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Speaker Responsibility for Synthetic Speech Derived from Neural Activity

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This article provides analysis of the mechanisms and outputs involved in language-use mediated by a neuroprosthetic device. It is motivated by the thought that users of speech neuroprostheses require sufficient control over what their devices externalize as synthetic speech if they are to be thought of as responsible for it, but that the nature of this control, and so the status of their responsibility, is not clear.

KEYWORDS: *control, neuroprosthetics, ownership, responsibility, synthetic speech*

I. INTRODUCTION

"Covert speech" refers to the mental act of imagining speaking without producing any vocalization. This act can be a precursor to overt speech or separate from it. In cases where an individual is deprived of his or her ability to speak (as in cases of aphasia or locked-in syndrome), covert speech is fundamentally disconnected from overt speech. Neuroprosthetic technology is being developed that can provide a means to externalize this otherwise covert speech, by recording neural signals. Covert speech, in these technologies, acts as a trigger for a system capable of recording and processing brain signals associated with it. Ultimately, the system produces audible synthetic speech that mirrors what would otherwise have been unvoiced, covert speech.

Issues arising here are explored with reference to the state of the art in the area of neuroprosthetics for language production, associated ethical issues, and to concepts of responsibility, control, and ownership as derived from Fischer and Ravizza's (1998) influential work.

II. NEUROPROSTHETIC SPEECH TECHNOLOGY

"Covert speech" here refers to the mental act of vividly imagining speech or ". . . the silent production of words in one's mind" (Perrone-Bertolotti et al., 2014, 221). Other phenomena associated with "inner speech" and with the relationships between thought and language are interesting, but not the focus of this article (Sokolov, 1971; Vygotsky, 1987; Morin, 1993; DeSouza, DaSilveira, and Gomes, 2008; Perrone-Bertolotti et al., 2014; Alderson-Day and Fernyhough, 2015, 932). Covert speech corresponds with neural states of motor-area activity that match closely with those found in overt speech.

Covert speech shares neuroanatomical features with overt speech. For the present analysis, it is important to think of covert speech in terms of these neural features. The interest in this dimension of covert speech is that its neural correlates can be used to trigger neuroprosthetic devices such that it can be decoded and used to trigger a speech synthesizer (Guenther et al., 2009; Bocquelet et al., 2016b). The covert speech can therefore, via a neuroprosthesis, be translated into overt speech where natural speech is not available because of, for example, disease or injury.

The potential for recovering communicative abilities for people who have lost them, but who remain cognitively intact, is highly desirable. Speech prostheses promise to record the neural signals associated with covert speech from which can be decoded overt speech features. The electrical activity of the brain can be recorded in various ways, for example, by using intracortical probes, electrode arrays on the surface of the brain, or electrodes placed on the scalp. The activity so recorded can be used to restore communication according to a variety of approaches, each with associated challenges relating to factors such as invasiveness of implantable technology, spatiotemporal resolution, signal processing, and so on (Denby et al., 2010; Herff et al., 2015; Chakrabarti et al., 2015; Martin et al., 2016; Ramsey et al., 2018; Schultz et al., 2017).

For the purposes of this article, a system based on recordings from the articulatory-motor areas of the brain, and the driving of a simulated articulatory system is used (Brumberg, 2011; Mugler et al., 2014; Bocquelet et al., 2016a, 2016b). This is chosen as a good representative of neuroprosthetic speech technology, not least because it bypasses some interpretive questions surrounding how to identify complicated brain signals as representing meaningful states or not for the user of that technology (Chaudhary, Pathak, and Birbaumer, 2019; Spüler, 2019). It also does not require reflection on whether or not semantic or conceptual content coinciding with words is realized somehow in the brain, so no real analysis of "mind reading" potential is required (Rose, 2016; Merrill and Chuang, 2018; Roelfsema, Denys, and Klink, 2018). Ethical issues surrounding the privacy of the mental in terms of neurotechnology cannot be treated properly here (Meegan, 2008; Haselager and Mecacci, 2018; Mecacci and Haselager, 2019). Although these sorts of "mind reading" issues are interesting, especially where language and thought coincide, the focus here has to remain on the concepts of control and responsibility. This in turn serves to inform dimensions of these other discussions.

The instrumentalization of signals from the articulatory-motor areas of the brain can provide information on movements that would be made by the lips, tongue, velum, jaw, and so on., such that the sounds corresponding to these movements can be predicted. The predictions can then drive a simulated articulatory system, leading to the production of sounds and words that would have been spoken.

Activity in the articulatory-motor areas occurs even when speech is made covertly. This means one can imagine vividly speaking, and the neural activity evoked by that imagined speech then corresponds to the activity that would have produced the equivalent overt speech. Covert speech of this kind is therefore a good control parameter for a speech prosthesis because it can work even for those who are completely paralyzed, as with locked-in syndrome (Birbaumer, 2006), although this may not be the case for those who receive devices after having entered a locked-in state (Birbaumer and Cohen, 2007).

Technology like this has applications in various medical contexts, such as in cases of aphasia, locked-in syndrome, and speech pathologies where motor function is compromised, but cognitive ability is not. Paralysis is no obstacle to this kind of technology because it is directly controlled via the brain. Specifically, this control comes via acts of covert speech and the articulatory-motor electrical activity correlated with it.

III. CONTROL AND NEUROPROSTHESIS-MEDIATED SPEECH

The main claim to be developed here is that besides guidance control—the causal control of triggering a neuroprosthesis—*regulative control* over the synthetic speech output by the system is required. This is required if the synthetic speech produced by the system is to be thought of as responsive to the user's reasons for speaking in the first place. At the level of guidance control, issues of responsibility can be complicated owing to the role of signal processing in the system—how much causal triggering can be said to reside in the processed signal as opposed to that generated by the user is an open question. At the level of regulative control, issues of responsibility can arise owing to an "ownership" requirement for the content of speech acts, not least in response to the epistemic conditions of the speaker. These issues are fleshed out further below. One specific point has to be made in terms of regulative control and metaphysical alternatives because the preclusion of the latter in explaining responsibility is a driving force in Fischer and Ravizza. The idea is developed that some control (other than more guidance control) is required in order to

(a) establish the content of a synthetic utterance by locating it in an actual causal sequence (i.e., identifying the causal sequence from which it resulted) and
(b) retain reasons-responsiveness, without which ownership of speech is not available for the speaker.

This does not amount to helping ourselves to metaphysical alternatives to explain actions, but instead is a means of control over determining what an action *was* in the first place. In terms of speech acts, this includes control over the content of an utterance, which may not be obvious without the extra control.

Fleeting and Mere Thought

Two examples serve to open the analysis of the key issues in control to be explored here: the "fleeting thought" case and the "mere thought" case. These cases are intended to allow the drawing out of some conceptual issues, and so should not be read as pressing, practical ethical issues in need of a solution today. They are somewhat artificial, though without being too farfetched, and certainly within the bounds of possibility as described in Section III. Following description of these cases in terms of responsibility and control of a speech neuroprosthesis, further consequences are drawn out in terms of speech action.

1. Fleeting thought case: At a conference, the speaker is presenting for a long time. Unbidden, the thought occurs "when will this end?" Neuroanatomically, this is close enough to covert speech to be recorded by a neuroprosthesis and output as speech.

It seems that, in this case, nothing has gone wrong with the technical functioning of the neuroprosthesis system. It also seems that the user of the system has done nothing wrong in having merely undergone a thought. Nevertheless, they appear to have rudely interrupted a speaker at a conference. It seems unfair to suggest the prosthesis user is responsible for the thought—it arrived unbidden—even though it is that which provided the covert speech signal that resulted in the rudeness.

2. Mere thought case: At a conference, the speaker is presenting for a long time. In frustration one thinks to oneself, "when will this end?" Neuroanatomically, this is close enough to covert speech to be recorded by a neuroprosthesis and output as speech.

In this case, the user is responsible for the thought that leads to the rudeness of the synthesized speech. But the user intended only to think this way, not to voice the thought. It seems unfair to ascribe responsibility for the synthesized speech, even though the neuroprosthesis was in good working order and operated as designed.

In these cases, accounting for the speech action is required if a fair reading of the situations is to be found. In neither instance did the attendee intend to deride the speaker. Nevertheless, in the context of the conference, the exclamation of "when will this end?" might constitute derision of the speaker.

Relevant features of these situations include:

1) the deliberate (or not) nature of a thought,
2) how thought relates to instances of covert speech,
3) the relation of covert speech to the production of synthetic speech, and
4) an instance of synthetic speech as an action taken up in some way by an audience.

With these cases as a general framing for the discussion, it is worth fleshing out the account of the speech neuroprosthesis technology, and how it relates to Fischer and Ravizza's theory of responsibility and control.

IV. RESPONSIBILITY, CONTROL, AND THE NEUROPROSTHESIS

The idea of control in Fischer and Ravizza's account includes two dimensions, each already alluded to above: guidance and regulation. Exploring these allows us to show most efficiently the connections

between the account and the case of neuroprosthetic language devices. Guidance control is that kind of control connected with being able to cause an outcome to occur:

> …this control consists in the ability to identify with the reasons that lead to our actions, for these reasons to connect with actions in the appropriate way, and for these actions to connect with events in the external world in the appropriate way. What is crucial here is not that we have the ability to choose and do otherwise, but that we acquire our reasons autonomously and act on them in an uncoerced and uncompelled way. (Glannon 1999, 188)

Regulative control includes being able both to cause and to prevent an outcome (Fischer and Ravizza, 1991, 266), which relates to having metaphysical alternatives. Guidance control is what is required for the ascription of responsibility for an outcome. What counts for responsible action is how the eventual outcome arises—it must come from a moderately reasons-responsive mechanism that is owned by an agent, following an appropriate historical story.

For speech neuroprostheses, covert speech represents guidance control. It is the physical, neural correlates of an act of a user's covert speech that causes the speech prosthesis to operate. This is the result of the user's having made a decision to produce an act of covert speech: with specific training, a user of a speech neuroprosthesis can realize patterns of neural activity through their acts of covert speech, such that the system produces synthetic speech outputs corresponding to that covert speech. The user decides what to say, enacts the trained covert speech activity, and thereby causes the prosthesis to operate.

Fischer and Ravizza argue that moral responsibility is an essentially historical notion, meaning that attention must be paid to an agent's situation in a temporal trajectory in order to assess candidature for moral responsibility. In particular, agents must have, at some stage, "taken responsibility" for a "moderately reasons-responsive mechanism" that can lead to actions if they are to be held responsible for the actions from that mechanism.

A "moderately reasons-responsive mechanism" is one whose receptivity to reasons relates to recognizing the merits of reasons as stronger or weaker and whose reactivity to reasons relates to the inclination to act on the recognition of their strength/weakness:

> In judging a mechanism's receptivity, we are not only concerned to see that a person acting on that mechanism recognizes a sufficient reason in one instance; we also want to see that the person exhibits an appropriate pattern of reasons-recognition. In other words, we want to know if (when acting on the actual mechanism) he recognizes how reasons fit together, sees why one reason is stronger than another, and understands how the acceptance of one reason as sufficient implies that a stronger reason must also be sufficient. (Fischer and Ravizza, 1998, 70–71)

This is part of the agent's coming to "own" the mechanism that allows ascriptions of responsibility (Fischer and Ravizza, 1998, 207).

It should be made clear that the use of "mechanism" in Fischer and Ravizza is in terms of a rational, cognitive, decision-making mechanism, using reasons as input. As such, it is abstract. In the case of a neuroprosthesis for speech, the "mechanism" is a physical one, with neural correlates of covert speech actions as inputs. The insights that are forthcoming from one case are very much worth translating to the other, however. Indeed, the mechanism-centered approach to responsibility in Fischer and Ravizza works particularly well in the context of brain-computer interfaces such as neuroprostheses. In terms of a speech neuroprosthesis, the cognitive act of covert speech is realized neurally, following extensive training. This is the exercise of a learned, deliberate skill (Wolpaw et al., 2002, 769). From neural realization, the signals generated are mediated directly from the site of neural activity by the device. In not being mediated by muscle activity or other onward nerve activity, these kinds of interfaces are "… artificial output channels created by BCI systems" (Wolpaw et al., 2002, 780).

The decision to instantiate covert speech, drawing on whatever reasoning leads to that instantiation, is therefore picked up in a unique way by the physical mechanism. Rather than physical action resulting from neural signals, those signals lead instead to the activation of a software system. Nevertheless, the exercise of the skill required to start this activation is rationally based, and sensitive to the reasons

and reasonings of the prosthesis user. While the abstract, rational mechanism of Fischer and Ravizza's account must be somewhat adapted by way of analogy for this physical mechanism, it is not a wild analogy.

Nevertheless, in examining the implications of Fischer and Ravizza's account for neural speech prostheses, some modification is required. Fischer and Ravizza's account centers on how ascriptions of responsibility can be made for actions, requiring that reasons-responsiveness and control be established for them. Crucially, also that a responsible agent is responsible for those actions under their control:

> …an agent's actions may be produced by a variety of different mechanisms, including the normal exercise of practical reason, nonreflective habit, and (for example) direct stimulation of the brain. When an agent takes responsibility, then, he obviously is *not* accepting responsibility for all his actions *whatever their source;* rather, he is accepting responsibility for only those actions which flow from a certain source. This idea can be framed more precisely by saying that *an agent takes responsibility for acting from a particular kind of mechanism.* (Fischer and Ravizza, 1998, 215)

In the case of neuroprosthetic devices aimed at language processing, it is necessary to account for the responsibility ascriptions that can be made for a user's speech action emanating from the speech prosthetic mechanism. Because this mechanism includes neural signal processing, there is scope to question the sources of the eventual speech produced by the system overall. Artificial intelligence that has a corrective and/or predictive function adds complexity to the question of whether the output is accurately reflecting brain signals, or covert speech (Bocquelet et al., 2016b; Akbari et al., 2018). This relates, not least, to the deliberateness of the prosthesis user's input to the system.

A reasoned, deliberate decision to trigger the speech prosthesis via an act of covert speech may yet be impinged on by the processing of the system. This is illustrated in Fig. 1. How users of a speech prosthesis can control the eventual output from the system is central to understanding how they can (a) take responsibility for speech production and (b) have ownership of the speech produced.

Taking responsibility includes seeing oneself as a source of upshots in the world that are not "freakish accidents," and coming to see oneself as rightful target of "reactive attitudes" thereby (Fischer and Ravizza, 1998, 208–9). Although this is a general condition for moral agency, it is another feature of Fischer and Ravizza's explication that is germane to the cases of neuroprosthetic devices. It is especially pertinent in the case of neuroprostheses intended to provide communicative abilities for, for example, locked-in patients because it is a technological mediation of access to discourse. As such, the technology must mediate the user's seeing oneself as a source of communicative upshots and being a rightful target for reactive attitudes.

Given the role of non user-controlled signal processing in the mix, however, it seems clear that there is potential for the production of synthetic speech for which the speech neuroprosthesis user is not responsible. They cannot, after all, take responsibility for action "whatever its source." Examples of this kind of nonresponsibility case might include signal processing that records fleeting or mere thoughts. It might include cases where the artificial intelligence component does more prediction of the signal than might be expected or that perhaps seems to the user of the device as a "freakish accident."

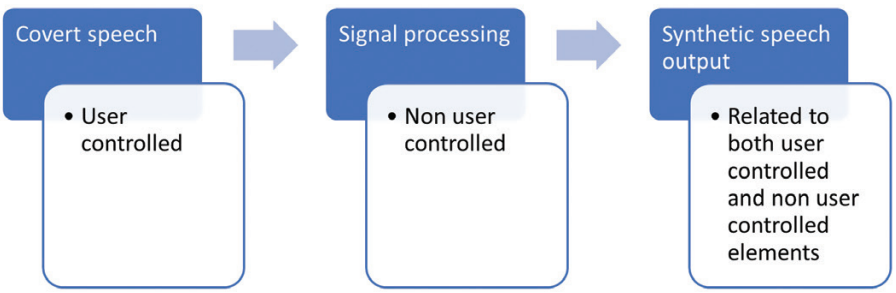

Fig. 1. Hybrid control of synthetic speech output, drawing on user input (covert speech), and signal processing.

	Issues	Responsibility	Ethical stakes
Speech production	Fleeting thought; mere thought; signal overprocessing	Guidance control (triggering a causal process)	Liberty of thought; misrepresentation
Speech action	Ambiguity; shifting context; 'mis-speaking'	Regulative control (bringing about and preventing outcomes)	Self-expression; misrepresentation

Fig. 2. Dimensions of prosthesis-mediated speech and examples of responsibility/ethical stakes.

Apart from these *speech production* responsibility dimensions, there are also *speech action* responsibility dimensions to consider. In a potentially shifting context, with semantic underdetermination of utterances in play, the need for dynamic responsiveness to speech output, audience reception, and general linguistic uptake is required. Even where a speech prosthesis produces an overt instance of covert speech perfectly, the synthesized speech may not be taken as intended by an audience. This would amount to the speech action, the action intended to be done by the speech produced, being compromised. For example, a description could be taken as a command, or a question as a demand. This is summarized in Fig. 2.

In order to adapt synthetic speech to these kinds of eventualities, a bigger role for regulative control is required if responsibility for synthetic speech action is to be sustained relative to the speaker's reasons for speaking as they do. This is so that intended speech content can be secured, despite potential ambiguity, misinterpretation, or other such familiar linguistic possibilities. As mentioned above, regulative control appears in Fischer and Ravizza as a way of ruling out appeal to metaphysical alternatives in accounting for moral responsibility. In what sense does this emerge in this context of speech action stemming from speech prostheses?

It is a good idea to stick with an "actual causal sequence" view of action in order to avoid issues thought to arise from free will/determinism debates in action. In the case of speech action, however, there is an epistemic constraint on the actual causal sequence, especially where artificial intelligence is implicated in the processing of the neural signal. Additionally, at the level of the synthetic utterance, where something like ambiguity is in play, where there is an uncertainty about what the *actual* causal sequence is, in terms of which actual reasons caused which type of meaning to be uttered, some room for error is required.

The determination of the actual causal sequence must be open to revision in proportion to the uncertainty over its course, including the extent to which artificial intelligence played a role. After all, the reasons for speaking in the first place ought to be the speaker's, not derived from a model of patterns of linguistic practice in general, even if modeled very well (Bengio et al., 2003). This requires that, following an actual utterance, a more fine-grained type of control than guidance is permitted to help ascertain the *actual* causal sequence leading to one meaning of an utterance over another.

Rather than openness to metaphysical alternatives, this kind of control has a function of steering interpretation of the space of possibility for an utterance, hence settling the actual causal sequence. It is not guidance control, as it ought not to be seen as simply more causal action. It is clarificatory of specific action and serves to ensure some interpretations are or are not made of a given utterance with uncertain causal history. This means control aimed at causing or preventing something (an ascription of an utterance to a speaker, or an interpretation of an utterance) from coming about. It is regulative control, albeit in a sort of epistemic mantle. Rather than appeal to metaphysical alternatives, this control appeals to alternative epistemic, or rational, or pragmatic conditions in settling which actual causal sequence is the one key for the utterance. It is control of metaphysical actuality.

Regulative control provides the means whereby speech prosthesis users can ensure their synthetic speech actions track the intentions behind their covert speech act, specifically in settling which reasons caused it. This amounts to retaining reasons-responsiveness for their synthetic speech outputs, and thereby responsibility for them.

Other neurotechnologies have prompted discussion concerning responsibility including, perhaps most strikingly, the case of deep brain stimulation (DBS) (Klaming and Haselager, 2013; Sharp and

Wasserman, 2016). Discussions here focus on the apparent possibility of something like personality change resulting from DBS treatment. In such cases, the question arises as to how responsible one ought to be considered, if it appears that one's preferences, dispositions, or reflective capacity is altered by the operation of a device. This undoubtedly has potential legal import, as explored in Klaming and Haselager (2013). More widely, in terms of responsibility per se, Sharp and Wasserman (2016) follow an approach that asks:

> Under what conditions do direct brain modifications reduce an agent's moral responsibility? We will identity several conditions that can diminish responsibility, and we will present an account that best explains how they do so. We will adopt a history-sensitive reflection account, under which brain-modifying technologies like DBS can, but do not necessarily, diminish an agent's responsibility. (2016, 174)

Issues of control in speech neuroprostheses are approached here in a similar fashion to Sharp and Wasserman in the DBS case. This analysis seeks to address how causal pathways between covert speech, technological mediation, and externalization by artificial means might affect attributions of responsibility.

Where the account developed here differs from the analyses of DBS is primarily in terms of what is eventually output. DBS cases look generally at action in terms of a person's disposition and preferences over time, and evaluating how they ought to cohere (e.g., Sharp and Wasserman, 2016, 182). The focus here is not on how a speech prosthesis might affect agent responsibility, but how intact agent responsibility is reflected in the operating of the speech device.

In the DBS cases, questions of responsibility attach to actions in the context of a possible change of background conditions, such as whether the DBS device causes sudden gambling in an otherwise frugal person. Questions over the normativity of the past over the future, of diachronic elements in personality, or of reflective capacity emerge here (Sharp and Wasserman, 2016, 177ff). These pertain to volitional capacity or the psychology of an agent in different ways. This is different to the speech case, wherein volition is not impaired. In fact, it is the intact nature of volition that makes the speech case more pressing, and why regulative control is particularly necessary for ownership of speech mediated in technology.

In emphasizing the importance of regulative control, the speech neuroprosthesis account departs from a "pure" version of Fischer and Ravizza's position. "Ownership" of speech in particular needs a degree of regulative control not necessary, on Fischer and Ravizza's account, for responsibility. In order to flesh this out further, and connect it to the specific case of speech neuroprosthetics, the ownership dimension of Fischer and Ravizza's account requires further discussion.

V. OWNERSHIP

A condition on being a morally responsible agent is that one comes to regard the mechanisms that prompt action as one's own. This is "ownership" of the mechanism. In viewing a moderately reasons-responsive mechanism as my own, I build up clusters of dispositional beliefs about its reliability (Fischer and Ravizza, 1998, 218). Ownership in this account is connected to the history of the mechanism relied on for morally relevant action.

Whereas means of dealing with ambiguity, error, and so on have developed for communication in general, these structures cannot be presumed to be simply reproduced in practices of neuroprosthetically mediated communication. Scrutiny is required on the otherwise "taken-for-granteds" of familiar communication. Moreover, that the problems noted here are not unique to neuroprostheses does not mean that they are not significant for the device or its end users. The generic problems need to be framed in terms of this technology (Garud and Rappa, 1994; Winner, 2004), just as they can be so framed for other technologies or communicative practices like text messaging or emailing (Vignovic and Thompson, 2010; Thurlow and Poff, 2013).

As mentioned above, "mechanism" in Fischer and Ravizza means a faculty of practical reasoning. This account transposes Fischer and Ravizza's onto an actual physical mechanism, one causally triggered by neural activity that produces effects in the physical environment. Training in the use of the neuroprosthesis disposes the user toward the physical mechanism appropriately for them to take ownership of it as a functional part of their communicative repertoire, not just as a device.

A greater role for regulative control is required because communication can include semantically underdetermined utterances from the perspective of the speaker. Even when a neuroprosthesis functions well and is operated by a skilled user, the content of any utterance produced is somewhat up for grabs. This means that ownership over the neuroprosthetic mechanism does not extend automatically to the content of an utterance produced by it: ownership of the means of production does not translate immediately into ownership of the content produced. Not even when the correct cluster of dispositional beliefs attending that device are established in a proper historical manner can this be assumed, owing largely to the speaker's epistemic conditions.

Any speaker can predict to an extent what their interlocutors will take from their utterances, but there is always room for interpretation and the need for clarification. Walter Glannon writes,

> The importance of the agent's beliefs about the foreseeable consequences of actions and omissions underscores the need for a more thorough analysis of the knowledge component of responsibility, which early in the book Fischer and Ravizza explicitly state they will not do. (1999, 205–6)

Speech is one area of action in which beliefs about foreseeable consequences are often in need of updating and explanation. In addition to sensitivity to action, Glannon argues for the sensitivity of the causal process to the agent's epistemic state. He makes the case that assessment of a causal process' sensitivity to action is not sufficient to determine responsibility. By acting from a position of ignorance, an agent can make her lack of ability to control the outcome play a causally and morally significant role in the production of a consequent harm.

If I mistakenly believe myself to be best placed to avert some harm, and my doomed attempt precludes someone better placed from saving the day, the scene's unfolding as it does is due to my *epistemic* failures. Those failures, in ruling out others' intervention, rendered the sequence insensitive to action. Thus, the sequence's sensitivity to epistemic conditions, rather than actions, ultimately produced the harm. The position Glannon takes generally is particularly pertinent in the case of neuroprosthetic technology and speech action.

It is not enough that a speech prosthetic merely hits on the right output now and then; it must be reliable from the perspective of the user. The user must own the mechanism of action through guidance control, but also the speech outputs. The main question here asks: what is sufficient for the user to have ownership over their technology-mediated speech?

Ownership of synthetic speech is about the relationship between agent and utterance. This is a dimension of control apart from a causal story of mapping brain signals to synthetic speech output. It involves how the meaning of an utterance maps to a speaker's general values, intentions, desires, and so on. "Responsibility for" an instance of synthesized speech in terms of covert speech having caused it is not the same as "ownership of" the meaning of that synthesized speech.

This is a question of regulative control that is, perhaps, uniquely relevant to speech acts. Acts such as these draw heavily on communicative norms (Grice, 1957; Turri, 2018). Without a robust regulative control dimension, it is not clear how these aspects of speech action could be accounted for from a speaker perspective. Given this, we require an account of how user control can be established not only for the neuroprosthetic device, but for the speech outputs it facilitates as well. Besides guidance control and the responsibility questions arising for it in terms of synthetic speech production, there is a regulative control responsibility question in terms of determining the content of speech action for speech neuroprostheses.

As it was referred to above, this includes control over determining exactly which causal sequence was actually in play regarding some speech content, for example, whether a remark was sarcastic or sincere, or whether one interpretation of an ambiguous phrase was intended or another. Regulative control here amounts to control over the orientation of the actual causal sequence in play between reasons for uttering something, and the meanings of those utterances.

VI. SPEECH ACTION AND NEUROPROSTHESES

The triggering of a speech neuroprosthesis via covert speech (guidance control) grounds the responsibility for the process, but not necessarily the content of the output. For ownership of speech actions mediated via a prosthesis, it is a prerequisite that the prosthesis user has acquired the reasons to speak

as they do autonomously and are acting according to those reasons in an uncompelled fashion. This is not obviously the case with the neuroprosthesis example, owing to the way the device is triggered.

Guidance control, via an act of covert speech, triggers the speech device. The device itself contributes via recording, processing, decoding, and synthesizing to the overall causal chain from triggering to eventual synthetic speech. Regulative control is required on the part of the users if speech is to be thought of as responsive to their own reasons, not just the functioning of the system. For speech in general, this kind of control is required at least in response to general communicative norms.

In the opening example cases of first a fleeting thought and then second a mere thought, the neuroprosthesis can be said to have functioned well in some sense, whereas the guidance control provided by the neural signals it recorded, processed, and output is insufficient to account for the users' speech action responsibility in the right way. In terms of guidance control, the picture is simply one of the users having caused some synthesized speech. Now in terms of speech action, things are more complex and contribute to a misrepresentation of the speaker (assuming they are not in fact wont to be rude to conference speakers).

Moreover, as a speech act it could be possible that "when will this end?" produced as a voluntary thought meant that the listener was so interested in the paper that they had a burning desire to ask a question. Rather than deriding the speaker, that phrase could plausibly signal intense interest and affinity with the speaker's work.

Also (plausibly), it could simply be related to, say, the listener's hunger pangs and knowledge that next door there awaited a buffet. As such, "when will this end?" produced involuntarily could be unrelated to the speaker's presentation at all. Nevertheless, in all likelihood, derision would likely be taken from that phrase by most upon hearing it. What these nuances aim to indicate is that speech action is not always, or necessarily, cut and dried in the production of an utterance. What is said and what is done with what has been said are apt to come apart in unpredictable ways.

Speech actions are not the same species of actions as, say, flipping switches, tossing coins, or other discrete events. Whereas many accounts would conclude that an agent has direct control *of* standard speech, in the case of speaking through a neuroprosthesis it might seem that the agent can only have indirect control *over* the synthesized speech eventually produced. It might seem most similar to the control I have *of* my arm and that which I have *over* the light I turn on. This is due to the lengthier causal process, most of which occurs externally to the agent. In this way, although we might still say that the agent's act included the production of the synthesized speech, that synthesized speech is more like the ripple caused by a stone thrown into a lake than it is like the throwing of the stone—synthesized speech is more like a consequence of an act than an act itself.

The neuroprosthetic speech system is triggered by patterns of neural activity associated with covert speech. These are learned, via training, but they correspond to acts of covert speech. In formulating what one wants to say, a phrase is arrived at, then the skilled prosthetic user goes about realizing the neural patterns required to trigger the system accordingly. This sets in motion a chain of events including neural recording, signal processing, and decoding. In the end, speech is synthesized and externalized, which ought to accord with the initial covert speech.

Is this process, constituted by the chain of events just mentioned, leading from the action to the consequence "sensitive to action"? For Fischer and Ravizza, the process is sufficiently sensitive to action to ascribe responsibility *if and only if* the consequences follow from that action. As well as causal control of the prosthetic mechanism, a kind of "responsive sequence" is required; a "causal pathway" (Fischer and Ravizza, 1991, 272) from the action to the event in the world. To retain sensitivity to action in the case of a speech neuroprosthesis, some factor besides guidance control is required, as only with the inclusion of some other factor can the consequences (synthesized speech output) follow appropriately from the user's action (covert speech).

For example, where artificial intelligence is involved on the processing of neural signal, this could contribute more than the user is comfortable with (perhaps word choice, or the "go command" to utter at all). The language model used by such artificial intelligence might be very advanced, and very accurate, but not reflect the user's reasons for speaking or not speaking. This has to be accounted for, if the causal pathway is to be sensitive to reasons enough for responsibility ascription. The user must have the sort of control with which they might disavow an utterance apparently theirs, as well as assert ownership of the content of their utterances.

This means including regulative control as a means of establishing which among a set of metaphysical possibilities actually happened—not choosing among metaphysical possibilities to establish free will. Did the users utter × as an instance of *y*? Did they utter × as an instance of something else? Did they utter × at all (did the system take over)? Only with this kind of inclusion can derision of the speaker be avoided in cases 1 and 2 from above. Scope must be there for the user to prevent, not only to cause, an action.

Where speech action is considered, inclusion of more than guidance control is required in accounting for explication of ambiguity too. Making sense of "when will this end?" not as derision, but excitement to ask questions, or of hunger, or indifference, is a challenge from the speaker's perspective where a neuroprosthetic device is in play. When the device operates well and produces perfectly the phrase covertly spoken, but that phrase is misinterpreted by an audience, there is the chance for failure of ownership. While ambiguity is a fact of language to be considered by any speaker, mediating it in a device represents a challenge for ownership in that the device user may "own" the words produced synthetically, but the effect of those words may diverge from anything the speaker intended, e.g., excitement taken as derision. These effects may not be anything the device user would willingly claim ownership over.

The synthetic speech output by a prosthesis must, for its meaning to be preserved as intended, be related not only to the guidance control of covert speech, but to speaker intentions, contextual factors, linguistic conventions, and more. In relating this kind of control need to ownership, the issue is bound up with how the device user develops reliable dispositions toward the device.

Latitude of interpretation is what allows the device users to develop reliable dispositions toward their device in the face of possible ambiguity. What is clear is that in terms of guaranteeing ownership and therefore underwriting responsibility ascription for speech action, guidance control is not sufficient. That alone does not necessarily allow the users to claim ownership of the effects of their technology-mediated speech actions. What is at stake is the dynamic ability to control production of synthesized speech in the light of emergent conditions in order to preserve intended meaning, from covert speech act through signal processing, to synthesized speech output, and audience reception. It amounts to control over the identification of which actual causal sequence is relevant to the utterance actually made. This would constitute regulative control because it includes being able both to cause and to prevent an outcome. So, responsibility ascription in speech neuroprostheses requires regulative control.

VII. CONCLUSION

This article has argued that besides guidance control, regulative control in an epistemic sense is required on the part of a speech prosthesis user to determine an actual causal sequence. If synthetic speech resulting from the system is to be thought of as responsive to the user's own reasons, this is necessary. This is important, too, in order to account for speakers' responses to general communicative norms. The analysis departs from a pure version of Fischer and Ravizza's position in emphasizing the role for regulative control. The important point is that for speech applications in particular, we require more than "mere" responsibility for the production of some speech.

Ownership in particular needs a degree of regulative control not necessary on Fischer and Ravizza's account for responsibility generally. This degree is required for speech as this is a dynamic area with wide scope for unpredictable, and variously interpretable, contents. Speakers must be equipped to respond to, for example, their own communicative intentions, their actual utterances, and the reactions and interpretations of their audience, in order to be responsible for the content of their communicative input. In many cases, the identification of an actual causal sequence leading to an action might be straightforward. In this case, it is not, and so this must be accounted for if we are to be able to account for responsibility in it.

One practical way to achieve this would be via a feedback loop between users' actual causal control and speech output. In this way, the user gets "first listen" to the putative output and can verify it before it is produced. This could fulfill the guidance control condition for moral responsibility as proposed by Fischer and Ravizza, and also realize robust regulative control dimensions. Together, this would establish that verbal outputs from prosthetic sources were ascribable to neuroprosthesis users in terms of device actions, and as speech action.

In both fleeting thought and mere thought cases, this would serve to mitigate issues from device users' point of view. The "first listen" could spur the users into issuing some kind of veto over the output or prompt them to turn off their device altogether.[1]

This discussion also suggests some specific responsibilities on the interlocutors of a speech neuroprosthesis users to provide latitude in interpretation. In order for users to be able to develop reliable dispositions toward their device, this latitude represents scope for creating the intended reception of a synthetic speech act. An apparent expression of derision would seem so uncouth as to prompt us to pause in judging the speakers, especially if they are using a device to communicate. As an audience for such speakers, we may pause and think of the sorts of factors outlined in Figs 1 and 2, and the possibilities of fleeting or mere thought. It seems to go without saying that, were we in conversation with someone using a complicated speech prosthesis, we ought to grant them leeway in expression and interpretation. We should, of course, but the point has these deeper issues of control that serve to highlight some conceptual differences between device-mediated and conventional speech.

Unlike the mentioned DBS cases, these issues do not revolve around questions of potentially impaired psychology or volition. Rather, the neuroprosthetic speech case is one in which the proper realization of unimpaired volition is what is at stake—the responsiveness of neuroprosthesis users' speech to their own reasons. This requires an augmented role for regulative control because it is this kind of control that can identify an actual causal sequence.

Rather than helping oneself to metaphysical alternatives, in the sense of an opposition between free will and determinism, this involves identifying *which* metaphysical alternative is the *actual* one relevant to the causal sequence. This control involves aligning an actual speech action with the reasons that prompted it from the agent's perspective. This includes taking responsibility for it (e.g., rather than disavowing it where artificial intelligence may have prompted it). It further serves to determine speech content where this is uncertain. This discussion is particularly due for speech neuroprostheses, but ought to provide some scope for other neurotechnology discussions besides where speech is at stake, and in which responsibility may be under scrutiny.

NOTE

1 A device that could be switched off would likely raise issues in itself, for instance around how to determine when the on/off command had been issued deliberately by the user. Similar user control issues would arise here in a different context.

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