

What makes a medical intervention invasive?

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ABSTRACT

The classification of medical interventions as either invasive or non-invasive is commonly regarded to be morally important. On the most commonly endorsed account of invasiveness, a medical intervention is invasive if and only if it involves either breaking the skin ('incision') or inserting an object into the body ('insertion'). Building on recent discussions of the concept of invasiveness, we show that this standard account fails to capture three aspects of existing usage of the concept of invasiveness in relation to medical interventions—namely, (1) usage implying that invasiveness comes in degrees, (2) that the invasiveness of an intervention can depend on the characteristics of the salient alternative interventions, and (3) that medical interventions can be invasive in non-physical ways. We then offer the beginnings of a revised account that, we argue, is able to capture a wider range of existing usage. Central to our account is a distinction between two properties: *basic invasiveness* and *threshold invasiveness*. We end by assessing what the standard account gets right, and what more needs to be done to complete our schematic account.

INTRODUCTION

Medical interventions are frequently classified as either invasive or non-invasive. The invasiveness of a medical intervention is commonly regarded to be morally important due to the implicit or explicit value judgements that accompany the terms 'invasive' and 'non-invasive'.^{1,2} It is often thought, for example, that non-invasive medical interventions should be preferred over invasive medical interventions, other things being equal.^{3,4}

In many cases, the classification of medical interventions as invasive or non-invasive is based on

The Standard Account. A medical intervention is invasive if and only if it involves either breaking the skin (henceforth sometimes 'incision') or inserting an object into the body ('insertion').

In some cases, this account is adopted implicitly. In others, it, or something very close to it, is made explicit,^{5,6} for example, the Oxford English Dictionary defines an invasive medical intervention as 'a diagnostic or therapeutic procedure in which the skin is broken (e.g. with a surgical blade or syringe), or an instrument is introduced into a body cavity'.⁷ Conversely, non-invasive medical interven-

tions are those diagnostic or therapeutic procedures that do 'not require the insertion of instruments (often including hypodermic needles) through the skin or into a body cavity'.^[ii]

Although the standard account is commonly encountered, it does not capture all uses of the term in relation to medical interventions. Consider two examples. First, medical procedures that are invasive according to the standard account are sometimes described as non-invasive. The diagnostic tools collectively called non-invasive prenatal testing exemplify this. This form of testing relies on the analysis of blood drawn from the pregnant woman and can detect a wide range of (hereditary) conditions.⁸ As the name clearly indicates, this form of testing is considered non-invasive, even though it involves piercing the skin with a needle to retrieve a blood sample. This suggests that the standard account is mistaken in taking incision and insertion as sufficient for invasiveness. Second, some medical interventions that do not involve breaking the skin or inserting instruments are nonetheless described as invasive. An example is electroconvulsive therapy (ECT), which involves administering an electric current to the brain.⁹ The skin remains intact throughout the procedure, and it does not involve the insertion of an object. Nevertheless, ECT is sometimes described as invasive.^{10–13} [iii]

this spatial definition of invasiveness: off-target effects, effects of an intervention spreading to other areas of the body. However, this understanding of invasiveness is not normally used for medical interventions. Instead, it is often used in the field of pathology and in relation to microorganisms and patterns of cancerous growth. Therefore, we leave this definition aside in our discussion on the invasiveness of medical interventions.

ⁱⁱTwo technical clarifications are in order. First, we take 'non-invasive' to be equivalent to 'not invasive'. Thus, the second quote, stated as a sufficient condition on non-invasiveness, is logically equivalent to a necessary condition on invasiveness (we are also simplifying and assuming that inserting an instrument through the skin is the same as breaking the skin). Second, though the Oxford English Dictionary makes mention of insertion into a *body cavity*, we have not included this in the standard account. We suspect that most would accept our broader category of inserting an object into the body, which includes, but is not limited to, the insertion of an object through a body cavity. We remain neutral on whether merely inserting an object into a body cavity—for example, inserting a toothpick a short distance into someone's nostril—is sufficient for insertion.

ⁱⁱⁱAs a reviewer helpfully noted, someone could respond by pointing out that the energetic stimulation is physical and is thus a physical incursion in to the brain. We agree. However, the standard account cannot clearly make sense of this, insofar as the stimulation plausibly involves neither an incision, nor an insertion of an object into the body. In order to accommodate the claim that such interventions are (physically) invasive, we need to add something else to the account; and determining what this further ingredient

ⁱIn the medical context, the Oxford English Dictionary includes a second definition on invasiveness that focuses on spread into adjacent tissues. See also Davis & Van Koningsbruggen¹⁴ for their use of this second definition to reassess non-invasiveness of non-invasive brain stimulation techniques. Elsewhere, Davis⁴⁴ again refers to

This suggests that the standard account is mistaken in taking the disjunction of incision or insertion as necessary for invasiveness.

This divergence between uses of the term and the standard account, as well as further differences we mention below, suggests that the standard account is not an apt candidate for making sense of our uses of the term and may not be capturing what individuals have in mind when using the term. In order to do this, we will need to move beyond the standard account.

In this article, we revisit and revise the standard account. This account has already received critical attention in the small body of literature on invasiveness, and some authors have made initial moves towards revising it.^{2–4 14–16} Here, we attempt to go one step further and develop a fuller schema for a revised account that avoids some of the problems faced by the standard account. We begin by outlining three respects in which existing usage of the concept of invasiveness deviates from the standard account. First, the term is sometimes used in ways implying that invasiveness comes in degrees; for example, an intervention can be more or less invasive. Second, whether an intervention is considered invasive can depend on the characteristics of the salient alternatives. Third, some medical interventions can be invasive in non-physical ways; for example, talking therapy. Insofar as the standard account is intended to capture existing usage, these deviations constitute problems for the account. We then offer the beginnings of a revised account that would avoid these problems. In recognition of its incompleteness, we refer to our proposal as a schema or schematic account. Our schema involves distinguishing various subtypes of invasiveness. We end by assessing what the standard account gets right, and what more needs to be done to complete our schematic account. Our overarching aim is to clarify the concept of invasiveness, as it applies to medical interventions, that is implicit in the existing usage. We hope that this clarification might serve as a basis for further conceptual and normative work which might explore, for example, what moral significance a medical intervention's invasiveness has, and whether existing usage of the term ought to be altered.

Our discussion will focus on cases that would uncontroversially count as medical interventions, but what we say should apply more broadly, including, for example, the administration of risk assessment questionnaires in psychiatry, public health measures such as quarantine and nursing procedures such as cleaning and dressing a wound.

THREE DEVIATIONS FROM THE STANDARD ACCOUNT

The examples of non-invasive prenatal testing and ECT given in the introduction indicate a mismatch between the standard account and the way in which the terms 'invasive' and 'non-invasive' are actually used in relation to medical interventions. The conditions offered by the standard account are neither necessary nor sufficient for invasiveness, as the term is in fact used. We propose that there are at least three important aspects of how these terms are used that are not captured by the standard account. First, the standard account does not capture the idea, implicit in how the terms are used, that invasiveness comes in degrees. Second, the standard account does not capture the context-sensitivity of 'invasive' (or sentences of the form 'X is invasive'), such that whether it is true that an intervention is

is will be a difficult matter. One could insist that the stimulation involves inserting particles into the body, and particles are objects. But we think this would be overly broad, and would face issues. For example, the television set in a hospital waiting room could, for similar reasons, be said to insert photons, and thus objects, through individuals' corneas. But we suspect that this would not be considered invasive.

invasive depends on the characteristics of alternative interventions. Third, the standard account does not capture the idea, implicit in some usage of the term, that medical interventions can be invasive in non-physical ways.

Degrees of invasiveness

An intervention either meets the necessary and sufficient condition offered by the standard account or it does not; on this account, interventions are either invasive or non-invasive. Often enough, usage conforms to this binary characterisation, as, for example, with the categorical distinction between invasive brain stimulation—such as deep brain stimulation (DBS)—and non-invasive brain stimulation—such as transcranial brain stimulation.^{5 17 18} Similarly, different forms of medical ventilation are understood to be either invasive—for example, tube ventilation—or non-invasive—for example, mask ventilation.^{19 20}

As others have pointed out, however, in other instances 'invasiveness' is used in a way that implies that invasiveness comes in degrees.^{14 15}^[iv] For example, it is quite common to describe one medical intervention as more or less invasive than another.² Open abdominal surgery is taken to be *more* invasive than laparoscopic surgery,²¹ and optogenetics using nanoparticles is deemed *less* invasive than optogenetics using brain implants.^{22 23} Such comparisons can naturally be understood as suggesting that the two interventions being contrasted differ in the degree to which they are invasive, and that one is invasive to a greater degree than another.

Another sort of use suggesting that invasiveness can come in degrees involves qualifications of the term. A phrase frequently encountered in relation to various medical interventions is 'minimally invasive'; for example, 'minimally invasive surgery',²⁴ 'minimally invasive blood glucose monitoring',²⁵ and 'minimally invasive optogenetics'.²⁶ Similarly, medical interventions are sometimes referred to as highly, fairly or somewhat invasive.^{27–30} Such terminology clearly suggests that an intervention can be not only invasive or non-invasive but that it can also be invasive to different degrees.⁴

Context-Sensitivity

Reflecting on qualifications of the term 'invasive' also highlights a further way in which some usage of the term deviates from the standard account. Whether an intervention is seen as highly, moderately or minimally invasive often seems to depend on what alternatives we consider. For example, intubation for ventilation is usually referred to as invasive, while the insertion of a tube for gastrointestinal or gynaecological endoscopy is typically referred to as minimally invasive.^{31 32} The standard alternative for endoscopy would be surgery, while that for tube ventilation would be mask ventilation.

Furthermore, sometimes which alternative interventions are considered affect not only whether an intervention is taken to be minimally, moderately or highly invasive but also whether the

^{iv}Glannon¹⁵ objects to the binary distinction between 'invasive' and 'non-invasive' medical interventions in psychiatry, noting that some interventions described as non-invasive on grounds that they do not involve surgical interference ought to be described as invasive since they alter brain function. He argues that we should instead distinguish between 'less and more invasive interventions', 'where the degree of invasiveness corresponds to the extent of changes the intervention induces in the brain'. See also Davis & Van Koningsbruggen¹⁴ (p1). We, too, acknowledge that medical interventions are frequently described in the literature to be invasive to different degrees. However, we also recognise that referring to the invasiveness of an intervention in binary terms is consistent and commonplace. As we will show, our schema allows for both sorts of uses, rather than recommending a rejection of one or the other.

intervention is taken to be invasive *at all*. This can be illustrated by comparing an example from above—non-invasive prenatal testing—to a blood draw for blood glucose analysis of a diabetes patient. Both of these procedures require an intravenous blood draw done in hospital by a medical professional. However, while the former is referred to as a non-invasive form of prenatal testing, the latter is considered to be an invasive form of blood glucose monitoring.^{25 33 34} Despite the fact that the blood draws are identical interventions, they are labelled differently in terms of invasiveness. We suspect that a difference in the salient alternatives could explain the apparent inconsistencies in labelling in this case. Non-invasive prenatal testing is regarded as such in virtue of the salient alternatives for prenatal testing—that is, amniocentesis and chorionic villus sampling. These alternatives require a sample of amniotic fluid and a sample of tissue from the placenta, respectively. In contrast, glucose monitoring via a blood draw may be seen as invasive when compared with the chief alternatives: namely, finger prick, subcutaneous micro-sensor, and radiation and electromagnetic wave technology.

According to the standard account, an intervention's invasiveness depends on the nature of *that* intervention only. Yet in existing usage, an intervention's invasiveness is not purely a matter of the features intrinsic to that medical intervention; the nature of the alternatives we consider seems to matter as well.

Non-physical invasiveness

According to the standard account, a medical intervention is invasive only if it involves a physical intrusion into the body, that is, breaking the skin or inserting an object into the body. However, interventions are sometimes characterised as invasive even though they involve no physical intrusion, especially when they affect highly personal and sensitive parts of a person's mental life.³⁵ For example, psychotherapy has been described as invasive, despite a complete lack of physical contact: '[p]schotherapy, while not physically invasive, can be personally invasive' (p316).³⁶

The notion that medical interventions can be seen as invasive in non-physical ways is also supported by the findings of the empirical interview study by Bluhm and colleagues.³ They found that interventions were perceived to be invasive in different ways, including 'emotionally' or 'psychologically invasive'—as with psychotherapy, 'which requires talking about one's thoughts and emotions with a therapist' (p5)—or 'lifestyle invasive', for example, by requiring repeat appointments or long-term commitment, or by disrupting patients' daily routines. Participants in Bluhm and collaborators' study³ illustrated the idea of non-physical invasiveness when comparing psychotherapy to other neurointerventions, such as DBS: 'I think that medically and physically DBS is more invasive. But it doesn't really go into a patient's personal thoughts or inner self, so I think in that sense it's less invasive than psychotherapy' (p4). A similar sentiment is put forward by Iwry and collaborators³⁷: '[a]ny direct interference with neural activity, even beneficial, might be described more accurately as 'minimally invasive'... the fact that it [non-invasive brain stimulation] does not break the skin does not mean, figuratively speaking, that it cannot cross other important personal boundaries' (p2). These other, non-physical ways in which an intervention may be invasive are not captured by the standard account.

Psychotherapy provides us with an example of an intervention that may be invasive in terms of its effects on the mind.⁴ Yet matters are somewhat more complicated with interventions that act on the brain in a more direct way but are, like psychotherapy, intended to affect patients' mental states. For instance,

some interventions that involve neither incision nor insertion are sometimes considered non-invasive though they do have direct effects on the brain intended to yield effects in the patient's psychology. Consider transcranial direct current stimulation and transcranial magnetic stimulation. These interventions are often considered to be non-invasive, though we suspect that they may sometimes be taken as such because speakers are relying on the standard account, and the corresponding conception of physical invasiveness.^[v] In a recent study on the use of 'invasive' in neuroethical debates about neurotechnology, Collins and Klein³⁸ claim that neuroethicists seem to mainly be sticking to a physical notion of invasiveness—which, as they describe it, may be captured by the standard account—and for this reason may not be thinking of such interventions as invasive. Referencing Bluhm *et al.*,³ they suggest that in doing so, neuroethicists may be missing out on non-physical forms of invasiveness that end users of such technologies take to be important (see, especially,³⁸ pp8–11). And in a response to Bluhm *et al.*,³ the need to include and explore the significance of non-physical conceptions of invasiveness is also argued for by Lighthart and collaborators.³⁹

Taking stock

Invasiveness is sometimes used in scalar, context-sensitive and non-physical ways. None of these uses can be captured by the standard account. The logical form of the standard account, stated as a necessary and sufficient condition on an intervention being invasive, prevents it from capturing uses of the term involving degrees. The fact that the standard account refers to features of the putatively invasive intervention only, not to alternative interventions, prevents it from capturing uses that depend on those alternatives. The focus of the standard account on incision or insertion prevents it from capturing non-physical forms of invasiveness. In the next section, we offer the beginnings of an alternative account that could capture these uses. Since what we offer is only a partial account, we will refer to it as a new 'schema' for thinking about invasiveness.

A NEW SCHEMA

We can begin by focusing on two of the ways in which 'invasiveness' is sometimes used that are not captured by the standard account: (1) it is sometimes used in a way that implies that invasiveness comes in degrees—such that an invasive intervention can be more or less invasive and (2) it is sometimes used in a way that is sensitive to contexts, in at least two respects: (a) whether the intervention is thought to be minimally, moderately or very invasive can depend on which alternatives we have in mind and (b) whether an intervention is deemed to be invasive or not can depend on which alternatives we have in mind.^[vi] We propose to illuminate these features of usage of the term 'invasive' via an analogy with other terms that share some of these features: what

^vHowever, it seems to us that these interventions may also be *physically* invasive. To see why, recall our example of ECT above, which often is taken to be invasive. If ECT is physically invasive, despite the fact that it involves neither incision nor insertion, then it suggests that there is some further criterion to physical invasiveness not captured by the standard account. Whatever this criterion is, it may also be present in the cases of transcranial direct current stimulation and transcranial magnetic stimulation. If people would take such interventions to be invasive even in cases that do not directly change subjects' mental states, then it is plausible that they are also physically invasive.

^{vi}For our purposes, we wish to leave open what sets the relevant comparison class in a given context. We are not convinced, however, that the only relevant interventions in a comparison class are always the available alternatives to that intervention, in a given context.

are often called positive adjectives—for example, ‘tall’, ‘long’ and ‘strong’—and their corresponding comparative adjectives—for example, ‘taller than’, ‘longer than’ and ‘stronger than’.^{vii]}

Consider, for instance, how we use ‘length’ and the related terms ‘long’, ‘short’, ‘longer than’ and so on. Some of these terms can be used in a binary way—for example, an object can be either long or not long. Yet length-related terms can also be used in comparisons which imply degrees; an object can be longer or shorter than something else. We can make explicit comparative statements along these lines; for example, Kazuo Ishiguro’s *Klara and the Sun* (352 pages) is longer than Harry Frankfurt’s *On Bullshit* (80 pages).

In addition, our use of some length-related terms is not sensitive to contexts. The truth of ‘*Klara and the Sun* is 352 pages long’ does not depend on the length of other things, nor does the truth of ‘*Klara and the Sun* is longer than *On Bullshit*’. Yet the truth of some length-related claims can be. For instance, a two-metre-long alligator is long, when compared with all animals in the Everglades, but not when compared only with other alligators. Similarly, whether an object is moderately long or very long can depend on alternatives considered. A sixty-page article is very long, when compared with articles in philosophy journals, but only moderately long when compared with articles in American law reviews.

We can make sense of these different uses of length-related terms by appealing to some underlying property that objects can have: namely length. Some things—like this article—have a length. Other things—like justice—do not. If something has length, its length can come in differing magnitudes; for example, an object can be a centimetre, a metre or a kilometre long, and a book can be 10 000, 30 000 or 150 000 words long. And something can have a length without being considered long; a 500-word paper has a length, yet we would not consider it long. This is because, as the terms are often used, whether ‘is long’ applies depends on how its length compares to some comparison class.

Similarly, we want to suggest, we can make sense of different ways of talking about invasiveness in virtue of some underlying context-insensitive property; an analogue of length. We will refer to it as *basic invasiveness*. Medical interventions can possess a greater or lesser amount of basic invasiveness, and we can understand one intervention as being more invasive than another in virtue of the first intervention possessing more basic invasiveness. Assuming that incision and insertion are relevant to invasiveness, it may be that, other things being equal, an intervention which involves a larger cut will be more invasive than an intervention involving a smaller cut, and an intervention which involves a deeper insertion will be more invasive than an intervention involving a shallower insertion.

Relatedly, whether an intervention is invasive or not depends on whether its level of basic invasiveness lies above some threshold, which might be zero, but could be greater. This would be analogous to uses of ‘long’: whether something is long or not depends on whether its length crosses some threshold which can vary with the context. For the sake of clarity, we, henceforth, sometimes refer to this kind of invasiveness as *threshold*

invasiveness. The location of this threshold, and, thus, whether an intervention qualifies as threshold invasive, can, at least in some cases, depend on what we are comparing it to. Recall the example of non-invasive prenatal testing that is described as non-invasive even though it requires a blood draw, whereas a blood draw for blood glucose analysis is described as invasive. Although both interventions involve some—plausibly the same—amount of basic invasiveness, only one of these passes the threshold set, at least partly, by its comparison class. Similarly, whether an intervention is minimally, moderately or very invasive will depend on whether its level of basic invasiveness lies in some particular range, and the ranges of basic invasiveness picked out by these terms can be affected by the features of the relevant comparison class; recall that gastrointestinal endoscopy is often described as *minimally* invasive, while endotracheal ventilation is not.

Before getting into more detail, we think it is worthwhile to point out some features and implications of this model as well as some of the places in which the analogy with ‘long’ and related terms breaks down.

Consider the following three claims:

- i. A is more invasive than B.
- ii. A is invasive.
- iii. A has some amount of basic invasiveness.

On our model, (i) entails (iii); if A is more invasive than B, then A needs to have *some* amount of basic invasiveness. Similarly, (ii) entails (iii); if A is invasive, then it has to have *some* amount of basic invasiveness. The ‘invasive’ in (ii), we think, can be understood as our threshold invasiveness.

However, notice that (iii) does *not* entail (ii). An intervention—like non-invasive prenatal testing—can have some amount of basic invasiveness without thereby being threshold invasive, in virtue of the fact that it does not pass the relevant threshold.

Similarly, (i) does not entail (ii) either. What needs to be the case for (i) to be true is that (iii) is true, and that A has a higher level of basic invasiveness than B (which may be zero). The truth of sentences of this form, as we suggested, is not affected by other alternatives we are considering. On the other hand, (ii), as we understand it, makes a claim about threshold invasiveness, and is sensitive to the alternatives considered in that context. It can be true that non-invasive prenatal testing is non-invasive even though it has some level of basic invasiveness, and indeed more basic invasiveness than some other interventions—for example, applying a bandage—because its level of basic invasiveness falls below the relevant threshold. This coheres with the analogy with ‘long’ and related terms. Although *Klara and the Sun* is longer than *On Bullshit*, neither would be considered long when compared with history books.

There are, however, places in which the analogy with ‘long’ and related terms breaks down.

First, notice that regardless of what finite object we are talking about, and what finite length it has, the claim that it is long might be true when it is compared with some alternatives and not others. For any finite object that is long in one context, we might imagine another context in which it is not long, given that there is no upper limit to length.^{viii]} However, some claims regarding whether a medical intervention is invasive may remain true (or false) whatever the comparison class. We find it difficult

^{vii}Strictly speaking, the adjectives given in these examples are often called *explicit comparative adjectives*, and contrasted with *implicit comparative adjectives*—eg, ‘is tall compared with’, ‘is long compared with’, etc. There are competing accounts of the semantics of positive adjectives and their corresponding comparative adjectives, see, for example.^{45–48} However, as we will see later, the analogy between variations of ‘invasive’ and these other sorts of terms break down in some places. Thus, we do not think those semantics will clearly work for ‘invasive’, as we understand it.

^{viii}To be clear, here we are thinking of logical possibility.

to imagine a comparison class which would make it such that open-heart surgery is not invasive. Thus, at least one version of (ii)—for example, ‘open-heart surgery is invasive’—may be true regardless of which alternatives we are considering.^[ix] Furthermore, whether an intervention is *minimally* or *highly* invasive does not seem to always depend on alternatives considered. It may be that a micropick for blood glucose analysis mentioned above, for example, will never be more than minimally invasive, regardless of what the comparison class is.^[x] That is, the context-sensitivity of ‘invasive’ (and related terms) seems to be limited in a way that the sensitivity of ‘long’ (and related terms) is not.

Another thing to notice is that, unlike length, basic invasiveness will be a function of multiple factors. In this particular respect, it is more like an object’s volume, which is a function of extension across three dimensions, or an organism’s health, which is a function of many factors. Consider, for the moment, the analogy with health. Though there are, of course, many disanalogies between invasiveness and health, we wish to emphasise that our analogy rests merely on the fact that health is a function of multiple factors. A human being’s health is determined by a variety of factors—for example, freedom from pain, ability to perform everyday activities and good functioning of one’s internal organs and systems. Supposing that the standard account is right at least in suggesting that incision and insertion are relevant to invasiveness, we have at least two factors that affect basic invasiveness. Another potential determinant may be harm-based: an intervention’s invasiveness may be affected by either actual harm, risk of harm or harm typically associated with interventions of that type. Harm-based considerations have been mentioned in relation to interpreting the concept of invasiveness by others as well.^{4 14 15 40 41}^[xi]

Furthermore, notice that two humans can have equal health even if they differ drastically in those health-determining features. For example, a human experiencing chronic pain but able to perform all everyday activities can be just as healthy as a human with no pain and limited functional abilities. Similarly, two medical procedures may be equally invasive and have the same amount of basic invasiveness, while differing in those features of which basic invasiveness is a function. For example, an intervention involving a large cut, but which stays relatively close to the surface, may be just as invasive as an intervention involving a smaller cut that goes deeper.

The discussion thus far, we think, can help to make sense of the fact that ‘invasive’ is sometimes used in a binary way, but sometimes in a graded way; and that it is sometimes used in a

way that makes the truth of the sentence sensitive to contexts, and sometimes in a way that does not.

PHYSICAL AND NON-PHYSICAL INVASIVENESS

So far, we have shown how our schema can accommodate talk of degrees of invasiveness by acknowledging greater or lesser amounts of basic invasiveness. We have also shown how our schema can accommodate the fact that some ascriptions of invasiveness as well as some qualifications—for example, minimally, moderately and very—depend on alternatives considered. This also helps us to avoid some apparent problems faced by the standard account; for example, its inability to accommodate the claim that non-invasive prenatal testing is not invasive, even though it has some amount of basic invasiveness. With respect to this last point, what helps us to avoid this issue is the fact that we do not take incision or insertion as *sufficient* for threshold invasiveness.

We also think that this model can accommodate a further feature of existing usage: that invasiveness is sometimes used in reference to mental, rather than physical, intrusions. Consider again the analogy with health. Above, we mentioned some factors that determine health: pain, ability to perform everyday activities and organ functioning. These are determinants of the kind of health that we sometimes refer to as ‘physical health’. But there is another kind of health—mental health—which has a different, though perhaps overlapping, set of determinants. For example, limited mobility is plausibly directly relevant to physical health but not directly relevant to mental health; while depressed mood is plausibly directly relevant to mental health but not directly relevant to physical health.

Similarly, we suggest that one can distinguish at least two subtypes of basic invasiveness—physical and mental—and that these will be functions of different, though perhaps overlapping, features. For example, the size and depth of an incision or insertion are plausibly relevant to the basic physical invasiveness of an intervention. These, we think, will not be determinants of basic mental invasiveness.

Though we do not intend to give an exhaustive list, we can mention some plausible candidate determinants of basic mental invasiveness. With respect to particular states, we think some candidates include the number or proportion of a person’s mental states implicated in an intervention, the degree of any modification to those states and for relevant mental states, the location of the implicated states in the subject’s hierarchy of values. With respect to more holistic features, whether the intervention results in a disruption of mental functioning, whether it affects the overall coherence of an agent’s mental states or whether it results in, or risks, harm to the subject’s mental health are further features worth exploring. If any of these are determinants of mental invasiveness, then it is plausible that the *extent* of the disruption, effect on coherence or harm to subject’s mental health will be relevant as well.

CAN THE STANDARD ACCOUNT BE RECONCILED WITH OUR SCHEMA?

We have argued that the standard account fails to capture three aspects of how users of the term seem to be thinking about invasiveness in relation to medical interventions. We have also offered the beginnings of an alternative account that could capture these aspects. In this section, in the interests of charity to the standard account, we revisit the

^{ix}One possible explanation might be that though the location of the threshold is always set by alternatives, there is still some sort of limit on where it can be set, such that, for any possible location for that threshold (within limits), open-heart surgery is above that threshold.

^xThere may, however, be contexts in which the micropick is not invasive. We find it plausible that in such contexts, it is also not *minimally* invasive.

^{xi}Rudnick⁴ argues that the concept of invasiveness may be redundant and misleading in the clinical-ethical context, and he suggests eliminating notions of invasiveness from medical terminology, replacing notions of invasiveness with further detailed and defined notions of harm. Relatedly, Davis & Van Koningsbruggen¹⁴ have proposed to revoke the label ‘non-invasive’ from certain types of brain stimulation, arguing that the label unjustifiably implies that these interventions are associated with no or minimal (risk of) harm. Though we recognise that notions of harm could relate to the concept of invasiveness, we are not convinced that invasiveness could or should be equated to or replaced by notions of harm. Instead, we envision invasiveness as a multifactorial concept in which harm-based considerations could potentially be one factor.

standard account and consider whether and to what extent it can be reconciled with our schema.

Our analysis to this point makes clear that the standard account does not capture all existing usage of ‘invasive’. However, our analysis has also involved distinguishing various subtypes of invasiveness—for example, basic invasiveness and threshold invasiveness, physical invasiveness and mental invasiveness. This opens the door to the possibility that the standard account is adequate as an account of one or some of these subtypes.

To begin with, we could acknowledge that the standard account is an account only of physical invasiveness and is, thus, silent on mental invasiveness. Interpreting the standard account in this way allows a proponent of the account to avoid some of the problems that we identified above. If the account does not cover mental invasiveness, then talking therapy, though possibly mentally invasive, would not count as a counterexample to it.

The standard account also identifies two features of interventions that are plausibly relevant to physical invasiveness: incision and insertion. We find it plausible that both are determinants of basic physical invasiveness. If an intervention has either, then it has a non-zero amount of basic physical invasiveness; and, other things being equal, the more it has of one of them—for example, the greater the incision or deeper the insertion of an object into the body—the more basic invasiveness it has. This helps to account for much of the appeal of the standard account, and plausibly, many of our uses of ‘invasive’.

However, we do not think that these are the *only* determinants of basic physical invasiveness. We need to countenance more determinants in order to account for some interventions that are commonly regarded as invasive—and in a physical rather than mental way—though they involve no skin break or insertion. Examples would include exposing a person to X-rays or to a laser beam, and other authors give more examples.^{27 36 42 43}[xii] We suspect also that many would regard procedures that involve the mere *withdrawal* of an object—for example, withdrawal of a urinary catheter or nasogastric feeding tube—as physically invasive, though these too do not clearly involve a skin break or insertion. By claiming that invasiveness requires either insertion or incision, the standard account fails to account for the invasiveness of these interventions.

^{xii}For examples of others discussing this, or similar, points, see Ford and Deshpande³⁶: ‘The question then arises whether technologies like gamma knife, ultrasound, transcranial magnetic stimulation, or electroconvulsive therapy are invasive. They are not physically invasive in so far as they do not pierce the skin; however the radiation, sound and magnetic waves, and electricity all penetrate into the brain and can be invasive on a person’s life’ (p317). Fitz and Reiner⁴² on transcranial direct current stimulation (tDCS): ‘Although the electrodes do not penetrate the brain, the electrical current must do so, as otherwise it would have no effect on neural function. Thus, tDCS is minimally invasive *in some meaningful sense*’ (p411, italics in original). Cabrera *et al.*²⁷: ‘TMS [transcranial magnetic stimulation] and tDCS are often classified as non-invasive to emphasize their external nature. In this piece we refer to these two technologies as “minimally invasive”, in part to underscore the notion that they impose exogenous magnetic fields or electrical currents upon the brain, and can thus be considered at least somewhat invasive’ (p35). On MR-guided focused ultrasound and Gamma Knife Radiosurgery, Lipsman *et al.*⁴³ write: ‘there is no operation, no penetration of the skin, incisions or cranial openings, but it is nevertheless a permanent, ablative lesion made in key brain structures and pathways driving pathologic symptoms. How to reconcile then an operation that does not involve cranial access, but that nevertheless generates a permanent, irreversible brain lesion? Is this invasive or noninvasive?’ (p16)

Furthermore, the standard account faces problems in cases where an incision or insertion occurs, but the intervention is deemed not to be invasive. Recall one of our examples from above: non-invasive prenatal testing, which is typically regarded as non-invasive, even though it does involve a (small) break in the skin. Our schema, on the other hand, avoids this issue. Even if we accept incisions and insertions as determinants of basic invasiveness, and as sufficient for an intervention *having* basic invasiveness, our account does not imply that they are sufficient for threshold invasiveness, which is plausibly the type of invasiveness being denied in relation to non-invasive prenatal testing. By claiming that either insertion or incision is *sufficient* for invasiveness, the standard account fails with respect to these cases.

Finally, we think it is plausible that even with respect to the incision and insertion determinants, there is more to the story. Compare, for example, a one-centimetre incision on someone’s forearm to an incision of the same size on their eye. The latter, we suspect, would tend to be considered as more invasive than the former, but this cannot be explained by an appeal to the size of the incision. Or compare inserting a scalpel one inch deep into someone’s thigh to doing the same into someone’s throat. Again, we suspect the latter would be considered more invasive, yet this cannot be explained by an appeal to the depth of the insertion. If we are right on this, then either there is some further determinant that explains these differences, or the incision and insertion determinants themselves are qualified in some way or other.

CONCLUDING THOUGHTS AND FURTHER QUESTIONS

The failure of the standard account to provide anything more than a very incomplete account of physical invasiveness, the schematic nature of our own account, and the lack of any well-developed alternatives make one thing clear: there is much philosophical work yet to be done on invasiveness.

We think that one task to be addressed in this work is to specify in full the determinants of basic physical and mental invasiveness. However, there are a number of other important questions that also remain to be addressed.

One set of questions concern the relationship between physical and mental invasiveness. Can these be combined into a single metric of ‘overall’ invasiveness, rather as we might combine physical and mental health into a metric of overall health? And if so, are such comparisons always possible, or only in some contexts? Intuitively, it may seem strained to compare, say, the physical invasiveness of an appendectomy with the mental invasiveness of a session of Freudian psychoanalysis. But in other cases, comparing physical and mental invasiveness seems less problematic.

Suppose that we are considering two potential treatments for a mental disorder. Drug A is given by oral administration but has mental side-effects; for example, it can induce mild listlessness. Drug B, on the other hand, is administered via injection, but has no unintended effects on mental states. Given the injection required, drug B will typically be taken to be more physically invasive than drug A, but drug A is plausibly more mentally invasive than drug B, given its side effects. It is reasonable, we suggest, to trade off the greater physical invasiveness of drug B with the greater mental invasiveness of drug A, and to ask how the ‘overall’ invasiveness of each compares to that of the other. Or, suppose we are comparing two alternative psychiatric treatments for the same condition—say, pharmacotherapy

and DBS for depression. Suppose that both treatments are both physically and mentally invasive, though to differing degrees; the first has lower basic physical invasiveness than the second, and the second has lower basic mental invasiveness than the first. In this context, it seems to us legitimate to trade the greater mental invasiveness of one intervention off against the greater physical invasiveness of another in order to arrive at an assessment of overall invasiveness. We suspect that, given the very significant physical invasiveness of DBS, it is likely to come out much more invasive overall, despite the fact that it is less mentally invasive than the pharmacotherapy.

A second set of questions concern the context-sensitive uses of ‘invasive’. One question is whether there are reasons to resist such uses. It might be thought that, once we allow for explicit comparisons—as in ‘more invasive than’—it would be better to eschew context-sensitive uses. But, assuming that context-sensitive uses continue to be employed, a further question concerns how we should define the comparison class, or how a context picks out the relevant class—a difficult matter which we have studiously avoided addressing in this paper.

Finally, a third set of questions concern the normative significance of invasiveness. Does it matter morally whether, or the extent to which, a medical intervention is invasive? If so, when does it matter and why? And if not, might the concept nevertheless have some utility as a rough indicator of something that does matter morally, such as harmfulness, wrongfulness or restrictiveness? We leave these and many other questions as topics for future work.

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REFERENCES

- Buller T. Neurotechnology Invasiveness and the extended mind. *Neuroethics* 2013;6:593–605.
- Gaillard M. “Invasive” and “non-invasive” Technologies in Neuroscience communication”. *Bo* 2017;6:6.
- Bluhm R, Cortright M, Achtyes ED, et al. They are invasive in different ways.”: Stakeholders’ perceptions of the Invasiveness of psychiatric Electroceutical interventions. *AJOB Neurosci* 2023;14:1–12.
- Rudnick A. On the notion of (medical) Invasiveness. *Health Care Anal* 2011;19:99–106.
- Bikson M, Esmailpour Z, Adair D, et al. Transcranial electrical stimulation nomenclature. *Brain Stimulation* 2019;12:1349–66.
- MedlinePlus Medical Encyclopedia. Noninvasive. 2023. Available: <https://medlineplus.gov/ency/article/002269.htm> [Accessed 31 Jul 2023].
- Oxford English Dictionary. Invasive, Adj. Available: www.oed.com/view/Entry/98931 [Accessed 22 May 2023].
- Carbone L, Cariati F, Sarno L, et al. Non-invasive Prenatal testing: Current perspectives and future challenges. *Genes* 2021;12:15.
- Kellner CH, Obbels J, Sienaert P. When to consider electroconvulsive therapy (ECT). *Acta Psychiatr Scand* 2020;141:304–15.
- Philip NS, Sorensen DO, McCalley DM, et al. Non-invasive brain stimulation for alcohol use disorders: state of the art and future directions. *Neurotherapeutics* 2020;17:116–26.
- Rasmussen KG, Richardson JW. Electroconvulsive therapy in palliative care. *Am J Hosp Palliat Care* 2011;28:375–7.
- Trapp NT, Xiong W, Conway CR. Neurostimulation therapies. *Handb Exp Pharmacol* 2019;250:181–224.
- Watts BV. A time-out before every ECT treatment. *J ECT* 2016;32:224.
- Davis NJ, van Koningsbruggen MG. Non-invasive” brain stimulation is not non-invasive. *Front Syst Neurosci* 2013;7:1–4.
- Glannon W. Treating psychiatric disorders: less invasive and noninvasive interventions. In: Glannon W, ed. *Psychiatric Neuroethics: Studies in Research and Practice*. Oxford: Oxford University Press, 2018: 87–134.
- Cousins S, Blencowe NS, Blazeby JM. What is an invasive procedure? A definition to inform study design, evidence synthesis and research tracking. *BMJ Open* 2019;9:e028576.
- Bhattacharya A, Mrudula K, Sreepada SS, et al. An overview of noninvasive brain stimulation: basic principles and clinical applications. *Can J Neurol Sci* 2022;49:479–92.
- Lozano AM. Waving hello to noninvasive deep-brain stimulation. *N Engl J Med* 2017;377:1096–8.
- Guia M, Ciobanu LD, Sreedharan JK, et al. The role of non-invasive ventilation in Weaning and Decannulating critically ill patients with Tracheostomy: A narrative review of the literature. *Pulmonology* 2021;27:43–51.
- Perkins GD, Mistry D, Lall R, et al. Protocolised non-invasive compared with invasive Weaning from mechanical ventilation for adults in intensive care: the breathe RCT. *Health Technol Assess* 2019;23:1–114.
- Goto O, Koizumi E, Higuchi K, et al. Cutting-edge Technologies for gastrointestinal therapeutic Endoscopy. *J Nippon Med Sch* 2021;88:17–24.
- Chen S, Wu J, Cai A, et al. Towards minimally invasive deep brain stimulation and imaging: A near-infrared Upconversion approach. *Neurosci Res* 2020;152:59–65.
- Liu X, Qiu F, Hou L, et al. Review of noninvasive or minimally invasive deep brain stimulation. *Front Behav Neurosci* 2021;15:820017.
- Hunter JG. Minimally invasive surgery: the next frontier. *World J Surg* 1999;23:422–4.
- Villena Gonzales W, Mobashsher AT, Abbosh A. The progress of glucose monitoring—A review of invasive to minimally and non-invasive techniques, devices and sensors. *Sensors (Basel)* 2019;19:800.
- Vogt N. Minimally invasive Optogenetics. *Nat Methods* 2018;15:242.
- Cabrera LY, Evans EL, Hamilton RH. Ethics of the electrified mind: defining issues and perspectives on the principled use of brain stimulation in medical research and clinical care. *Brain Topogr* 2014;27:33–45.
- Lehman AC, Wood NA, Farritor S, et al. Dexterous miniature robot for advanced minimally invasive surgery. *Surg Endosc* 2011;25:119–23.
- Matsubara T, Yamashita T. Remote Optogenetics using up/down-conversion phosphors. *Front Mol Biosci* 2021;8:771717.
- Nuñez M, Zinbarg RE, Mittal VA. Efficacy and mechanisms of non-invasive brain stimulation to enhance exposure therapy: A review. *Clin Psychol Rev* 2019;70:64–78.
- Mettler L, Clevin L, Ternamian A, et al. The past, present and future of minimally invasive Endoscopy in Gynecology: A review and speculative outlook. *Minim Invasive Ther Allied Technol* 2013;22:210–26.
- Tang Y, Anandasabapathy S, Richards-Kortum R. Advances in optical gastrointestinal Endoscopy: a technical review. *Mol Oncol* 2021;15:2580–99.
- Hadar E, Chen R, Toledano Y, et al. Noninvasive, continuous, real-time glucose measurements compared to reference laboratory venous plasma glucose values. *J Matern Fetal Neonatal Med* 2019;32:3393–400.
- Tang L, Chang SJ, Chen CJ, et al. Non-invasive blood glucose monitoring technology: A review. *Sensors* 2020;20:6925.
- Treiman K, Padwa H, Mark TL, et al. The assessment really helps you with the first step in recovery.” What do clients think substance use disorder treatment intake assessments should look like? *Subst Abuse* 2021;42:880–7.
- Ford PJ, Deshpande A. The ethics of surgically invasive Neuroscience research. *Handb Clin Neurol* 2013;118:315–21.
- Iwry J, Yaden DB, Newberg AB. Noninvasive brain stimulation and personal identity: ethical considerations. *Front Hum Neurosci* 2017;11:281.

- 38 Collins B, Klein E. Invasive Neurotechnology: A study of the concept of Invasiveness in Neuroethics. *Neuroethics* 2023;16.
- 39 Ligthart S, Tesink V, Douglas T, *et al.* The normative evaluation of Neurointerventions in criminal justice: from Invasiveness to human rights. *AJOB Neurosci* 2023;14:23–5.
- 40 Bluhm R, Sipahi ED, Achtyes ED, *et al.* Stakeholders' ethical concerns regarding psychiatric Electroceutical interventions: results from a US nationwide survey. *AJOB Empir Bioeth* 2023:1–11.
- 41 Heney DB. Perceptions of Invasiveness and fear of Stigmatization in mental health care. *AJOB Neurosci* 2023;14:20–3.
- 42 Fitz NS, Reiner PB. The challenge of crafting policy for do-it-yourself brain stimulation. *J Med Ethics* 2015;41:410–2.
- 43 Lipsman N, McDonald PJ, Illes J. Perceptions of Invasiveness: A moving target for Neuromodulation. *AJOB Neurosci* 2023;14:15–7.
- 44 Davis NJ. Invasiveness is inevitable in psychiatric Neurointerventions. *AJOB Neuroscience* 2023;14:13–5.
- 45 Kennedy C. Vagueness and grammar: the Semantics of relative and absolute Gradable adjectives. *Linguistics & Philosophy* 2007;30:1–45.
- 46 Kennedy C. 3.3 adjectives. In: *Routledge Companion to Philosophy of Language*. Routledge, 2012: 328–41.
- 47 Klein E. A Semantics for positive and comparative adjectives. *Linguistics and Philosophy* 1980;4:1–45.
- 48 Larson RK. Scope and Comparatives. *Linguist Philos* 1988;11:1–26.