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Could a robot feel pain?

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Abstract

Questions about robots feeling pain are important because the experience of pain implies sentience and the ability to suffer. Pain is not the same as nociception, a reflex response to an aversive stimulus. The experience of pain in others has to be inferred. Danaher's (Sci Eng Ethics 26(4):2023–2049, 2020. https://doi.org/10.1007/s11948-019-00119-x) 'ethical behaviourist' account claims that if a robot behaves in the same way as an animal that is recognised to have moral status, then its moral status should also be assumed. Similarly, under a precautionary approach (Sebo in Harvard Rev Philos 25:51–70, 2018. https://doi.org/10.5840/harvardreview20185913), entities from foetuses to plants and robots are given the benefit of the doubt and assumed to be sentient. However, there is a growing consensus about the scientific criteria used to indicate pain and the ability to suffer in animals (Birch in Anim Sentience, 2017. https://doi.org/10.51291/2377-7478.1200; Sneddon et al. in Anim Behav 97:201–212, 2014. https://doi.org/10.1016/j.anbehav.2014.09.007). These include the presence of a central nervous system, changed behaviour in response to pain, and the effects of analgesic pain relief. Few of these criteria are met by robots, and there are risks to assuming that they are sentient and capable of suffering pain. Since robots lack nervous systems and living bodies there is little reason to believe that future robots capable of feeling pain could (or should) be developed.

Keywords Robot · Pain · Sentience · Nociception

> *'the question is not Can they reason? nor Can they talk? but Can they suffer?' (Bentham 1780).*

Questions have been asked about whether or not a robot might be able to feel pain (Danaher 2020; Smids 2020; Sebo 2018). This issue is of particular interest because of the relationship between the experience of pain and sentience. An entity that has the phenomenological *experience* of pain must be sentient, because the ability to feel pain requires sentience. Those that can experience pain can suffer, and hence should be afforded moral status.

What does it mean to have moral status? DeGrazia and Millum (2021) define moral status as follows: 'To have moral status, an individual must be vulnerable to harm or wrongdoing. More specifically, a being has moral status only if *it is for that being's sake* that the being should not be harmed, disrespected, or treated in some other morally problematic fashion.' Terms closely related to moral status include moral patient, moral standing, moral considerability, personhood, and moral subject (Muhelhauser 2017).

An entity that has moral status is one for which we should have moral concern. Sebo (2018) writes, 'Where there is sentience there is reason for moral concern, for an entity that can experience pain can suffer". Balcombe (2016) in his book 'What a fish knows' is clear about the relationship between pain, suffering and sentience. 'Organisms that can feel pain can suffer, and therefore have an interest in avoiding pain and suffering. Being able to feel pain is not a trifling thing. It requires conscious experience' (pp 71).

If robots were shown to be able to feel pain, they would also deserve moral status. Conversely, if they are unable to feel pain, it is not clear that they would deserve moral concern. Sparrow (2004) reports the view that 'unless machines can be said to suffer, they cannot be appropriate objects for concern at all'. Nussbaum (2022), writing about animals, concludes that 'We do no harm to non-sentient creatures when we kill them, and since they do not feel pain we need not worry too much about the manner'.

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Being able to experience pain is not the only indication of sentience—sentient beings can also feel pleasure and other emotions and will have a subjective view of the world. As Nussbaum (2022) writes, 'the world looks like something to them, and they strive for the good as they see it. Sometimes sentience is reduced to the ability to feel pain; but it is really a much broader notion, the notion of having a subjective view of the world'. Nonetheless, having the ability to feel pain requires sentience.

It is possible for a being to be sentient yet unable to feel pain, as illustrated by the example of congenital analgesia, a rare genetic disorder of humans who do not feel pain. This possibility is not explored further here since our focus is on the experience of pain and what that means. Human individuals with congenital analgesia are clearly still sentient, for they have conscious experience of the world. However, consideration of the possibility that one day there could be machines that were deemed sentient yet were unable to experience pain is beyond the scope of this paper. The emphasis here is on the idea that if an entity has the phenomenological experience of pain, it must be sentient and capable of suffering. The experience of pain is like a litmus test for sentience.

The terms 'sentience' and 'consciousness' are often treated as meaning the same, although some authors prefer one or the other. Damasio and Damasio (2022) use the term 'consciousness' rather than sentience. In what they describe as 'a new theory of consciousness', they distinguish between "the simpler ability to 'sense' or 'detect' objects and conditions in the environment" and consciousness, which "occurs when the contents of mind are 'spontaneously identified as belonging to a specific owner'" (pp 2231). They point out that there are living species such as bacteria and plants that can sense or detect objects and conditions in the environment without having either a nervous system or internal representations of those objects or conditions. By contrast, they argue, consciousness involves internal representations. For them, 'consciousness is present in living organisms capable of constructing sensory representations of components and states of their own bodies, but not in organisms limited to sensing/detecting' (pp 2234). Nussbaum (2022) talks about sentience rather than consciousness. She describes how living creatures, from mammals to fish and birds, are assumed to be sentient.

In this paper, it is assumed that sentience and consciousness are the same—a common assumption. Some writers do make a distinction between sentience and consciousness. For instance, Nani et al. (2021) suggest that plants may be sentient, but not conscious. For them, sentience represents 'the immediate perception of an organism that something internal or external is actually happening to itself—it requires, therefore, feedback through a basic system of transmission signals.' Although Nani et al. propose a conception 'of different degrees of sentience, ranging from non-conscious sentience to conscious and self-conscious sentience' they acknowledge that this is unusual 'as it is commonly assumed that being sentient is the same as being conscious'.

Discussions about the possibility of robots feeling pain, and of how we might determine whether they do, have tended to rely on speculations about future possibilities, as discussed in Sect. 2. Connections have been drawn between accounts of animal rights and robots (e.g. Gellers 2020; Gunkel 2012; Ryland 2020). However, these discussions pay little attention to the scientific experimental methods that have recently been used for exploring animal sentience (see Sect. 4).

Many philosophers have speculated about the subjective experiences, or lack of experience, of animals. For Descartes, animals were effectively clockwork mechanisms without subjective awareness or reasoning powers. His follower, Malebranch, provides an account that represents this view (1689):dogs, cats and other animals, 'eat without pleasure; they cry without pain; they believe without knowing it; they desire nothing; they know nothing' (Malebranch 1689; Translated from Huxley 1896). Kant also saw animals as little more than machines, although he objected to the cruel treatment of animals by humans on the grounds that it would make the perpetrators more likely to be cruel towards fellow humans. He argued that we have an indirect moral responsibility towards them (Kant, Lectures on Ethics, 1997). The utilitarians were sensitive to animal suffering and wished to prevent it, as indicated by the quotation above from Bentham (1780), and further elaborated by Singer (1975) in his book on Animal Rights.

Far more scientific evidence is available now about animal experiences and reasoning ability than was available to Descartes, or even to Kant or Bentham. Some of that evidence is summarised in the following Sect. 4 on 'Inferring pain in animals'. Increasingly that evidence is being taken into account by writers such as Korsgaard (2018)[1] and Nussbaum (2022).[2] At the same time, there are those such as Danaher (2020), and Gordon and Gunkel (2022) who speculate about the possibility of robot suffering with little reference to available scientific evidence.

In this consideration of the possibility of pain and suffering in robots, we begin with a brief description of pain itself. We then turn to an examination of the idea of pain in robots. The current progress towards developing robots that react to aversive stimuli is reviewed, followed by a discussion of how

[1] Korsgaard (2018) in her book 'fellow creatures: our obligations to other animals', takes a Kantian approach but argues that all sentient animals, and not just humans, deserve moral status.

[2] Nussbaum (2022) in her book, 'Justice for Animals' reviews philosophical approaches to animal sentience, and applies her 'Capabilities Approach' to argue the case for creating a flourishing life for sentient creatures.

robot pain and sentience might be inferred or recognised. This is contrasted to the scientific approach to determining the experience of pain in animals. Some arguments against the possibility of robots feeling pain are presented and, in a final section, the consequences that follow from an assumption of sentience for both animals and robots are considered.

1 What is pain?

If we are to think about whether or not robots could feel pain, it makes sense to begin with an account of what pain is. The problem with understanding pain is that we cannot directly know what pain other entities are feeling. We have a better understanding of human pain than of the possible pain of other entities because we experience it ourselves, and because fellow humans can describe their experience of pain to us. As Rose et al. (2014) write, 'A fundamental difficulty in research on pain is that there are no simple, unequivocal ways to measure it aside from verbal communication with human subjects and even that method is subject to error.'

The recently revised definition of pain from the International Association for the Study of Pain is: "An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage." (Raja et al 2020). The accompanying notes state that pain and nociception are different phenomena, and that pain cannot be inferred solely from activity in sensory neurons.

Nociception, 'apprehending the harmful', refers to a reflex operation of the peripheral nervous system—which may not involve a subjective awareness of pain. It incentivises aversive movement and is 'an essential warning signal to potentially harmful or injury-producing stimuli. It facilitates learning in early life, and encourages rest and healing following injury' (Finn 2017). Those rare individuals who suffer from congenital analgesia and are unable to feel pain suffer repeated injuries, exacerbated by their failure to respond to injury by guarding and restricting the movement of the injured body part (Wall 1999).

Nociception is not the same as pain: the *experience* of pain involves more than a reflex. As Wall (1999) emphasises, activity induced in the nociceptor and nociceptive pathways by a noxious stimulus is not pain, which is always a psychological state. Pain signals from three types of sensory nerve fibres are transmitted to the spinal cord and enter the brain: *A beta* fibres*; A delta* fibres; and *C fibres*. All of the brain structures receive input signals generated by tissue damage. In addition, the brain does not just receive sensory messages but also sends out signals which can amplify or reduce the chemical messages (Wall 1999).

Pain can be felt in the absence of injury (Lalkhen 2022). People who have had limbs amputated can continue to feel pain even though the limb is no longer there (Wall 1999). As well as acute pain due to tissue damage, there is also chronic pain: primary chronic pain syndrome (e.g. fibromyaligia syndrome) and secondary chronic pain syndrome (pain that persists after a nerve injury, cancer or trauma (Lalkhen 2022).

Not all injury and tissue damage results in pain. Stressors that are acute and intense can result in a short-term suppression of pain known as 'stress-induced analgesia' (Butler and Finn 2009). In a dangerous situation, the body can dampen down pain signalling, allowing the possibility of escaping despite injury. Soldiers injured in battle may be initially unaware of their pain (Wall 1999). Stress can have a similar effect in animals. A deer shot by a hunter may take off with the herd, and only later be found wounded and behaving as if in pain. Prey animals such as cattle can supress signs of pain to avoid detection by predators (Bomzon 2011).

The experience of pain can be reduced in humans through the administration of analgesics: non-steroidal anti-inflammatory drugs (NSAIDs), paracetamol, and opoids can all relieve pain. Analgesics, NSAIDs, and opoids are also used for the treatment of pain in animals (Flecknell 2008). A problem with the use of analgesics for animal pain is that since animals cannot report their pain, it has to be inferred from their behaviour. For example, in laboratory rodents, pain-related signs and behaviour include a hunched posture, decreased body temperature, and decreased nest building activity (https://www.research.psu.edu/animalresourceprogram/surgery/anesthesia-pain-recognition. Birds in pain usually show a change in or absence of normal behaviours: for example, one-legged standing, or decreased interest in their surroundings (Malik and Valentine 2018). Analgesics administered to animals believed to be in pain can often be shown to restore normal behaviour.

To experience pain is to suffer—although the extent of that suffering depends on the nature and strength of the pain. Clearly, pain is not the only form of suffering that can be experienced—there are other forms: for instance, the mental anguish provoked by the death of a loved one, the suffering experienced by a prisoner with no hope of release, or the suffering of a sow pig enclosed in a crate and unable to turn around. Interestingly in humans, there seems to be some overlap between the pain caused by a physical event and the social pain caused by social rejection or heartbreak, and there is evidence that analgesics can sometimes reduce emotional pain (Ratner et al 2018). However, our focus here is on the feeling of pain that physical damage and injury can create.

In summary, there is more to pain than a simple reflexive response to an aversive stimulus. Pain is primarily a subjective experience, and one that involves both body and mind, with complicated interactions between physical sensations, emotions, attention, and expectations. Mental states of stress can affect the experience of pain and pain itself, especially chronic pain, can create stress. Expectations also play a role, as indicated by influence of both placebos and nocebos. The effects of chemical intervention in the form of administered analgesics provides further indication of the complex mechanisms of pain.

2 Robots and pain

As well as asking whether robots could feel pain, we can ask why would we want to try to develop robots that can feel pain? For Bryson (2010), 'there is no reason to make a robot experience suffering', even as part of a program to enable it to detect and report ill treatment or damage. She states that a robot should be 'utterly replaceable', and that robot owners 'should *know* their robots do not suffer, and will never 'die''. She queries why we would want to build robots that become frustrated with or unhappy about the taks and roles that they are given when it makes much more sense to build them as efficient and effective tools.

Nonetheless, some have claimed that there would be advantages in creating robots that can feel pain. Richardson et al. (2020) argued that developing self-preservation systems for robots could lead to the development of empathy, claiming that 'robotic pain systems will promote robotic autonomy, system lifespan, and robotic altruism—a robot's ability to assist other robots, humans and other living organisms.' Asada (2019) similarly argues that the development of empathy in robots depends on the development of a nervous system so that they can feel pain, and a mirror neuron system so that they can notice the pain of others. This, he claims, would lead to the emergence of 'proto-morality' and to robots becoming moral agents. Man and Damasio (2019) propose a way of creating robots with feelings by means of a new design principle. They argue that to develop machines with feelings, they need to be built as homeostatic machines with vulnerability. They advocate building robots that are concerned with self-preservation, with the idea that a robot concerned about itself could develop the equivalent of feelings.

2.1 Robots that appear to feel pain

There has been some progress in creating robots that *appear to* be sentient or that seem to feel pain. The humanoid robot Sophia, developed by Hanson Robotics, has controversially been given Saudi Arabian citizenship. Some people might imagine the Sophia robot to be aware and cognizant because it can make convincing facial expressions and answer questions. However, it is essentially a show robot (Sharkey 2018). Various robots have been developed to behave as if they could feel pain or distress. The Furby was programmed to say 'Me scared' if held upside down (Fisher 2013). The Pleo robot dinosaur twists and turns in apparent discomfort if held upside down. 'Shelley' is a robot tortoise designed to teach children not to abuse robots (Ackerman 2018). Its shell has vibration sensors that can detect touches and impacts, and its embedded LEDS light up to indicate when it is 'happy'. If a child hits, kicks, or picks up the robot, the head and limbs retract inside the shell.

There could be some benefits to creating robots that appear to feel pain. For instance, Tan et al. (2022) report the development of a medical training simulator that creates facial expressions of pain depending on the physical palpation of the abdomen of a robot medical simulator. They suggest that the simulator could improve awareness of differing pain expressions and reduce gender-based and racial bias in the recognition of pain. The Simroid robot was developed by Kokoro and Co. for clinical training in dentist school. It has sensors to enable it to give feedback to dentistry students. When poked hard, it yelps and grimaces to show pain (https://www.roboticstoday.com/robots/simroid-description).

People can be reluctant to deliberately harm a robot, as Darling (2021) established when she ran a workshop with Pleo robots and required the participants to 'torture and kill' the robots. They refused to do so. Their reasons for refusing were not transparent, but were probably attributable to an anthropomorphic view of the robots, and an instinctive avoidance of harming something that appeared to be alive and to feel pain. When asked, the participants agreed that the robot was 'just an unfeeling machine', but they still felt uncomfortable about mistreating them (Darling 2021, p 211). Darling also reports the outrage that followed the release of a video clip by the robotics company Boston Dynamics in which a dog-like robot 'Spot' was kicked by the engineers. The point of the video was to show how stable the robot was, but enough people protested at its treatment that CNN reported it.

2.2 Robots that can feel pain

The actual progress towards developing robots capable of feeling pain is quite limited and focused on the implementation of pain reflexes. Kuehn and Hadaddin (2017) developed a system to facilitate collision avoidance in robots that relied on a simulated version of tactile sensitivity. They focused on nociceptor sensors to evoke a pain reflex and developed an 'artificial robot nervous system' which creates 'pain spiking signals' in response to a mechanical stimulus or collision. The signals corresponded to different levels of pain sensation and were used to activate pain-reflex movements, adapting the movements of a robot arm. Depending on the spiking rate, the robot executed protective behaviour, moving back from the colliding object in the strongest case.

Asada (2019) reports the development of a tactile sensor that can discriminate between a soft and hard touch. The tactile sensor has also been linked to a child-resembling robot, 'Affeto', which exhibits wincing expressions when the touch pressure exceeds a threshold (Shwarz 2020). Liu et al. (2022) report the development of electronic skin, designed to create biological skin-like haptic sensations in a robotic hand. The response of the artificial synapse they developed varies depending on the level of pressure applied to the skin. They suggest that associative learning could be used to create a human body-like pain reflex.

Sur and Amor (2017) developed a machine learning system for robots that was trained to associate visual cues with subsequent physical perturbations in the form of physical contact with a human interaction partner, and to predict future perturbations. Feng and Zeng (2022) claim greater biological plausibility for their approach. They developed a 'Brain-inspired Robot Pain Spiking Neural Network', with a learning rule and a population coding method. They used a Nao robot as an experimental platform for their network, implementing two tasks: (i) alerting of an injury and (ii) preventing potential injury. In the implementation, the arm of the Nao was hit by a black object, moving it from its predicted position, bending its elbow, and creating a 'pain' response. Associative learning linked the detection of the impact of the black object to the firing of a pain module. A camera recorded the interaction with the black object, so that when the black object was detected again, the robot could carry out avoidance behaviour.

3 Inferring pain in robots

As we have seen, it has been suggested that creating robots capable of feeling pain might lead to the development of machines with empathy. Even though actual progress towards creating robots that experience pain is extremely limited, arguments have been made to the effect that it could be possible to do so and that robots may one day be sentient. It has been suggested that since we are unable to know if anyone or anything other than oneself is sentient, we should give robots the benefit of the doubt and assume that they are sentient and capable of experiencing pain if they behave as though they were (Sebo 2018).

In response to the prevalent uncertainty about which entities are sentient, Sebo (2018) outlines three different principles: (i) an incautionary principle, (ii) a precautionary principle, and (iii) an expected value principle. The incautionary principle permits 'treating other beings as non-sentient in the case of uncertainty' (p. 8). The precautionary principle requires 'treating other beings as sentient in cases of uncertainty' (p. 8). The expected value principle holds that 'in cases of uncertainty about whether or not a particular being is sentient, we are morally required to multiply our degree of confidence that they are sentient by the amount of moral value that they would have if they were, and to treat the product of this equation as the amount of moral value that they actually have' (p. 11). Sebo prefers the precautionary principle and the expected value principle on moral grounds, but concludes that the latter allows for the idea of partial sentience. His acceptance of the possibility of degrees of sentience leads him to conclude that a wide range of beings should be granted 'at least partial moral status' (p. 29). This range could include 'fetuses, animals, plants, robots and more' (pp. 29–30).

Danaher proposes a theory of 'ethical behaviourism' (Danaher 2020) that could be seen as related to Sebo's precautionary principle (Sebo 2018). Danaher's theory of 'ethical behaviourism' states that 'robots can have significant moral status if they are *roughly performatively equivalent* to other entities that have significant moral status' (Danaher 2020, pp 2023). According to this position, 'what's going on 'on the inside' *does not matter* from an ethical perspective'. Danaher concludes, 'Performative artifice, by itself, can suffice for a claim of moral status' (p 2025) (although he admits that this is a 'counter-intuitive view'). For him, a robot that exhibits the same behaviour as an animal that is already recognised as a moral patient, should be afforded the same recognition.

For Danaher, the requirement that a biological body is necessary for moral status is 'unjustifiable biological prejudice and mysterianism' (Danaher 2020). He rejects the 'Different Ontologies Objection' to ethical behaviourism, an objection which contrasts biological beings with non-biological machines. He illustrates his claim with the example of someone discovering one day that their spouse is an alien from the Andromeda galaxy, even though they never stopped acting as their loving spouse. He argues that it would be cruel to reject their spouse's moral status on this basis.

The idea of a non-biological machine that is indistinguishable from a living creature has been raised by various writers. Schwitzgebel and Garza (2015) consider the possibility of 'a genuinely conscious human-grade AI, fully capable of joy and suffering, with the full human range of theoretical and practical intelligence and with expectations of future life' (p. 19). Tye (2017) imagines a robot rabbit that looks just like a real rabbit, and that has internal states that cause it to respond as a living rabbit would to pain inducing stimuli. He claims that even though it was 'artificial through and through', its consciousness should be assumed. Bostrom and Yudkowsky (2014) also indulge in 'what if' considerations. They acknowledge that current AI systems have no moral status but claim that 'an AI system will have some moral status if it has the capacity for qualia, such as the ability to feel pain' (p. 7).

Interesting though it is, the possibility of a robot that is identical to a living entity remains the province of science fiction. In the meantime, Danaher's account of ethical behaviourism, like Sebo's precautionary principle, risks false positives and is likely to be over-inclusive. It is short on details and not very clear on what counts as 'performative equivalence'. The 'rough' equivalence concept recognises that behaviour will not be identical, but 'is enough if it displays most of the relevant performative cues in similar circumstances.' He is less clear about who will make the decisions about behavioural equivalence, or how many circumstances should be considered, and what time period should be involved.

Smids (2020) criticises ethical behaviourism on the basis that what goes on inside does matter, and behavioural performance is not enough. He points out that when considering what to believe about a robot dog that behaves as though it was in pain, it makes sense to consider the design process. A more likely explanation for the robot dog's behaviour is that it has been designed to simulate pain-related behaviours when hit. He also argues that, contrary to Danaher (2020), the ontology of a robot matters when considering whether it is or is not sentient. In the case of the robot dog, we know that it 'lacks the nerves, a central nervous system, and all other relevant biology that enable biological dogs to feel pain.' (p. 2862). He concludes that 'we should allow all evidence to contribute to determining a robot's moral status' (p. 2864).

Advocates of the 'relational approach' (Gunkel 2018; Coeckelbergh and Gunkel 2014) go so far as to dismiss what they term the 'properties' approach, whereby moral status depends on whether or not an entity is sentient or has the capacity to suffer. They argue that our moral obligations towards robots should depend on our relationships with them, and not on any properties that they might have. Based on the work of Levinas (1969), for them, moral status is determined by the extent to which an entity 'takes on a face' and enters into our moral community. Thus, they argue that a named robot in our homes that we interact with as a companion should be afforded moral status. However, since the relational approach dismisses the issues of sentience and the experience of pain with which we are concerned in this paper, it is of limited relevance here.

4 Inferring pain in animals

When Danaher (2020) proposed his approach of ethical behaviourism as a means of determining the sentience of robots, he did not discuss the approaches taken towards inferring the experience of pain in animals. Allen (2004) writes of 'the understandable difficulty philosophers face in keeping up with the latest scientific research, especially when it comes to assessments of animal pain' (Allen 2004 p. 620). Even so, a consideration of the approach taken to inferring the experience of pain in animals must have some relevance to arguments about inferring pain and suffering in robots.

There is an emerging consensus about the set of criteria that indicate that an animal can experience pain. There is debate about whether entities such as insects can feel pain (Adamo 2016) or whether their response to damaging stimuli is solely attributable to nociception. However, there is general acceptance that mammals and birds do feel pain. Nussbaum (2022), for instance, assumes that living creatures, from mammals to fish and birds, are sentient. According to her, in terms of invertebrates, the cephalopods (squid, cuttlefish, and octopus) have a strong claim to sentience; she is less certain about crustaceans (shrimp, crabs, lobsters). She draws a line at plants, and the plant like animals: Cnidarians (corals, jellyfish, sea anemones) that have no brains or central nervous system and Porifera (sponges), which have no nervous system at all, seem unlikely to have sentience.

The more an animal resembles us, the easier it is to recognise when it is feeling pain, since it is likely to behave as we do. Thus, it is easier to recognise that mammals such as dogs, cats, cattle, pigs, and elephants feel pain than lobsters and crabs, or insects. There used to be doubt about the ability of birds and fish to feel pain, but there is a growing understanding that they do.

For instance, there is accumulating evidence that fish can feel pain. The experiments reported by Braithwaite (2010) illustrate a scientific approach to inferring pain in animals. For example, Braithwaite and Sneddon carried out a series of experiments with trout which indicate that fish experience pain. In one set, there were four conditions. In one, the trout were injected with bee venom in the area where sensitive nerve tissue had been found. In the second, they were injected with vinegar. In the third, they were injected with a neutral saline solution, and in the fourth they were just handled. Fish in the first two groups behaved as though in distress. When they were given morphine, the distressed behaviour ceased. It was also found that when the fish were distressed, they behaved differently in response to novel changes in their tank—returning to a normal response once they had been given morphine. The implication is that the fish experienced pain, a pain that was relieved when they were given an analgesic.

The fish experiments illustrate factors that contribute to the recognition that an animal species feels pain. They include observations of an animal's behaviour when in pain, combined with the ameliorating effects of analgesics. They also involve establishing the presence of a nervous system capable of registering pain. The conclusion that fish feel pain is still controversial: Rose et al. (2014) criticised the experiments and concluded that fish are unlikely to feel pain—claiming that experimental results with fish can be explained as nociceptive reflexive responses, and that fish consciousness is neurologically implausible. Balcombe (2016) and

Nussbaum (2022) reject their claims—Nussbaum, because they rely on the absence of a neocortex in fish and, as she points out, pain in birds is recognised even though they also lack a neocortex.

Sets of neurological and behavioural criteria for animal pain have been proposed (Bateson 1991; Varner 1998; Sneddon et al 2014). Sneddon et al. (2014) provide a detailed set of criteria. The list includes (i) evidence of central processing of nociception involving brain areas that regulate motivated behaviour (including learning and fear), (ii) nociception that activates physiological responses (e.g. change in respiration, heart rate, or hormonal levels), (iii) protective behaviour such as wound guarding, limping, rubbing, or licking, and (iv) evidence of such effects being reduced by analgesia or local anaesthetics. Indicators considered to be important by Birch (2017) in terms of animal protection legislation include 'the *self-delivery of analgesics*, whereby the animal learns to administer pain relief drugs such as opioids in an operant-conditioning setup; *motivational trade-offs*, whereby the animal behaves as if weighing its preference to avoid a noxious stimulus against other preferences; and *conditioned place avoidance*, whereby the animal learns to avoid locations at which it previously encountered noxious stimuli'.

Even this brief review of the approaches that have been taken in efforts to determine the sentience of various species of animals shows a markedly different approach to that taken by those who consider the possibility of robot sentience. The scientific approach taken to investigate whether or not fish feel pain provides a good illustration; rather than just observing the behaviour of fish, experimental interventions are taken to establish their responses to painful stimuli, and to the remediating effects of analgesics.

As we have seen, Danaher's (2020) account of ethical behaviourism emphasises the role of the behaviour of a robot in inferring its ability to suffer. Sebo (2018) argues for a precautionary approach, according to which an entity that appears to suffer should be given the benefit of the doubt and treated accordingly. However, the scientific approach taken in investigations of animal sentience suggests that mere observation of behaviour is not enough. Instead of assuming that a robot dog is feeling pain if it yelps and whimpers when it is kicked, consideration should be paid to other criteria for animal sentience. For instance, some evidence of an underlying neurological substrate should surely be required. It is also important to consider the design of the robot, as argued by Smids (2020). Danaher's determined avoidance of scientific evidence in his discussions of robot sentience seems hard to justify. It could be argued that the scientific approach to sentience is still behaviourist, in the sense that it also involves observations of behaviour. However, there are important differences. The scientific evidential approach to sentience involves consideration of both behavioural and neurological criteria, and can also involve experimental intervention.

5 Arguments against robots feeling pain

Arguments against the possibility of robots feeling pain have been dismissed on the basis that they rely on a 'properties' approach (Danaher 2020; Gunkel 2014), but such dismissal does not mean that the properties approach is wrong. Essentially, there are crucial differences between living beings and non-living machines that make it unlikely that a robot could ever become sentient.

Fuchs (2022) presents a cogent account of the emergence of conscious experience as a consequence of the homeostasis, and 'vital embodiment' of living beings. The maintenance of homeostasis, 'manifests itself in the phenomena of drive, hunger, thirst, displeasure, or satisfaction and pleasure' (Fuchs 2022). Fuchs relates his account of vital embodiment to distinctions made by Sharkey and Ziemke (2001) between mechanistic and phenomenal embodiment. He claims that an AI-based robot could only be mechanistically embodied.[3] Phenomenal embodiment implies a conscious experience beyond the reach of artificial machines.

According to Sharkey and Ziemke (2001), since a robot does not have a living body, it can only be weakly embodied. Strong embodiment requires a living *autopoetic* body (Sharkey and Sharkey 2008). '*Autopoiesis*' is a concept introduced by Maturana and Varela (1980). The term means "auto (self)-creation" from the Greek *auto* for self and *poiesis* for creation or production. An autopoietic body is a homeostatic machine that maintains its own organisation. It has a unity that distinguishes it from its environment, a unity that depends on the autonomy of its individual cells, or "first-order autopoietic units". The solidarity of these individual cells constitutes the organism as an integrated behavioural entity and second-order autopoietic unit", due to the fact that "the structural changes that each cell undergoes in its history of interactions with other cells are complementary to each other, within the constraints of their participation in the metacellular unity they comprise" (Maturana and Varela 1987).

Autopoietic machines can be distinguished from those that are allopoietic. An allopoietic machine such as a car or a robot cannot maintain its own organisation. It depends on components produced by other processes that are

[3] Fuchs (2022) omits the point made by Sharkey and Ziemke (2001) that artificial systems can only represent *weak* mechanistic embodiment, with analogy to the distinction made by Searle (1980, 1997) between strong and weak Artificial Intelligence. Weak embodiment, like weak AI refers to the situation in which the effects of embodiment are modelled and explored but true embodiment is not achieved.

independent of the organisation of the machine. In addition, the chemical, mechanical and integrating mechanisms of living things are missing from robots. New sensors or body parts could be added to or removed from a robot without affecting its "multicellular solidarity". Although a robot has a body that enables it to move around in the environment, its body is not an integrated whole in the way that a living body is. Since robots have no nervous system there is no conscious self that is able to experience pain. On the basis of these considerations, it is difficult to see how consciousness and sentience could ever emerge in such machines. The future robots that are imagined to be indistinguishable from living beings are unlikely to ever become a reality.

6 The consequences of assuming sentience

Even though the creation of robots that experience pain is unlikely, claims about possible robot sentience are still made. What consequences would follow if in the future it were to be decided that a robot was sentient? The example of conferring citizenship on the robot Sophia (Sharkey 2018) provides an indicative illustration. There have been suggestions that robots should have rights, although their right to rights has been mooted on the basis of our relationship to them (Gunkel 2014). Danaher's (2020) suggestion is that there would be 'a duty not to physically damage a robot, or erase its memories, or switch it off without an overriding moral justification'. Of course, it would make no sense to suggest the use of analgesics to reduce the pain that robots might be supposed to feel. A person taking a robot to bits to fix it has no need to worry that it will suffer from pain as a result.

Animal species that have been recognised as sentient do not necessarily receive better treatment as a result. For instance, the UK's Animal Welfare (Sentience) Act of 2022 recognises all vertebrates and cephalopods, molluscs, and decapod crustacea as sentient beings. But this recognition has limited impact, since as Hunt (2023, The Guardian) points out: 'The UK government recognised octopuses, crabs and lobsters as sentient beings in November 2021—but with no change to fishing practices or in restaurant kitchens. The law recognises that lobsters can feel pain, but it's still not a crime to boil them alive.' The Animal Welfare (Sentience) Act required the setting up of an Animal Sentience Committee made up of experts who can issue reports indicating the extent to which government decisions have taken account of the welfare of sentient animals. But it has neither an advisory nor an enforcement role.

There have been many efforts to develop further legal protection for animals to prevent their suffering (see Nussbaum 2022, Chapter 12 for a review of US animal protection law). There are also many examples of recommended actions and behaviour. For example, Beauchamp and DeGrazia (2020) recommend three basic principles for animal research ethics: (i) the principle of no unnecessary harm, (ii) the principle of basic needs, and (iii) the principle of upper limits to harm. Their catalogue of basic needs includes the following: nutritious food and clean water, safe shelter, adequate stimulation, exercise and opportunities for species-typical functioning, veterinary care, and freedom from significant experimental harms such as pain, distress, and suffering.

Nussbaum (2022), when pointing out that suffering can involve more than pain, argues that sentient animals deserve the right to a flourishing life. What that means depends on the nature of the animal. As she points out,

> there are things that are serious harms and wrongs to a human being that would not be wrongs to a dolphin: for example, the denial of an education conferring basic literacy. On the other hand, the ability to swim unfettered through large tracts of water is a key ability in the life-forms of fish and marine mammals, but to deprive humans of a chance to swim for endless miles is no injustice (Nussbaum 2022, p. 152).

Unfortunately, we have some way to go to ensure a flourishing life for many animals—since we continue to farm, kill, and cause suffering in animals that we know are sentient. Gibert and Martin (2022) write, 'There is no reason to believe that any AI system is sentient today in such a way that it could be wronged for its own sake, but there are strong reasons to believe that other entities, like nonhuman animals, do have a subjective experience of the world, and that we are currently treating them in a way that we simply cannot justify.'

What could it mean to ensure that a robot had a flourishing life? The question makes little sense. For most animals, the opportunity to procreate and to raise their offspring is important—but a robot has no such desire (unless programmed with some version of a desire to reproduce). Many animals need the company of conspecifics to live happily—but again robots have no such need unless specifically programmed to seek out other robots, or other beings. Could we say that a robot that is kept in a dark cupboard with nothing to do is suffering? Current robots have no drive towards movement, stimulation, and friendship unless they have been programmed to exhibit such behaviour.

The risks of over- or underinclusion of entities in the moral circle of concern should also be considered. The risk of underinclusion, and setting a high bar for sentience, is that we mistreat sentient creatures and cause them to suffer. Even if we acknowledge that current robots are not sentient, there could be downsides to allowing them to be mistreated and harmed. This is the argument made by Darling (2021) and also Coeckelbergh (2021) on the same basis as Kant's arguments against the mistreatment of animals. The mistreatment of robots could foster cruelty and meanness in the humans that practice it—our natural empathy towards something that appears to be in pain should be encouraged rather than rejected.

As pointed out earlier, the precautionary approach (Sebo 2018; Birch 2017) and ethical behaviourism (Danaher 2020) risk overinclusion. Overinclusion can give rise to some problems in animal ethics. For instance, if all animals were assumed to be sentient, this could lead to an unscientific approach and a dilution of animal protection legislation (Birch 2017). As Adamo (2016) points out, assuming that insects feel pain could result in funds being allocated to more expensive methods of housing and testing insects, and a consequential slower introduction of methods for curbing insect-vectored disease and an increase in human suffering.

A different set of risks could arise from the overinclusion of robots in the sphere of those entities thought to be able to suffer. Belief in a robot's sentience could lead to children and adults investing time and energy in caring for a robot that did not require such care (Smids 2020). A person might even risk their life to save a robot (Schwitzgebel and Garza 2015). If a robot was believed to be sentient, there could be an expectation that it has feelings for, and cares about, humans (Sharkey and Sharkey 2010, 2012). Such beliefs could lead to the inappropriate deployment of robots in roles that require empathy for and understanding of humans, such as carers for older people (Sharkey and Sharkey 2012), nannies or childminders (Sharkey and Sharkey 2010), or even teachers (Sharkey 2016).

There may be some circumstances in which interacting with a robot could lead to some health benefits—for instance, people with dementia might gain from interactions with a robot like the Paro seal robot (Sharkey and Wood 2014). Even so, it is better to be clear that the robot is not actually sentient or alive. The risks of overinclusion outweigh the benefits.

7 Conclusions

Our concern here has been to examine the possibility of robots experiencing pain. Having the experience of pain implies sentience and consciousness. It is not the same as nociception, a reflex response to an aversive stimulus. It is a subjective experience that involves both body and mind, whereby a central nervous system both receives pain signals and transmits signals that can amplify or reduce those signals.

Because we do not have direct access to the minds of other people, or other animals, we cannot be certain about whether or not they are in pain. In animal ethics, and robot ethics, different approaches have been taken to the attribution of painful experience.

In animal ethics, a methodology for determining the ability to experience pain is emerging. Criteria for sentience, based on scientific evidence, have been proposed by Bateson (1991), Sneddon et al. (2014), and Birch (2017). The criteria are proposed as a means of distinguishing between creatures that do not experience pain, but are capable of nociception and the detection of aversive stimuli, and those that do feel pain. For instance, the experience of pain is more likely in animals which have a central nervous system that alters their behaviour in response to an aversive stimulus, and that respond to, or even work for, analgesic pain relief.

In robot ethics, there has been little discussion of scientific evidence pertaining to painful experience. Instead, it has been argued that if an entity behaves in the same way as one that is recognised as having moral status, it should be allocated the same status. Thus, according to ethical behaviourism (Danaher 2020), if a robot behaves like an animal that is recognised as experiencing pain, it should also be assumed to be sentient. Yet, it should be apparent that if we were to apply the same scientific criteria as used in animal ethics to current robots, there would be little reason to believe that they could be feeling pain, whatever their behaviour.

Arguments against the possibility of robots feeling pain have been dismissed by some (e.g. Danaher 2020; Gunkel 2012) on the basis that they rely on a 'properties' approach. Nonetheless, the argument can be made that, as allopoietic machines that are neither living nor homeostatic, robots are not able to suffer or to experience the world (Fuchs 2022; Sharkey and Ziemke 2001). They lack a nervous system, and there would be no point in offering them analgesic pain relief. In a discussion about whether or not insects feel pain, Adamo (2016) reflects an assumption that robots are not sentient when she writes that, 'in essence, robots and computer simulations demonstrate how pain-like behaviour can be produced without the subjective experience of pain'.

Applying a precautionary approach to robots and assuming that they are sentient and able to feel pain is potentially dangerous. The dangers relate to placing inappropriate trust in robots to care for and about people (Sharkey and Sharkey 2010, 2012). Problems could also result from people wasting their caring resources on robots that do not need such care. On the other hand, even where animals have been recognised as being sentient and capable of suffering, they are still mistreated.

Although some authors (e.g. Bostrom and Yudkowsky 2014; Schwitzgebel and Garza 2015; Tye 2017) have speculated about the future development of robots that are indistinguishable from living beings and fully conscious, there is currently little reason to believe that such a future will ever become a reality. It is concluded here that, unlike most animals, robots are not able to experience pain and that it would be a waste of scarce welfare resources to attempt to protect them from such suffering. There could be some advantages in developing robots with some form of nociception that caused them to move away from something that might damage them. It might be useful to simulate pain in robots that are being used in medical or dentistry training packages (Tan et al 2022). Allowing or encouraging humans to apparently harm a robot is probably a bad idea and could risk the creation of a cruel and uncaring attitude. Nonetheless, in this consideration of pain, we have found no reason to believe that current or near future robots will be able to feel pain, and no good reason to try to create robots that can.

Data availability The author confirms that all data generated or analysed during this study are included in this published article.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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