



Conjoined twinning & biological individuation

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Abstract In dicephalus conjoined twinning, it appears that two heads share a body; in cephalopagus, it appears that two bodies share a head. How many human animals are present in these cases? One answer is that there are two in both cases—conjoined twins are precisely that, *conjoined twins*. Another is that the number of humans corresponds to the number of bodies—so there is one in dicephalus and two in cephalopagus. I show that both of these answers are incorrect. Prominent accounts of biological individuation, which treat the organism as an integrated whole, reveal that in these and other cases of conjoined twinning the ‘twins’ share a single human animal. This has a number of consequences for the debate about what we are. First, if animalism is true, individuals of our kind can be—and are—profoundly psychologically divided. Second, cephalopagus twinning does not divide animalism from its rivals, as has been claimed. Finally, animalists can reply to a vicious species of the ‘too many thinkers’ problem to which they are allegedly uniquely vulnerable.

Keywords Biological individuation · Conjoined twins · Animals · Organisms · Animalism · Personal identity

1 Introduction

In dicephalus conjoined twinning, it appears that two heads share a body. In cephalopagus conjoined twinning, it appears that two bodies share a head. How many animals are involved in these cases of conjoined twinning? One answer is that in both cases, there are two human animals fused together (Snowdon 2014, p 186).

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Another is that the number of animals corresponds to the apparent number of bodies—so, dicephalus is one animal, and cephalopagus two (Campbell and McMahan 2016). In this paper, I appeal to accounts of biological individuation to show that neither of these answers is correct: both cephalopagus and dicephalus, along with many other types of conjoined twinning, involve a single human animal.

This has a number of consequences for the question of what we are. Dicephalus and cephalopagus twinning are supposed to make trouble for animalism, the view that we are human animals, by showing that the number of us can differ from the number of human animals (Olson 2014, p 24). In dicephalus, it looks as though two of us share an animal—and being distinct, they cannot both be identical to this animal. In cephalopagus, it looks as though two animals share a brain. But then animalists must say that there are two thinkers for every thought in cephalopagus, rather than one, as it appears. This presents animalism with a ‘too many thinkers’ problem more vicious than similar problems facing its rivals (Campbell and McMahan 2010, 2016). Animalists have responded by arguing that dicephalus involves more than one animal, either in all actual or all possible cases (Blatti 2007; Liao 2006; Olson 2014; Snowdon 2014), but accepting that cephalopagus involves two (Olson 2014). This paper shows that this response is a mistake: both dicephalus and cephalopagus are one animal. But it also provides animalists with a reply to their vicious ‘too many thinkers’ problem.

I begin with dicephalus. In Sect. 2, I consider and reject reasons for thinking there is more than one animal in dicephalus. In Sect. 3, I argue that on any prominent account of biological individuation, the biological particular naturally referred to as ‘both twins’ will qualify as an organism. In Sect. 4, I argue that these same accounts of biological individuation rule out the possibility that the two ‘twins’ are organisms. So, dicephalus is a single organism. In Sect. 5, I show that the same considerations motivate the claim that cephalopagus is a single animal and in Sect. 6, propose that the same goes in many other cases of conjoined twinning. In Sect. 7, I draw out implications for the personal identity debate. Sect. 8 concludes.

2 More than one animal

In dicephalus twinning, twins are fused below the neck. Internal anatomy of dicephalus twins can vary, but we can take as a model a case described by Tim Campbell and Jeff McMahan, involving two hearts, two oesophagi, and two stomachs, three lungs, a single liver, a single small and large intestine, and single urinary, circulatory, immunological and reproductive systems (2016, p 230). It will be helpful to introduce labels for the candidate animals in a case of dicephalus like this. First, there is the particular we might naturally refer to as ‘both twins’. I will call this ‘Fusion’. Next, there are the two ‘twins’—call them ‘Lefty’ and ‘Righty’. Since Lefty and Righty overlap and share single circulatory and immune systems, there is no sharp boundary between them. But they are not entirely coincident: minimally, neither has the other’s head as a proper part. Let us assume more precisely that (a) the left brain belongs exclusively to Lefty and the right brain exclusively to Righty; (b) if a body part is exclusively controlled and regulated by

one brain, it belongs exclusively to the twin whose brain that is; and (c) any parts which are not exclusively controlled and regulated by one brain will be shared, belonging equally to both Lefty and Righty.¹ According to the ‘one animal’ construal of dicephalus I will defend in Sects. 3, 4, Fusion is an animal, whilst Lefty and Righty are not.

Before that, though, why have others claimed that there is more than one animal in dicephalus? First, Stephan Blatti (2007) argues that dicephalus is a ‘borderline case’ for the application of the concept HUMAN ANIMAL. He takes this to support the claim that the number of animals present is ‘more than one but less than two’ (2007, p 602). A borderline case is something which qualifies as a candidate instance in virtue of possessing several paradigmatic properties of the kind in question, but fails to qualify as a clear instance in virtue of lacking others. Blatti writes that dicephalus twins express some properties characteristic of exactly one human animal, and others characteristic of two—like the ‘presence of two distinct subjects of experience, as well as the overabundance of various organs and appendages’ (2007, p 604). So, the suggestion seems to be that Fusion is not a clear instance of either one or two human animals, but is a borderline case of both. But whilst it’s certainly true that the properties Blatti cites might bring one’s intuitions into conflict, to conclude from this that the number of human animals in dicephalus is greater than one is to assume that our intuitive response here is correct—that these properties are in fact relevant to determining the number of organisms. Whether this is so is a substantial metaphysical question, answering which requires reflection on what human animals, or organisms more generally, really are. As I shall argue below, such reflection delivers the verdict that Fusion is exactly one organism, and hence one human animal—unusual though she may be.

A second, similar approach appeals to the number of organs in dicephalus. Tim Campbell and Jeff McMahan take the ‘limited duplication of organs’ in the case described above to indicate that there is only one organism—Fusion (2016, p 230). Moreover, they note that we can imagine an ‘Extreme Case’ (Liao 2006, p 344) with no duplication of organs below the neck. In response, advocates of the opposing view claim that Campbell and McMahan’s organ count is unduly selective. Paul Snowdon, for instance, notes that even in the Extreme Case it is not only the brain which is duplicated: there will also be four eyes, two noses, four ears, and so on (2014, p 186; see also Blatti 2007, p 602).

The underlying thought on both sides seems to be that organisms correspond approximately one–one to complete organ sets. But this claim about the correspondence between organs and organisms simply seems wrong. Splenectomies do not create partial animals; nor does possession of an accessory spleen qualify one as one-and-a-bit animals. Moreover, we can easily imagine someone born with a nearly full set of accessory organs—an accessory heart, stomach, spleen, liver and intestine, say. It doesn’t seem, though, that the presence of these organs would be evidence we were facing more than one animal. Taking inventory of the organs in dicephalus is not a promising strategy.

¹ I revisit these assumptions about Lefty and Righty’s composition in Sect. 4.

Third, Eric Olson proposes that at least in actual cases of dicephalus, where there are two brainstems, there are two organisms—because ‘if it were possible for one organism to die while the other survives, there would have to be two organisms’ (2014, p 28). Olson thinks that where there are two brain stems, it is possible for one twin to die whilst the other survives. This proposal presumably rests on the thought that the brainstem stands in an important relationship to *life*. In earlier work, Olson takes the brainstem’s function to be coordinating an animal’s ‘life-sustaining functions’ (1997a, p 140). On this basis, he takes the death of the brainstem to be sufficient for biological death: without the brainstem coordinating life-sustaining functions, an organism’s parts will cease to ‘work together as a unit in the manner characteristic of a living organism’ (ibid.). This, I think, underwrites his claim that in cases of dicephalus with two brainstems, there are two organisms.

These claims about the brainstem and life have been called into question. Alan Shewmon has argued that the majority of life-sustaining or ‘somatically integrating’ functions are not directed by the brain, or localised to any particular area of the body—somatic integration is a ‘holistic phenomenon involving mutual interaction of the parts’ (2001, p 473). He proposes that the brain functions to modulate and fine-tune the life-processes of an already living organism. On this basis, he denies that brain-death suffices for biological death—and acknowledging this, Olson (2016, p 297) has more recently rejected the connection between the brainstem and the ‘continuation of a human life’. But even if it were true that in typical humans the death of the brainstem was sufficient for biological death, this would not show that a human could not have two brainstems, or that the destruction of a human brainstem always brings about the cessation of a human life. If total heart failure were normally sufficient for death, this would not show that a human could not be born with two hearts—or that if such a human was born and one heart stopped, somebody would die. Claims about what typical humans can and cannot survive do not obviously license claims about the correspondence between human lives and functioning body parts of a particular kind.²

Olson might reply that this misses his point: that if the left brainstem were destroyed the result would ‘look much like the death of an organism’—the organs under its control would stop functioning, the limbs on that side would be paralysed, and the spinal cord on that side would atrophy (2014, p 28). By contrast, whatever complications might be brought about by the failure of an accessory heart would not look like death. But whilst Olson may be right about which complications would be brought about by the destruction of a brainstem, to say that they would ‘look like’ death is just not true. As Olson acknowledges, the right heart might continue to circulate oxygenated blood to all of Lefty’s tissues: the total body-mass is ‘not

² Peter van Inwagen (1990, pp 202–203) describes an organism with two ‘organs of maintenance’ (‘Neocerberus’), proposing that it could not survive the destruction of one of these organs, since the resulting life would have different causes than that of Neocerberus. But this has the implausible result that if such a creature’s organs of maintenance took turns in maintaining its life-processes, ‘the’ creature would cease to be whenever operations shifted from one organ to the other (Zimmerman 1999, p 200). For this and other reasons, one might dispute that lives are to be individuated in this manner—rather than, say, by reference to the organisms which have them, which can themselves be individuated in other ways (see Sect. 3).

abnormally extensive' (Campbell and McMahan 2016, p 240), and in some cases of dicephalus, a single heart does circulate blood to the whole (e.g. Kaveh et al. 2014). At the very least, we should expect it to continue supplying some parts of Lefty. So, in at least some parts of Lefty, the metabolic processes constitutive of life would continue. And in virtue of the fact that Lefty and Righty share many vital organs and systems, the destruction of Lefty's brainstem would almost certainly expose Righty to a host of medical complications. In these respects, the result would look very *unlike* the death of an organism. Moreover, framing the case as one in which Fusion, an animal with two brainstems, suffers the destruction of a brainstem, immediately presents a better description of the result. Fusion suffers multiple organ failure, partial paralysis, and perhaps complications attendant on reduced circulation, but remains alive. This description seems adequate, is consistent with the continued supply of oxygenated blood to the failed organs and paralysed limbs and explains the ongoing medical complications Fusion would experience.

Fourth, S. Matthew Liao (2006, p 340) proposes that dicephalus involves two animals because it involves two distinct capacities for the regulation and control of life processes such as metabolism, growth, assimilation, responsiveness, movement and reproduction—call these 'L-capacities' for short. He proposes that organisms have L-capacities essentially. Liao argues that in dicephalus, one can identify two distinct L-capacities, and so that there are two animals. However, it is unclear how these L-capacities are to be individuated. On the one hand, Liao suggests there are two L-capacities in dicephalus because 'one can identify which twin is controlling which organ or body part' (Liao 2006, p 341). This looks like another appeal to the idea, disputed above, that somatically integrating functions are localised to the brain or brainstem. Even if it this were correct, though, this would not show that each organism has precisely *one* capacity for controlling and regulating life—rather than, say, as many as there are somatically integrating functions. On the other hand, there are hints that Liao does not have the localisation idea in mind. He claims that there are two L-capacities even in the Extreme Case, in which there is a single shared brain stem (2006, p 345)—and that embryos have L-capacities even at the early stage at which twinning occurs, when they lack brainstems (2006, p 340). But this leaves it quite mysterious how L-capacities are to be individuated—and, again, why we should think each organism has precisely one.

Finally, it has been argued that developmental facts support the 'two animal' construal of dicephalus. For instance, of the Extreme Case, Liao claims that it involves two organisms because it results from 'incomplete division'—dicephalus happens when a single egg splits into two embryos, each of which has an L-capacity and so is an organism, but when cleavage is not complete (2006, p 345; see also Snowdon 2014, p 186). An initial problem is that we can imagine cases of dicephalus lacking the relevant aetiology—perhaps ones produced in a lab. Liao acknowledges this, in considering what he calls the 'Genetic Engineering Case'—in which an intrinsic duplicate of the Extreme Case is artificially produced. He claims that in virtue of being an intrinsic duplicate, the result would be two organisms—since it would have two distinct capacities for co-ordinating and regulating life processes (2006, pp 345–346). But this suggests that, really, the aetiology is irrelevant: it is the intrinsic properties of the organic matter with which we are now

faced which determine how many organisms should be counted in it. It also reveals Liao's reasoning to be circular, since the only reason offered for thinking the Extreme Case *had* two L-capacities was that it began life as two embryos.

Moreover, there are counterexamples to the underlying idea that, if a biological particular was produced from two embryos, two organisms are to be counted in that particular. Take very asymmetric cases of conjoined twinning, such as those producing what might naturally be described as a person with an extra leg. These do not seem to involve two organisms. Even if they do, there are other counterexamples. Sometimes, dizygotic twins fuse altogether, resulting in a genetic chimera—an otherwise ordinary looking animal which has different genomes at different parts of its body (Dupré 2012, p 22). To claim that a genetic chimera is really two animals is a stretch. In this kind of chimerism, we might say that whilst there were at one point two organisms, at some point they fused to create a single organism. Why might the same not be true of dicephalus? That biological particular was produced from two embryos is no guarantee that it constitutes two organisms now.

3 Biological individuation

Ordinarily, it is not difficult to tell how many organisms we are faced with—but there are a number of notable problem cases, among them aspen groves and the Portuguese man o' war. Various accounts of the organism have been offered with a view to solving these individuation problems. In this section and the next, I appeal to these accounts to show that there is only one animal in dicephalus.

These accounts address individuation questions in two ways: by providing criteria for organismhood, with which we can determine whether a biological particular is an organism, and by providing criteria of inclusion, with which we can determine what counts as part of an organism. To show that there is one human animal in dicephalus requires showing both that Fusion is a human animal, and that Lefty and Righty are not. I take for granted that Fusion, Lefty and Righty are human animals if and only if they are organisms. Since every human animal is an organism, they cannot be human animals unless they are organisms; if they are organisms, it is difficult to see what other kind of organism they might be.³ Granting these assumptions, the task at hand is to show that Fusion is an organism, and that Lefty and Righty are not. I take these issues in turn—dealing with Fusion in this section, and turning to Lefty and Righty in Sect. 4.

The appeal to accounts of the organism is complicated by the multiplicity of accounts on offer (Clarke 2010). These accounts can be divided into two approaches: according to physiological approaches, physiology should tell us what organisms are; on evolutionary approaches, it should be evolutionary theory. There

³ As such, I sometimes use 'human animal' and 'organism' interchangeably. Of course they are not equivalent, but the difference will not matter for my purposes.

are variations on the two approaches—but as I outline below, all deliver the verdict that Fusion is an organism.

Physiological accounts appeal to the notion of functional integration: an organism is a functionally integrated whole, whose parts are interconnected and causally interact, undergoing continuous change (Sober 1991). Different physiological accounts precisify this in various ways. Thomas Pradeu (2010) offers an immunological account. Here, functional integration is understood in terms of strong biochemical reactions occurring at a local level between parts of the organism, but immune interactions define the organism, since these reactions are ‘systemic’, rather than local: immune receptors police ‘all the cells and tissues of the organism’ (2010, p 258). These receptors, on Pradeu’s account, reject not what is foreign, but what is unusual: they respond to sudden or large molecular changes in the things with which they come into contact. For the immune system to tolerate an object is for it to both be *present*, that is, being surveilled by the system of immune receptors, and not to elicit an immune response. If objects originating outside the organism are tolerated, they are thereby parts of the organism. So, the immune system does not rely on a pre-existing self/non-self distinction; it grounds one. Thus, an organism is a ‘functionally integrated whole, made up of heterogeneous constituents that are locally interconnected by strong biochemical interactions and controlled by systemic immune interactions that repeat constantly at the same medium intensity’ (2010, p 258). Against this definition, it seems clear that Fusion qualifies as an organism. Her parts are functionally integrated, strongly biochemically related, and immunologically tolerated.

Another physiological approach appeals to metabolism—the set of processes enabling organisms to resist entropy and maintain their form by extracting energy from organic matter in the environment, using this energy to continuously construct their own cells and tissues, and eliminating waste. On this view, an organism is a system ‘comprised of diverse parts which work together to maintain the system’s structure, despite turnover of material, by making use of sources of energy and other resources from their environment’ (Godfrey-Smith 2012, p 25)—a ‘metabolic whole’ (Dupré and Malley 2009, p 2). Again, this account seems to qualify Fusion as an organism—since her parts function together as a unit to maintain her overall structure, making use of energy-sources from the environment, which are supplied to all her parts by a single circulatory system. More generally, it seems likely that any physiological approach will deliver the verdict that Fusion is an organism. Physiological accounts treat organisms as functional wholes—systems comprising specialised parts functioning together as a unit. Fusion just seems to be such a system—as Campbell and McMahan (2016, p 230), in pressing the dicephalus objection, note.

Evolutionary approaches treat the organism as the evolutionary individual (Godfrey-Smith 2012, p 19): the biological unit which bears adaptations and responds to natural selection. One version of the approach appeals to sexual reproduction: it views any and all particulars which proceed from the fertilisation of a single egg to be parts of a single organism (Janzen 1977). Often, this means that an organism will be a scattered object. What might appear to us to be many dandelions or a large group of aphids may, on this criterion, be a single scattered organism,

since both dandelions and aphids sometimes reproduce asexually. Not only does this account support the view that Fusion is an organism (and that Lefty and Righty are not), it suggests the same is true of all cases of monozygotic twinning: that, rather than two distinct organisms, monozygotic twinning always produces a single, scattered organism. The view also suggests that genetic chimeras resulting from dizygotic embryonic fusion will comprise two organisms. These results are unattractive—and the account, unsurprisingly, is not widely accepted.

More plausible evolutionary approaches avoid this result by noting that evolution requires only that there be a population exhibiting heritable variance in fitness (Godfrey-Smith 2012, pp 19–25). This condition can be satisfied even by asexually reproducing populations, so we need not accept the claim that whatever proceeds from a single fertilised egg is a single organism. Godfrey-Smith proposes that something is an evolutionary individual to the extent that it has three key features enabling it to participate in natural selection. First, a bottleneck life-cycle—one in which reproduction produces something the size of a single cell or a few cells, which then grows to the size of an adult. Second, germ-soma separation. Third, integration: individuals should be composed of specialised, mutually dependent parts exhibiting a division of labour beyond germ-soma separation, and they should maintain ‘a boundary between a collective and what is outside it’. Against this standard, Fusion again qualifies as an evolutionary individual: she has bottleneck origins, exhibits reproductive specialisation and is highly integrated. Her parts are specialised, mutually dependent and exhibit a division of labour, and her skin forms a clear boundary between Fusion and what is outside.

Finally, Ellen Clarke (2013) defends a functionalist account. On this picture, evolutionary individuals need not have any specific feature, like bottleneck origins. But they must possess both ‘policing mechanisms’ and ‘demarcation mechanisms’. A policing mechanism is any mechanism which inhibits the capacity of an object to undergo within-object selection. A demarcation mechanism is one which increases or maintains the ability of the object to undergo between object selection. Possession of these by individuals is what gives rise to the heritable variance in fitness required of evolutionary populations. Because these definitions are functional, both types of ‘individuation mechanism’ are multiply realisable. Reproductive specialisation, a bottleneck life-cycle, spatial contiguity and the immune system can all function as policing mechanisms; sexual reproduction and physical boundaries can function as demarcation mechanisms. Against this functional definition, Fusion qualifies as an evolutionary individual. She possesses policing mechanisms in the form of reproductive specialisation, a bottleneck lifecycle, spatial contiguity and an immune system. She possesses demarcation mechanisms in the form of sexual origins and the clear physical boundary provided by the skin.

More generally, it seems likely that any plausible evolutionary account will deliver this verdict. Those which avoid counting monozygotic twins as one, or genetic chimeras as two, avoid these implausible results by appealing to the physiological characteristics possessed by the individual twins, or the individual chimera. But these are physiological characteristics Fusion, too, possesses—so these accounts will count Fusion as an organism.

At this stage, one might object that organisms cannot be proper parts of other organisms (Sider 2001). Together with a claim that Lefty and Righty are organisms and proper parts of Fusion, this would entail that Fusion is not an organism. But even if this appeal to maximality were justified, it could get a grip on the case only if we were independently in a position to decide which—Fusion, or Lefty and Righty—were better candidates for organismhood. But Lefty and Righty immediately seem worse candidates for organismhood, against the above accounts, than Fusion. They are poorly demarcated from one another: no skin or membrane separates the parts of Lefty from the parts of Righty, preventing migration or mixture between them. Neither forms an integrated whole, with each having parts engaged in metabolic exchange and biochemical interaction with parts which are not its own. They lack their own policing mechanisms; a single immune system polices the cells and tissues of both. So, a maximality principle would more readily motivate us in denying that Lefty and Righty are organisms, rather than that Fusion is.

In short, both of the prominent approaches to biological individuation support the verdict that Fusion is an organism. This rules out the possibility that there are two animals in dicephalus—since if there were two animals in dicephalus, Fusion would not be one of them. But Fusion qualifies as an organism on any prominent account of what being an organism involves.

4 Biological inclusion

That Fusion is an organism shows that there are not two animals in dicephalus, but there remains the possibility that there are three, two of which overlap and are proper parts of the third. In this section, though, I argue that this cannot be right.

Assume, for *reductio*, that Lefty and Righty are organisms. In support, one might point out that Lefty and Righty possess many characteristics of organisms—bottleneck origins, specialised parts which are functionally integrated with one another (as well as, admittedly, with parts of the other twin), and reproductive specialisation. They engage in metabolism and exhibit immune responses. Each is demarcated from its environment, though not from the other twin, by a physical membrane. It is not clear that these are especially compelling reasons for proposing that Lefty and Righty are organisms in their own right—not least because, to the extent that these things are true of Lefty and Righty, they are also true of my right foot complement and many of my other large proper parts. But let us set that aside.

If Lefty and Righty are organisms, though, this calls into question the assumption I made earlier about what determines their parts. Recall that I employed the following criteria of inclusion: (a) the left brain belongs exclusively to Lefty, and the right brain exclusively to Righty; (b) if a part is exclusively controlled and regulated by one brain, it belongs exclusively to the twin whose brain that is; and (c) any parts not exclusively controlled and regulated by one brain belong equally to Lefty and Righty. This means, minimally, that neither twin has the other's brain as a proper part.

Biological particulars are cheap—so for the purpose of delineating a biological particular, the inclusion criteria employed in Sect. 2 were fine. But on the assumption that Lefty and Righty are animals, the criteria are problematic. The accounts of the organism considered in Sect. 3, in defining the organism thereby provide criteria of inclusion, and none of them license us in excluding the right head, or anything else, as a part of Lefty, on the grounds that it is not controlled or regulated by the right brain.

Take the metabolic approach. It says that an organism has as parts all the entities that interact to achieve shared metabolic goals (Dupré and Malley 2009, p 11)—so, anything will be a part of Lefty that collaborates with her other parts in metabolism. Let's say that two biological particulars collaborate in metabolism if their biological activities interact and promote their shared metabolic interests by contributing to the maintenance of a larger biological entity upon which both rely for their continued metabolic activity.⁴ This captures the sense in which, for instance, tissues in my foot and hand collaborate in metabolism. Their biological activities are interconnected in virtue of their connection to a shared circulatory system, and both contribute to the maintenance of a larger biological structure upon which both rely. By the same token, it also suggests that the right head collaborates in metabolism with Lefty's other parts. Biological processes in the right head interact with those in Lefty's other parts through their shared vasculature. *Inter alia*, hormones secreted in the right brain and energy consumed by the right mouth enter the bloodstream and interact with biological processes going on throughout Lefty. Together with Lefty's other parts, the right head's activities contribute to the maintenance of a larger biological entity—Fusion—upon which all these parts rely. Just as much as the left head, the right head seems collaboratively involved in the metabolic activity of the rest. So, it should be considered a part of Lefty. Similar considerations show that the left head is a part of Righty, on this approach—and more generally, that the two are coextensive.

Similarly, on the immunological approach, the right head will be a part of Lefty if it is functionally integrated with its other parts through strong biochemical interactions, and tolerated by systemic immune interactions. It is clearly functionally integrated with Lefty's other parts in the ways already enumerated, as well as more locally, since at the putative boundary between Lefty and the right head there are strong biochemical reactions occurring no different in kind from those occurring locally where the left head meets the trunk. The shared immune system extends into the right head, and no immune response is triggered. So, the right head is tolerated. For these reasons, the right head is a part of Lefty. Again, these considerations will generalise, so on this approach too Lefty and Righty are coextensive.

More generally, any physiological account, and any of the more plausible evolutionary accounts which appeal to physiological features, would presumably deliver this result. These accounts treat organisms as functionally integrated *wholes*,

⁴ I intend 'rely' in a fairly weak sense here—such that if x relies on y, then y's continued metabolic activity supports x's, so *ceteris paribus* (e.g. without intervention), x's can't go on without y's. So, it won't be a counterexample to the claim that my liver relies on me that my liver could survive transplantation.

and so must recognise as parts of the organism anything with which its parts are functionally integrated in the relevant way. In short, claiming that Lefty and Righty are animals reveals our original assumption to be in error: considered as organisms, Lefty and Righty are entirely coincident, with one another and with Fusion.

This consequence—that dicephalus involves three distinct but entirely coincident organisms—seems absurd. As Olson notes, even those who accept that two things can coincide generally ‘deny that this is possible for two things of the same kind’ (1997b, p 101). Although examples of coincident objects of the same kind are available (see Spolaore 2012), in such cases it is possible to individuate the objects by appeal to their differing modal properties. But in the case of Lefty, Righty and Fusion, it is unclear how any difference in modal properties could be established. If all three are animals, they have biological persistence conditions: they survive as long as their lives continue. Since they are co-constituted, at any time they will be undergoing qualitatively identical biochemical processes. On the plausible assumption that living consists in the continuation of certain biochemical processes, anything which suffices to kill one of them should kill them all. Their being entirely coincident, together with their being animals, strongly suggests they have all their modal properties in common—leaving no reason to grant that three distinct animals are constituted out of the biomass in dicephalus, rather than one.

But even if one were happy to insist that three coincident animals were present in dicephalus, the resulting position would hardly be attractive. After all, the intuitive motivation for thinking that there are at least two animals in dicephalus is that there appear to be two qualitatively distinct individuals with different properties—most importantly, different psychological properties. But if Lefty and Righty have all the same parts, the intuition that they differ psychologically cannot be preserved without rejecting the supervenience of the mental on the physical. If Lefty, Righty and Fusion are entirely coincident, it seems inescapable that they are physically identical—and, if the mental supervenes on the physical, psychologically identical too. Consequently, a psychological distinction between these three can be preserved only at the cost of rejecting physicalism.

The assumption that Lefty and Righty are animals, then, has the unattractive consequence that there are three animals in dicephalus, constituted out of the very same matter, which (given plausible assumptions) differ neither in their modal nor their psychological properties, nor apparently in any other way. This consequence, if not absurd, is at least sufficiently unattractive to motivate rejecting the claim which generated it: that Lefty and Righty are animals. This completes the argument for the ‘one animal’ construal of dicephalus. On prominent accounts of biological individuation, Fusion is an organism, whilst Lefty and Righty are not.

5 Cephalopagus

Cephalopagus twins are fused at the brain, face, thorax and upper abdomen (Hovorakova et al. 2008; Sabih et al. 2010). There are few documented cases and, as with dicephalus, there is some variation in the degree of fusion and the distribution of organs. In an imaginary case described by Campbell and McMahan (2016, p 248)

which we can take as a model, there is a single cerebrum, a single face, mouth and throat, two cerebella and brainstems, two oesophagi and stomachs, and the ‘normal complement of organs and appendages in each half of the total bodily mass below the neck’. In this section, I argue that cephalopagus involves a single animal.

To begin though, why might one think that cephalopagus involves two animals? Campbell and McMahan offer two reasons. One is that in the case they describe, as in dicephalus, there are two brainstems, each of which uniquely controls and regulates processes occurring in one half of the body mass below the neck (2016, p 250). Since Campbell and McMahan reject, as I do, the view that human brainstems correspond one–one to human lives, the crucial idea here must be that each brainstem has a proprietary relationship to a certain part of the biomass below the neck. But it is not clear why this should be significant: after all, if an organism can have two brainstems, why should these brainstems not divide their labour?

Their second reason is that, given the right technology, the twins would be ‘separable’—they could be surgically separated, leaving us with ‘two self-sustaining organisms’ (2016, p 248). But the fact that such an operation would leave us with two organisms shows that there are two animals beforehand only on the assumption that animals cannot be created by fission—that it is impossible to end up with two animals by ‘splitting’ one.⁵ Campbell and McMahan offer no reasons for thinking that this is impossible.⁶ Of course, it isn’t usually possible to create two humans by splitting one. But if the particular corresponding to ‘both twins’ in cephalopagus is a human organism, it is not a species-typical one—it has an unusual complement of organs, in virtue of which if it were split in the correct way, two living organisms could result. Moreover, the production of organisms by fission has precedent elsewhere in nature. Single-celled organisms reproduce by binary fission. And as Rory Madden (2016a, p 15, 2016b, p 205) points out, plant-cutting is a case in which we surgically create two plants where previously there was one. So, the possibility of surgically separating cephalopagus twins does not show that two animals are present pre-operatively.

A third reason one might offer for thinking cephalopagus involves two animals is that, unlike in dicephalus, it involves two sets of reproductive organs. Of course, there being two sets of reproductive organs no more shows that there are two organisms than there being two hearts does. But if it were possible for cephalopagus to result from the fusion of dizygotic embryos, and so the gametes produced by one set of reproductive organs were genetically distinct from those produced by the other, its offspring could fail to be genetically related to one another as siblings. This might motivate the thought that there were two organisms here, with distinct evolutionary fates.

⁵ A four-dimensionalist might have other reasons for taking the possibility of separation to be evidence that two organisms are present now. But since the assumption of three-dimensionalism is common to all those discussed here, I set four-dimensionalism aside. Thanks to S. Matthew Liao for highlighting this.

⁶ In another part of their paper, Campbell and McMahan (2016, p 245) consider and reject the view that severing the head of a typical human can be described as a case of fission, resulting in two organisms. But this rejection concerns the severed head case specifically, and does not speak to the possibility of human fission in general.

But it is not unheard of for the offspring of a single organism to exhibit precisely this kind of genetic divergence, as a result of genetic heterogeneity in the parent. Genetic chimeras can carry genetically distinct gametes, and as a result their children can fail to be related to one another as siblings typically are, and can appear to not be related to the parent in the usual way. In fact, one well-known case of genetic chimerism was revealed in just this way—after genetic testing found that a woman was apparently not genetically related to two of her three children as a mother would typically be (Yu et al. 2002). I take it that we should not say, in defiance of both appearances and the above accounts of the organism, that this woman in fact comprises two organisms. By the same token, we should not take the potential for genetic heterogeneity in the offspring of cephalopagus to indicate two organisms are present.

Against the two animal construal, the accounts of biological individuation appealed to above indicate that cephalopagus is a single organism, for very similar reasons. In cephalopagus, as in dicephalus, three particulars compete for animality: the one comprising ‘both twins’, call it F, and the ‘twins’ themselves, L and R. There is one animal just in case F is an animal and L and R are not. That this is the case is suggested by both physiological and evolutionary accounts of the organism.

On the metabolic account, F will be an organism if she is a metabolic whole—a collection of interacting biological entities contributing to shared metabolic goals. Typically, interaction between parts of human organisms is secured through their shared circulatory system—and whether there is a single circulatory system in cephalopagus has not been specified. In conjoined twinning, there is always some vascular fusion where the twins are conjoined. But this does not show that there is always a single circulatory system, since in some cases this vascular fusion is minimal, involving no major vessels and resulting in no significant cross-circulation. In such cases, we should count two circulatory systems, despite the vascular fusion.⁷ In cephalopagus, though, twins are extensively fused, from the head to the upper abdomen. Cephalopagus combines elements of thoracopagus and craniopagus twinning. In thoracopagus, twins are fused at the thorax and upper abdomen, and this always involves the heart: even where there are two hearts, these are joined by a vessel (Spencer 1996). In craniopagus, there is fusion at the skull. Unsurprisingly, given the involvement of major vessels around the heart and brain, thoracopagus and craniopagus involve more cross-circulation than other kinds of conjoined twinning (Szmuk et al. 2006). So, we should expect significant cross-circulation in cephalopagus, too. As a result of this cross-circulation, the biological activities occurring in all parts of F will interact. And the activities of the parts will

⁷ One might now wonder about the case of dicephalus Campbell and McMahan describe as involving a single circulatory system. I have interpreted this as the substantial claim that there is significant cross-circulation, rather than merely the vascular fusion present in all conjoined twinning. But Campbell and McMahan do not specify, and it’s conceivable that this is incorrect regarding this case. If it is, then the arguments of Sects. 3, 4 may not capture that case, but they will transfer to many other cases of dicephalus in which there is significant cross-circulation, which will include cases involving only one heart.

thereby contribute to the maintenance of a larger biological structure on which they all rely—namely, F.

The immunological account treats an organism as a functionally integrated system of parts which are strongly biochemically related at a local level, as well as being regulated by systemic immune interactions and not rejected. F's parts certainly meet the first two of these conditions, and they are all regulated, and not rejected, by immune interactions. So, the only remaining question is whether the immune interactions are *systemic*, rather than local: are they the action of a single immune system, which regulates the whole? The individuation of immune systems is not straightforward. One might point here to the central role of the lymphatic system in immunity—and again, it hasn't been specified whether cephalopagus involves one continuous network of lymphatic vessels, or two discrete ones. It seems unlikely that the lymphatic network on the left would be entirely discrete from that on the right, given the extent of fusion. But even if it were, this would not clearly settle the question. The immune system is not a network of vessels, but 'a system of receptors recognising abnormal patterns' (Pradeu 2010, p 255). In humans, these receptors are not found exclusively in the lymphatic network; among other things, the lymphatic vessels drain into the bloodstream, where immune receptors also circulate and perform immune functions. So, given significant cross-circulation, we should expect that immune receptors originating in both L and R will be in systemic circulation and functioning normally throughout F—and so there is indeed a single system of immune receptors regulating, and not attacking, the cells and tissues of the whole.

As well as satisfying these physiological criteria for organismhood, F exhibits the three features Godfrey-Smith emphasises in evolutionary individuals—a bottleneck lifecycle, germ-soma separation and integration. And like Fusion, F has both policing and demarcation mechanisms—reproductive specialisation, a bottleneck life-cycle, spatial contiguity, an immune system, clear physical boundaries and sexual origins.

The same considerations which speak against Lefty and Righty being organisms indicate that L and R are not organisms either. Initially, in thinking of L and R it is natural to think of each as constituted by the shared cerebrum, face, mouth and throat, together with one brainstem, and the organs controlled and regulated by that brainstem and the appendages on that same side.⁸ So, we take it that L and R are not entirely coincident. Each has only one heart, one stomach, one pair of lungs, and so on. As before, it is perfectly legitimate to stipulate that L and R are so constituted, if we are in the business of picking out biological particulars. But on the assumption that they are organisms, we cannot simply decide what parts they do and do not have.

If L is an organism, then the accounts discussed in Sect. 4 will treat as one of her parts anything which is integrated with her other parts in the relevant way. Since her parts are strongly biochemically connected to the right heart, stomach, lungs etc.

⁸ This has the odd result that each twin has control over limbs that aren't her own, via the shared cerebrum. Still, I take it this picks out roughly what we mean by (say) 'the left twin'.

and since these are tolerated by systemic immune interactions, they will count as parts of her on the immunological approach. On the metabolic approach, they will count as L's parts because they collaborate with her other parts in metabolism. And evolutionary accounts which make room for the idea that an organism is a functionally integrated physiological *whole* will also treat these as parts of L, since they are integrated and spatially contiguous with her other parts, and fall, together with her other parts, within a clear physical boundary. So, there are no grounds for denying that the organs on the right are part of L, if she is an organism. But this, together with the parallel reasoning about R, generates the result that if L and R are organisms, they are entirely coincident—both with one another, and with F. But there is no good reason to think that three organisms, apparently differing in no respect, are constituted out of the biomass in cephalopagus. So, we should conclude that L and R are not organisms—and cephalopagus involves a single human animal.

6 Other cases

It will be obvious by now that the above arguments have broader implications, indicating there is a single organism in many cases of conjoined twinning beside dicephalus and cephalopagus. For instance, the most common variety of conjoined twinning is thoracopagus (Mutchinick et al. 2011). As already noted, this always involves the heart and significant cross-circulation is the norm. There are two heads, and two pairs of arms and legs—so, from the outside, thoracopagus appears more superficial than dicephalus or cephalopagus, presenting us with two complete human body plans. Despite this, it's fairly clear that the arguments above imply that thoracopagus twins constitute a single organism. Given their shared organs and the degree of cross-circulation, there is substantial interaction between the biological processes occurring in all parts of the conjoint particular, and these parts rely on, and contribute to maintaining, the conjoint particular. The parts of the conjoint particular are strongly biochemically related, and tolerated by systemic immune interactions. The conjoint particular has bottleneck origins, germ-soma separation, and policing and demarcation mechanisms. So, on all of the above accounts of the organism, the conjoint particular is an organism. And again, if we take the 'twins' to be organisms, the same arguments will show that they are coextensive, and not distinct from the conjoint particular after all. The same result will fall out in many other cases, too—all those involving significant cross-circulation, in fact.

In fact, the reader may worry that the above arguments overgeneralise, implying that there is just one organism in all cases of conjoined twinning. Why might this be concerning? The issue might be that the accounts discussed here lack the resources to discriminate between cases of conjoined twinning, since the features appealed to in arguing that there is one organism in the cases discussed so far are present in every case. But in fact, cases of conjoined twinning can vary with respect to these very features. Most importantly, they can differ with respect to the degree of vascular fusion. In some cases, vascular fusion is superficial, resulting in no significant cross-circulation—which makes a difference to the extent to which the parts of the conjoint particular interact and form an integrated whole.

Take omphalopagus twinning, involving fusion at the lower abdomen. Internal anatomy varies, but in one reported case there was fusion at the liver and pericardium with no major vascular fusion, making it intelligible to talk of a ‘sharp line of demarcation’ between the twins (Hilfiker et al. 1998). In a case like this, substances circulating in one twin have no significant effects on the other—so, the activities of parts on the left and right do not significantly interact. So, a minimal condition for these parts being metabolic collaborators is not met, and the conjoint particular is not a metabolic whole. If we assume in addition that there is no fusion of the lymphatic system in this case, then it’s also plausible that the conjoint particular would not be an immunological whole. Immune receptors produced by each twin would tolerate the other’s tissue locally, at the site of fusion, and some immune receptors would inevitably be transferred from one twin to the other. But if this transfer were negligible, it might not amount to a systematic surveillance of the whole conjoint particular—the degree of interaction between immune receptors produced on one side and the parts of the other would presumably be much less than is typical. So, it might make sense to regard this as a case in which there are two distinct, if not entirely closed, systems of immune receptors, each with a more local jurisdiction. If physiological accounts count one organism in this case, then evolutionary accounts which appeal to physiological features will likely do so too.

Of course, where exactly a given account will draw the line between one- and two-animal cases will turn on difficult questions about the degree of interaction required for metabolic collaboration, and when immune interactions become systemic, answering which is beyond the scope of this paper. Moreover, since cases lie on a continuum with respect to these features, the relevant differences being ones of degree, rather than kind, on any account there may be a range of cases in which it is indeterminate whether we are faced with one organism or two. But since cases of conjoined twinning differ with respect to features that matter for organismic individuation on the accounts discussed here, with some cases involving a great deal more immune and metabolic interaction than others between parts of the conjoint particular, these accounts do have the resources to discriminate between one- and two-animal cases of conjoined twinning.

It should be acknowledged, though, that the line between one- and two-animal cases is unlikely to be found where we might naturally draw it—and perhaps this, really, is the concern behind the overgeneralisation worry. After all, it is quite counterintuitive to claim that there is only one animal in thoracopagus twinning, which appears relatively superficial. Here, I think common sense counts two animals. And one might object that these arguments threaten a raft of even more counterintuitive consequences. For instance, Peter van Inwagen (1990, p 59) imagines a case in which identical twins Alice and Beatrice each have a hand cut off and are then surgically fused at the wrist. Since the arguments here do not turn on how conjoined twins come to be, but on what they are like, they ought to be applicable to this case. As before, what we should say about the conjoint particular would turn on its underlying physiology—but it is at least conceivable that such an operation could result in significant cross-circulation of blood and immune receptors. If it did, then the conjoint particular’s parts would be functionally integrated metabolic collaborators, regulated by systemic immune interactions—and

we would have to say that the conjoint particular was an organism, and Alice and Beatrice were not.

This would be surprising, but it's less than obvious that this is a consequence we should be trying to avoid, particularly since nature does sometimes create one organism from two by anastomosing vascular systems. Take the golden star tunicate *Botryllus schlosseri*, a colonial marine animal which grows on submerged objects. In *Botryllus schlosseri*, zooids a few millimetres wide, each with a heart and stomach and surrounded by a membrane, form clusters connected by a structure called the 'tunic', providing a common vascular system. When two of these clusters meet, their vasculature can fuse together to create a larger colony, or not, depending upon the immune interactions between them. Since these interactions occur at the level of the colony rather than the zooids, Pradeu (2010, p 261) suggests that the entire colony is an organism. If the shared vasculature makes the zooids metabolic collaborators, then the metabolic account would say the same. Van Inwagen's case, if it is analogous in the relevant ways, merits analogous treatment.

More generally, counterintuitive results are a problem only if we think that our intuitions about how many organisms there are ought to be respected in this context. But there are good reasons to suspect that our intuitions are wrong here. Our intuitive judgments about the number of organisms are informed by perceptually salient cues, like surface morphology. The more it strikes us that we are looking at two human body plans, the more we are convinced that we are looking at two human organisms. Ordinarily, morphology is an excellent guide to the number of organisms: more often than not, where we find a complete human body plan, we find a functional, immunological and metabolic unit. But in conjoined twinning, morphology and physiology diverge in surprising ways—and it is surely physiology, rather than morphology, which determines how many organisms there are. Unless we are prepared to reject the picture of an organism as a functionally integrated physiological whole, a picture common to both physiological and evolutionary accounts of the organism, we must simply accept that in cases where physiology departs from the superficial features on which our intuitive judgments are based, our intuitive judgments are likely to be wrong: although there are both one- and two-animal cases of conjoined twinning, common sense cannot locate the boundary between them.

7 What we are

How, then, does conjoined twinning bear on the question of what we are? Campbell and McMahan (2010, 2016) take dicephalus to be a counterexample to animalism: a case in which there are two of us, but only one animal. The animalists cited in this paper have attempted to resist this by arguing that dicephalus involves more than one animal—either in all actual cases (Olson 2014; Snowdon 2014), or in all possible cases (Blatti 2007; Liao 2006). I have shown that this response is unavailable: in some, if not all, actual cases, there is only one animal. So, animalists can accommodate dicephalus only by saying that it involves one of us.

Campbell and McMahan take this to refute animalism: they take it to be evident that there are two of us in dicephalus, since each twin has her own private mental life, character and sensations (2016, p 230). Less question-beggingly, we might say, the psychological states and processes occurring in dicephalus are not unified in the manner typical for individuals of our kind, apparently forming two discrete mental systems, rather than one. The states and processes within each system are encapsulated from those in the other: for instance, the beliefs in one system do not collaborate with the desires in the other to generate behaviour, as the beliefs and desires of a single individual typically do. But as Olson (2014, pp 29–30) argues, these psychological facts establish that there are two of us only on the assumption that our individuation conditions are psychological: that is, that the number of us is determined by the number of mental systems. This assumption, if granted, is sufficient to refute animalism by itself, without the assistance of conjoined twins. It is simply a consequence of animalism that if a human organism can house multiple mental systems, then individuals of our kind can be, in this sense, psychologically divided.

I consequently do not take myself to have revealed that the possibility of such psychological division is a startling consequence of animalism. Rather, I have shown that if animalism is true, such psychological division is not merely possible, but actual—and that this is not a consequence any animalist can resist. If there is a surprise in the vicinity, it is just how common animalists must take this phenomenon to be. As I've argued, it seems likely that the 'one animal' verdict will be appropriate in a great many other cases of conjoined twinning—including thoracopagus, the most common variety. In any one-animal case of conjoined twinning involving two functioning brains, animalists will have to count a single, psychologically divided member of our kind.

Cephalopagus presents a different problem. Campbell and McMahan (2016, p 249) take this to be a case of two animals sharing a cerebrum. If thinking is localised to the cerebrum, they think, this will be a case of two animals but only one of us. Animalists, though, must say that if there are two animals, there are two of us—and since neither has a better claim to the cerebrum than the other, the two must share a cerebrum. This means that there are two thinkers for every thought in cephalopagus—so, animalists have a 'too many thinkers' problem.

An account of our nature has a too many thinkers problem when it indicates that two spatially coincident or overlapping particulars are thinking the same thoughts, where common sense counts only one thinker. A familiar argument against psychological continuity views, for instance, is that they entail that each of us is non-identical with the animal with which we're coincident—but that if animals can think, this implies that there are two distinct thinkers where each of us is. The proliferation of thinkers in such cases is metaphysically unappealing. It also gives rise to an epistemological problem: since the thinkers in too many thinkers cases think all of the same thoughts, it seems impossible for either to know which of the thinkers they are. A standard response to too many thinkers problems is to exclude one thinker on the grounds either that things of its kind don't exist, or that things of its kind don't think. But the too many thinkers problem presented by cephalopagus does not permit that response, since both of the thinkers are of the *same* kind—they

are both animals. Since animals are already committed to the claim that animals exist, and can think, they cannot exclude either thinker on these grounds. So, cephalopagus presents a too many thinkers problem worse than those facing other parties to the personal identity debate (Campbell and McMahan 2016, p 251). I'll call this the 'too many thinking animals' problem.

I have shown that cephalopagus, like dicephalus, is a single animal—so, animalists can, like everyone else, describe cephalopagus as just one of us. So, cephalopagus does not divide animalism from its rivals, and does not motivate rival views of our nature. More broadly, this argument suggests that animalists may not be vulnerable to the too many thinking animals problem. For a too many thinking animals problem to arise, there must be two overlapping animals, apparently thinking the same thoughts, which are not entirely spatially coincident—since if they are entirely coincident, grounds for thinking that they are distinct will be lacking. In cephalopagus, where it looked as though there were two overlapping but non-coincident organisms, appearances turned out to be deceptive. The 'two animals' were entirely coincident, and so only one after all.

It seems likely that the same will be true in any case where it appears that two animals overlap sufficiently to think the same thoughts: when the criteria of inclusion are applied, they will reveal these 'two' to be entirely coincident, and so only one after all. Plausibly, any putative case of two animals sharing a cerebrum will deliver this result, since conjoined twinning involving the brain results in significant cross-circulation. I don't know how to show that this goes for all possible cases of shared-cerebrum twinning. But even if it doesn't, I have shown that a 'too many thinking animals' problem is harder to generate than Campbell and McMahan appreciate. To establish that animalism has such a problem, its opponents must show that it is possible for one animal to share its thinking parts with a second, without either animal's non-thinking parts becoming entangled in the life processes of the other such that 'they' constitute a single animal.

8 Conclusion

Existing discussions of dicephalus and cephalopagus claim either that dicephalus comprises one organism and cephalopagus two, or that both comprise two fused organisms. Drawing on both physiological and evolutionary accounts of the organism, which treat an organism as a physiological whole and treat as parts of the organism anything with which it is appropriately physiologically integrated, I have argued that this is a mistake. Dicephalus, cephalopagus, and many other instances of conjoined twinning produce a single, atypical human organism.

This shows that both animalists and their critics have been mistaken about the significance of conjoined twinning for the personal identity debate. Dicephalus does indeed commit animalists to the existence of psychologically divided individuals, contrary to some animalists' claims. But cephalopagus fails to motivate rival views of our nature, as Campbell and McMahan allege. More generally, animalists have at their disposal a reply to the 'too many thinking animals' problem described by Campbell and McMahan: given that an organism is a physiological *whole*, any two

human animals with overlapping thinking parts are likely, in fact, to be one. So, as far as ‘too many thinkers’ problems go, conjoined twinning leaves animalists no worse off than their rivals.

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