chan*, the hawk mascot of Ichikai Town, or Akaiwa City's peach and grape character, *Akaiwamomo-chan.*

5 For example, Sapporo City Western District's *Sankakuyamabe*—a walking green triangular mountain.

6 For example, the strawberry and deer mash-up, *Yumezukin-chan*, of the Nagasaki branch of Japan Agricultural Coop.

7 For example, the Tokyo Metropolitan Police Department's *Pipo-kun,* and the Ministry of Justice's human rights mascot *Jinken Mamoru-kun.*

8 For example, *Maina-chan* for the government's personal identification scheme (My Number), and *Saiban-inko* for the introduction of a new jury-based legal system.

9 For example, Professor Jay Hosler's comics explaining *Apis* ecology, photosynthesis, and more use anthropomorphized bees, ants, and other insects as explainers and explainees. See https://jayhosler.com/science-comics.html.

10 For example, simple anthropomorphic figures representing insulin and glucose in an explanation of diabetes used by the Citizen – Medical Staff Alliance for the Prevention of Lifestyle-related Diseases. See http://www.kozonokai.org/medical-inf/tounyou/what.

11 For example, the popular TV health programme *Tameshite Gatten* regularly uses graphics and elaborate models containing anthropomorphized elements. See http://www9.nhk.or.jp/gatten.

[12] For example, *Visual Science Encyclopaedia* (ビジュアル理科事典, published by Gakken Plus in 2015), *Learn Middle School Science the Clever Way—4 Frame Classroom* (中学理科がちゃっかり学べる ゆる4コマ教室, published by Gakken Plus in 2018).

[13] For example, *Wonderful Life with the Elements* (元素生活, published by Kagakudojin in 2015), *Element Girls* (元素周期 萌えて覚える化学の基本, published by PHP Institute in 2008), and *Learn the Periodic Table with Comics* (マンガで覚える元素周期, published by Seibundo Shinkosha in 2012).

[14] *Moyashimon–Tales of Agriculture*. See http://kamosuzo2.tv.

[15] *Cells at Work (Hataraku Saibou)*. See https://hataraku-saibou.com.

[16] *Nymphs of the Plant Hormones* (*Shokubutsu Horumon Gijinka*). See http://hormone.webcrow.jp.

[17] *Higgstan* comics can be seen at http://higgstan.com.

[18] For example, the Swedish/US company Toca Boca produces chemistry and plant biology apps for children that heavily feature anthropomorphized chemical elements and plants (see https://tocaboca.com/apps/), while Dan Green and Simon Basher have published a series of science books featuring anthropomorphized organs, cells, chemical molecules, and even qualities such as mass and weight.

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