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RESEARCH ARTICLE

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Propping up interdisciplinarity: responsibility in university flagship research

Mads Dahl Gjefsen and Knut Jørgen Vie

Work Research Institute, OsloMet – Oslo Metropolitan University

ABSTRACT

Researchers' communication activities are influenced by motivations and abilities, but also by specific topics and artefacts of research. This is seldom acknowledged in efforts to embed responsible research and innovation in organizations through mechanisms that promote communication as synergistic activities. Nor is it sufficiently acknowledged in the literature on researchers' attitudes to communication. To open up a discussion on this issue, we draw on recent literature on affordances to explore how a certain 'prop' influences outcomes of research communication in the NTNU Cyborg initiative, which integrates biological neural cultures with electronic circuitry and robotics to build a cybernetic organism. The case illustrates the wide range of affordances – both enabling and constraining features – that a particular object of communication may have in different settings, indicating the need for artefact-specific approaches to researchers' attitudes to communication and to the institutionalization of RRI.

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Scientists' motivations for communicating affect whether and how communication and public engagement contributes to responsible research and innovation (RRI) (Loroño-Leturiondo and Davies 2018). Scientists' attitudes to communication are only part of the picture however, and the form and content of communication also depends on organizational and contextual factors, as well as the on topics and artefacts of research.

We are concerned here with the role of science communication in the context of university flagship research. Such research may be understood broadly as having a distinct emphasis on visibility, generally including some combination of centralized support from research-performing organizations, collaboration across departments and disciplines, and efforts to communicate and bring attention to research. The NTNU Cyborg initiative at the Norwegian University of Science and Technology – an effort combining cybernetics, neuroscience, and computer science to develop a cyborg – is one such example. Here we employ the concept of affordances (Gibson 1977; Hutchby 2001; Davis 2020), to examine how the material manifestation of research enables and constrains researchers as communicators in various situations. Our research question is: *how does the cyborg*

CONTACT Mads Dahl Gjefsen madsdg@cantab.net

afford particular outcomes of research communication, and how do its affordances manifest for different members of the interdisciplinary team?

The article proceeds by positioning the structural and relational model of affordances in the literature before presenting our case study. We then outline our methodology and present interview findings centred on three areas where outcomes of researchers' communication appears constrained or enabled by the initiative's focus on a cyborg: communication management, attaining benefits, and building collaboration. Findings suggest limitations to generic institutional mechanisms intended to stimulate RRI via research communication, and raises implications for further research on scientists' motivations for communicating, as we reflect upon in the conclusion.

Literature

Recognizing the inseparability of the technical and the social, and seeking to extend civic capacity and deliberation to the hegemonic spaces of technical experts, RRI intervenes in research and innovation to broaden transparency, reflection, and accountability, and to nudge technical activity in societally desirable directions (von Schomberg 2013; Owen, Macnaghten, and Stilgoe 2012). RRI's conceptual and methodological foundations include established traditions for public engagement with science,[1] but RRI also expands on these by insisting that dialogue and reflection should inform technical practice. Engagement, here, is a bulwark against unintended consequences and illegitimacy, and contributes to socially accountable science and technology, reflexive of and responsive to public values and priorities.

Considerable work has gone into classifying approaches to communication and dialogue between scientific experts and public stakeholders (Delgado, Kjølberg, and Wickson 2011; Rowe and Frewer 2005). Significant work is needed to enable communication and engagement to meaningfully contribute to RRI, and as Groves points out, scientists who are liable to join engagement processes are not necessarily best placed to influence innovation pathways (2017). Our concern in this article is not public engagement explicitly conducted as RRI, however, but rather the experiences with communication that might develop over time in any research community that attracts public attention. Our assumption is that a better understanding of artefacts' influence on communication outcomes may shed light on the prospect for RRI's deliberative ambitions.

As recently demonstrated by Boenink and Kudina (2020), communication is part and parcel of the 'value work' in RRI, whether this work occurs with the aim of establishing transparency, as emphasized by von Schomberg (2011), or as part of the procedures for articulating and integrating concern for societal values through systematic anticipation, inclusion, reflection and responsiveness, as outlined by Stilgoe and colleagues (2013).

Through their influence on communication activities, research-performing organizations can play important roles in institutionalizing RRI (Wittrock and Forsberg 2019). The institutional rationalities (values, practices and imperatives) of commissioning organizations must be taken into account in efforts to enhance civic capacity around science and innovation (Bickerstaff et al. 2010, 481). When scientists engage with audiences outside their immediate peer communities, they are faced with a balancing act that involves representing science as well as its organizations (Horst 2013). Yet, the development of organizational mechanisms that explicitly seek to motivate or reward outward-

facing activities that synergize with RRI, may conflate a wide range of communication activities. Organizations' reputation, for instance, represent a key source of drivers for instituting RRI-like mechanisms (Wittrock et al. 2020).

Empirical research on mechanisms for communication at research-performing institutions reveal a wide variety in performance indicators and standards, indicating a lack of intentionality about societal dialogue at European research institutions (Neresini and Bucchi 2011). Similarly, Hamlyn et al. (2015) show that an increasing number of 'enablers' work in a range of research-organizational settings such as marketing and human resources, creating uncertainty with regards to strategies and expectations, and that 'researchers and institutions remain uncertain about systems of rewards for public engagement' (Hamlyn et al. 2015, 5).

On the topic of individual researchers' attitudes to communication, the field of science communication and in particular the literature on *strategic* research communication has produced insights into how researchers formulate objectives, goals and tactics for communication efforts (Besley, O'Hara, and Dudo 2019). Besley and colleagues (2020, p. 3-4) outline six central goals which in different ways motivate scientists' public engagement efforts, including 'ensuring that our culture values science', 'ensuring adequate funding for scientific research' and 'professional reputation', focusing on generic goals rather than on the particular opportunities offered by specific objects of research. Predictors of willingness to communicate include deficit-model views about the harmfulness of public misinformation and ignorance, as well as scientists' sense of professional obligations to the public good (Besley, Oh, and Nisbet 2013; c.f. Besley et al. 2018). Absent in the strategic research communication literature, however, are studies of researchers responding to and capitalizing on the particular opportunities made available via their specific topics of research and associated artefacts.

In RRI, scientists' reasons for communicating have been explained with reference to their normative sense of responsibility to society and to provide good experiences (Loroño-Leturiondo and Davies 2018), with little relevance attributed to factors external to the researcher him/herself. Loroño-Leturiondo and Davies express concern about this 'surfeit of responsibility' and call for institutionally oriented research into the structures and organizations that influence researchers' science communication (2018, 179–182).

We propose that a valuable addition to the above is made by examining how objects of research influence the contexts and outcomes of communication. Objects that serve as reference points in or influence the direction of sociotechnical controversies have long been the subject of research in science and technology studies (STS) (Wynne 1988; Winner 1988). The interpretative flexibilities of emerging technologies vary in their amenability to different groups' agendas and needs (Pinch and Bijker 1984; Bijker 2010). The meanings and associations they evoke can help sustain particular sociotechnical imaginaries (Jasanoff and Kim 2013), influence the credibility of promises of technological solutions to complex problems (Markusson et al. 2017), and lend cohesion to expert communities and organizations (Gjefsen 2013, 2017). Their role should thus be acknowledged in any analysis of the contexts of research communication.

To explore this topic we draw on the concept of affordances, influentially defined by Hutchby (2001:, 444) as 'functional and relational aspects which frame, while not determining, the possibilities for agentic action in relation to an object.' The concept originated with Gibson (1977) who theorized the possibilities for action offered by the

physical environment. Hutchby considered affordances central to a sustained program for studying the interrelationship between 'ordinary actions in the context of […] material enablements and constraints' (2001, 453).

The concept is not without its critics. Rappert writes that the notion of affordance 'generates noncontrovertible claims that border on the banal or unhelpful; it closes down debates in often arbitrary ways when they could be usefully opened up; it relies on a series of unstated shared agreements; and it fails to provide a place for critical self-examination' (2003, 573).

Evans et al. (2017) shows inconsistencies in uses of the concepts, and proposes definitions and clarifications which will be used as a starting point for the present study. They see affordances as 'the "multifaceted relational structure" […] between an object/technology and the use that enables or constrains potential behavioural outcomes in a particular context', cautioning analysts to differentiate between affordances and features, and to focus on relationships with variability (Evans et al. 2017, 36; c.f. Faraj and Azad 2012, 254).

Recognizing these points, our operationalization of the concept here draws on Davis and Chouinard's (2016) structural and relational model of affordances, recently elaborated in book form (Davis 2020). This conceptual model is made up of interrelated *mechanisms* and *conditions* for how and when affordances come into play in the relationships between subjects and artefacts. *Mechanisms* represent 'gradations in the ways that artefacts afford', while *conditions* represent 'the diverse circumstances through which mechanisms take shape' (Davis and Chouinard 2016, 241).

Mechanisms (Table 1) are forms of enablement and constraint, and describe artefacts' tendencies to *request, demand, encourage, discourage, refuse* and *allow* different courses of action. Mechanisms can appear simultaneously, with varying intensities, and interrelate, such as when a rope fence in a botanical garden simultaneously *discourages* walking into an area and *requests* that visitors stay on a predefined path. *Requests* and *demands* refer to bids on action that are prompted by the artefact itself, while *encouragements*, *discouragements* and *refusals* are responses to subjects' initiatives, and *allowances* consist of neutral influences in the face of which a user may take different courses of action without reinforcement from the artefact.

Conditions of affordance (Table 2) complement the classification of mechanisms by directing attention to how affordances may produce different outcomes for different subjects at different times. Here, variations in different subjects' *perception* of possibilities, their *dexterity* in engaging with objects, and the *cultural and institutional legitimacy* which helps lend meaning and authority to actions, all contribute to explaining how different subjects' engagement may produce different results.

Table 1. Mechanisms of Affordance (adapted from Davis 2020, 63–86).

Artefacts …	Typical direction of influence
… *request* … *demand*	Artefacts place bids on users
… *encourage* … *discourage* … *refuse*	Artefacts respond to users' bids
… *allow*	Artefacts remain neutral to users' bids

Table 2. Conditions of Affordance (adapted from Davis 2020, 87–88).

Conditions	Relevant factors
Perception	Subjects' perception of objects and their functionality, barriers, opportunities, and constraints
Dexterity	The skill with which subjects can engage objects
Cultural and Institutional Legitimacy	The degree to which subject-object relationships are sanctioned by normative conventions and official codifications

The model's structural and relational aspects thus help us analyse how artefacts influence action under certain circumstances and not others, and how they might do so differently for different subjects.

Introducing NTNU cyborg

Our analytical starting point is the embodiment of research in the form of a cyborg (cybernetic organism) which has existed in different iterations within the university flagship research initiative NTNU Cyborg since its initiation in 2014. The NTNU Cyborg initiative seeks to develop a robot which is interfaced with biological cells that receive stimuli and learn from the environment in which the robot operates. Human stem cells are cultivated into brain cells and stimulated in a laboratory environment, forming neural networks who respond to electrical impulses. Although plans have changed over time, an early conception of the project intended for the mechanical robot to move around on the university campus, engaging with passers-by via screens, sounds and blinking lights and posting on social media. The robot's sights and sensations would be wirelessly communicated to the neural culture (stored in controlled laboratory facilities elsewhere on campus), and the system would learn, respond, and adapt to the physical environment. The neural culture and mechanical robot thus approximate the kind of integrated, self-contained entity commonly thought of as a 'cyborg', or what the researchers themselves refer to in scientific publications as a closed-loop reservoir-neuro system (Aaser et al. 2017).

NTNU Cyborg first arose as an idea within the university administration and gained traction during open meetings where researchers explored possibilities for collaboration. Popular appeal and visibility were stressed from the outset, as a senior figure in the university administration explained:

> I requested a robot that would travel on campus […] it could become a show-off for NTNU. […] it points towards a world which is very different from the one we have today. So, there was […] the outreach-component (Initiator and research director at an overarching research program).

A faculty member and early coordinator stressed communicability as central to NTNU Cyborg's two-fold aims, which consisted on the one hand of creating something physical and interactive which could promote the research, and on the other, of disciplinary research questions and the intersection of disciplines (Associate Professor in computer science and former project coordinator). The initiative's website states that the 'social and interactive Cyborg serves as a platform for studying neural signalling properties, robotics and hybrid bio-robotic machines.' The main departments involved are Engineering Cybernetics, Computer Science, Neuromedicine and Movement Science, and

Cancer Research and Molecular Medicine, from whom about a dozen senior faculty members and PhD candidates are active contributors. Another two dozen senior faculty members from other departments are involved as collaborators.

Computer science research objectives include improving upon silicone-based computer circuitry, where current chip technology is reaching limits of material size, processing power, and energy efficiency. Biological neurons' strengths in pattern recognition and sorting make neural cultures a candidate for further advances. On the neuroscientific side, NTNU Cyborg research may improve upon artificial limbs and other treatments that depend on understanding neurons' capacity to learn and self-organize. Applications include disease detection and treatment of neurodegenerative conditions. The initiative's website states that NTNU Cyborg could inform philosophical areas as well; 'studying the mechanism of memory, learning, concept formation, and neuronal model building of the external world may lead to a better understanding of the emergence of consciousness.'

Its wide range of applications places NTNU Cyborg in a landscape fraught with ethical and societal implications (Vie et al. 2020). Questions facing its researchers include what, if anything, distinguishes its neural cultures – which contain upwards of 100,000 neurons, the same as certain insects – from life considered deserving of empathy and care, the implications of artificial intelligence and consciousness – explored in popular imagination and fiction – as well as distributive questions around who may access future expensive treatments and augmentations. While the researchers see some of these fears as exaggerated or far removed from the plausible near-term impacts of their research, NTNU Cyborg initiators have also acknowledged the importance of including ethicists and social scientists in the initiative.[2] Its researchers demonstrate awareness and sensitivity to public concerns; as one neuroscientist put it, describing the stem cells that are cultivated into brain cells:

> We don't feel it is [a brain] but we don't know at what level of complexity we should start thinking about it as potentially a brain. Also, if you think about it, if it is human tissue, and […] the source is an individual. We don't believe […] that it actually captures a person or a person's brain. But still, if you were that person, you would be legitimate to ask, 'Is it?' (Researcher in neuroscience).

In media reports (Hornmoen, Vie, and Gjefsen forthcoming), and other communication settings, the research has often been presented with reference to the cyborg. Yet, the cyborg itself is neither static nor in itself the focus point of the research goals of contributing scientists; its visual and material expressions have changed over the years (Figure 1), and researchers' intentionality about how and when they refer to it has also evolved.

Methodology

Here, we report on work from Embodied Engagement – A Case Study of the NTNU Cyborg Project, a two-year RRI project led by researchers at OsloMet in collaboration with NTNU Cyborg. As an on-going research effort with a high degree of public visibility and interest, and with a number of ethical and societal implications, NTNU Cyborg offered a relevant case for studying researchers' interests and views of communication. The overall methodology of Embodied Engagement was interventionist and co-developmental. It included parallel empirical data collection activities that served to triangulate a basis for interpretation (Cox and John 2009). Methods included participant observation,

Figure 1. Examples of imagery in media coverage of the NTNU Cyborg initiative. Clockwise from top left: Troll (Aker-Bjerke 2016, image credit NTNU Cyborg) Researchers and robot (Wolden 2017, image credit Kai T. Dragland) Robot looking up at person, with header 'Our children, the machines' (Buset 2018, image credit Glen Musk), Researchers in office/lab setting (Wolden 2017, image credit Kai T. Dragland).

individual and group interviews with a total of 25 lay participants and 10 NTNU Cyborg-affiliates, as well as media analysis of NTNU Cyborg media coverage. Embodied Engagement culminated with an explorative exercise around RRI empowerment, where early-career researchers in NTNU Cyborg were tasked with preparing two open workshops based on separate preparatory activities, one of which included training in RRI through a module based on the projects Higher Education Institutions and Responsible Research and Innovation (HEIRRI) and Teaching Responsible Research and Innovation (TERRAIN) (Vie and Gjefsen 2020; c.f. Foley and Gibbs 2019; Hartley et al. 2016; Mejlgaard, Christensen, and Strand 2019).

As part of Embodied Engagement's co-developmental approach two senior NTNU Cyborg researchers joined the project management group and received regular updates on project activities and advised on research directions. NTNU Cyborg partners were responsible for providing access to interviewees and for logistical aspects of the abovementioned workshops and group interviews. This close involvement was necessary to enable the joint experimentation through workshops, but also represented a potential source of bias, both in interviewee selection and through interviewees' impression that NTNU Cyborg colleagues might access and react to statements made in interviews. To reduce the risk that conflicts of interest might influence interpretations or activities in Embodied Engagement, OsloMet partners developed interview guides, code books, and conducted data analysis independently, and interviewees were provided clear information in writing about the project's data management procedures.

While the above methodology as a whole informed the current work, the specific subset of data focused on in the current article, are 10 semi-structured interviews

carried out with individuals involved in NTNU Cyborg; 8 of these were involved as researchers and 2 were involved by virtue of their roles in the university administration. Common to these interviews was a focus on learning about the public communication experiences of those who had contributed to NTNU Cyborg, and about the receptiveness of interviewees to experimenting with new or different approaches to communication. Interviews targeted individuals who had contributed directly or indirectly to NTNU Cyborg's communication activities, and informants were contacted if they were named in media coverage or suggested by other NTNU Cyborg members. Questions (see Appendix) focused on interviewees' opinions about research communication, their research motivations and goals, and their views about the societal implications and ethical questions of NTNU Cyborg activities. Though limited, the 10-interviewee sample included those most closely involved in communication activities around NTNU Cyborg, and enabled saturation in the types of responses and sentiments expressed about interview topics.

Interviews took place in 2018 and 2019 and were audio recorded, transcribed, and coded for topics of analytic interest in NVivo. A code book was developed by the authors during the interview phase, highlighting factors which appeared to influence interviewees' intentions and the outcomes of communication, which (in contrast with abovementioned research (Loroño-Leturiondo and Davies 2018)) were repeatedly expressed in instrumental rather than normative terms. Consequently, coding grew to include dimensions such as *strategy*, *evaluation*, *resources and institutionalization*, and *NTNU*, as well as *communicability* – the latter dimension emerging in response to researchers' accounts of being constrained by or responding to particular patterns of attention apparently stemming from features of the cyborg itself. Other features highlighted in coding included societal and ethical considerations, collaboration across disciplines, and audiences and goals of research communication.

Findings

Research communication takes several forms in NTNU Cyborg, and most respondents reported having first-hand experience with communication as either sources in media articles, or from presenting at science festivals, student recruitment venues, television shows, and campus tours for high-profile visitors. One interviewee, head of communication at a college and communication advisor, described the lab associated with NTNU Cyborg as an 'unofficial visitor center' for ministers, parliamentary committees and other high-profile campus visitors from media and industry (Head of communication).

When explaining their reasons for engaging in research communication, interviewees gave both normative and more instrumental responses. A PhD candidate described communication as a prerequisite for doing research with benefits for those affected by paralysis, amputations, stroke and Parkinson's: 'it is important to convey these benefits […] if people do not know about the project, how can we get any support for it?' (PhD student in cybernetics). Another informant stated that communication in NTNU Cyborg counters negative cultural views or Frankensteinian connotations around robotics, AI, and neuroscientific engineering on brain cells . Another senior researcher in the project described communication as a matter of eliminating risks and taking advantage of the initiative as a chance to show what the science is about:

> if you eliminate [risks and] get out a clear message that shows what the sciences is about. What each group is working with? Why this is unique? What is the potential? That is excellent because […] we show how science happens (Researcher in neuroscience).

When asked specifically about the cyborg, interviewees described it as being at once integral to the project's existence and as having limited usefulness for their core research. They explained that simulated virtual robots more effectively enable many of the research tasks. The simulated robots 'are what it is all about, we use those for the actual research, to see how we can train neural cell cultures to perform something in a world that we simulate […] While the physical robots, they are of course more about the research dissemination' (PhD student in computer science). However, as one informant explained, project partners actively sought out media attention from an early stage in the project, and the cyborg served as a helpful visual reference point to that end: 'it is actually very non-visual, what we do. Our actual research activities' (Professor in computer science and project coordinator). An interviewee who worked on communication in the university administration referenced the cyborg in connection with compete for journalists' attention: '[it has] been very easy to sell. It has all the right buzz words' (Head of communication).

The cyborg was crucial, one informant reported, for attracting attention to the underlying research: 'if we had not had […] that way of presenting the hype of artificial intelligence, we would never have taken part. The basic research would never have gotten attention and been presented to companies, politicians, decision makers and the like' (Professor in computer science and project coordinator). Interview findings suggest that the cyborg contributed to communication outcomes in three important areas – communication experimentation and management, attaining benefits, and developing collaboration – but with different implications for the participating researchers.

Communication experimentation and management

The first thing to note is that the cyborg seemed to prompt researchers to experiment with communication, eventually requiring internal coordination and management. Several interviewees spoke about the physical cyborg as something that contributed to playful and explorative communication early in the initiative:

> We also made a head for the robot. The cybernetics-guys, they made a box, quite simply, with lights flashing to the rhythm of the neural signalling. […] So that was what attracted a big audience […] [Interviewer: But did you feel that you were able to speak about what you actually do, your research?] Yes, spinal injuries and such become secondary of course. But we always used to explain what the project consisted of (PhD student in neuroscience B).

In the language of the structural elements of the mechanisms of affordance, their pursuit of an interactive cyborg *encouraged* initiative researchers to develop features with novelty and audio-visual appeal, which might in turn *request* the attention of audiences. While more substantial research goals may have become secondary to the audiences' initial interest, the cyborg still *allowed* researchers to segue towards what they considered to be more important implications of their work.

While communication activities started at the initiative's outset, the precise strategies and goals of attention were not pre-planned, but improvised along the way, shaped partly by the possibilities offered by the cyborg. Informants recounted stories where such experimentation produced unwanted results, as when the cyborg was depicted as troll (top left, figure 1 above):

> [B]efore we actually built a [mechanical] face for the robot, [we had the] idea that we could use some kind of avatar on the screen, and the idea was that the screen would be onboard the robot at some point. […] we made a version with, troll. Customized to the Norwegian culture (Associate professor in computer science and former project coordinator).

The uncanny troll face was viewed negatively by some NTNU Cyborg collaborators, for whom its connotations appeared to break with disciplinary norms:

> I thought it was a bit trivializing. […] as a neuroscientist I don't want to show troll face. […] I cannot speak for others, but I have a feeling none of the people who are actually working in all the interdisciplinary teams liked that, that part. I think we were all a bit embarrassed at that point, and of course that was the only thing we could show to begin with (Researcher in neuroscience).

Here, we see the relational aspects of affordance come into play, as the stakes involved for research partners in adopting different communication approaches began to diverge. While all participating researchers may have been able to *perceive* the cyborg's possible uses in communication, only the cyberneticists and computer scientists had the *dexterity* to experiment with new features and visual expressions. What is more, to the neuroscientists, adopting a troll face in communication efforts lacked *cultural and institutional legitimacy* – referring, here, to disciplinary norms around professionalism, and to how the troll face distracted from primary research goals and clinical implications. The troll face episode prompted internal discussions and more intentionality and coherence in the NTNU Cyborg initiative's communication efforts. In these discussions, differences in terminology and the need for precision about the organizational and geographical location of certain research activities[3] were also brought up, partly in response to the use of the word 'brain' as a shorthand for neural cultures, which figured in several media articles:

> [T]hose of us who work on computers like to say, use the word brain. For [the neuroscientists] I suppose they feel that when they are part of media content that uses the word brain, they might feel that they are making fools of themselves within their own disciplinary community (Professor in computer science and project coordinator).

> [A]n idea that somebody is having a brain on a dish is naive. […] it has come to the media on a couple of occasions. The body is at Gløshaugen and the brain is at St. Olav's. First of all, St. Olav's is the location of the hospital, but it is like saying that you have an actual brain within the hospital. So whichever way you look at it it's problematic in my opinion (Researcher in neuroscience).

The choice of terminology could be seen as reinforcing the cyborg's apparent centrality to the initiative, which to some interviewees exacerbated unwanted risks. The decision to place a cyborg at the centre of an interdisciplinary research effort *demanded* embodiment and thus also *encouraged* narratives that related the constituent research activities to the humanoid figure, resulting here in narratives where neuroscientific components are

concerned with the head or brain of the initiative, while the cybernetic activities are explained as the body. But again, the *cultural and institutional legitimacy* of this narrative differs for the researchers involved. To one neuroscientist, precision in terminology and imagery was crucial for their professional credibility: 'I don't want to be stamped doctor Frankenstein. […] It's a stigma that you can never ever get rid of, no matter what you do' (Researcher in neuroscience).

As their experience with media attention increased, researchers in NTNU Cyborg increasingly coordinated what words and narratives to use and avoid. Improvizations and playfulness were gradually replaced by a shared narrative that acknowledged different researchers' priorities. After a few 'internal discussions […] we came up with a good way, or a better way to describe, the, especially the neural part' (Associate professor in computer science and former project coordinator).

When asked about the cyborg's role in generating attention around their research, informants described a dynamic where the cyborg would be foregrounded to raise initial interest and meet journalists' expectations, before researchers could discuss their primary research. Asked if the cyborg distracts from what they wanted to communicate, one interviewee replied: 'Yes, but it is also what gives us attention in the first place. So, without it, we would not be doing any dissemination' (PhD student in neuroscience B). The informant used a previous newspaper interview as an example:

> There, the cyborg created that possibility, of course. And when we spoke it was about how we grow the cells and how we connect that to the equipment and things like that. And then I began to talk about the medical aspects. […] in a way it was as if other things had to be established first. To create a foundation for the interview (PhD student in neuroscience B).

Here, the researcher felt able to segue from the journalist's interest in the cyborg, to their own research. Other informants described instances where they had been unable to accomplish this: 'currently, it is difficult enough in a way to explain how this cyborg will work. Without talking about diseases as well. […] I think the [angle] might have been decided on in advance, before we were asked to participate' (PhD student in neuroscience A). The cyborg, then, *allowed* researchers to talk about constituent, fundamental research, but also strongly *discouraged* – verging on *refused* – alternative starting-points for raising media interest, such as delving straight into one's own research or its applications. Faced with journalists whose initial questions and focus was on the mechanical cyborg, the cyborg also *demanded* that if participating researchers wanted to direct attention to their constituent research activities, they needed to develop ways to manage communication activities and crafting narratives connecting the cyborg to their particular research goals.

Moreover, informants felt that the cyborg produced expectations for what research progress should look like, after a media outlet had asked if they had something new to show them 'we have made lots of progress, but [there are] no new images, and there are no new robot movements' (Professor in computer science and project coordinator). Thus, while the cyborg may have *requested* public attention and *encouraged* early communication activities, it may have also served to *discourage* prolonged public interest in the initiative itself, as the course of research ultimately did not seek to produce the sorts of robotic advancements implied by the foregrounding of the cyborg.

Attaining benefits

Another dimension explored in interviews was whether researchers felt that the cyborg influenced their ability to generate particular outcomes from communication activities. When asked if the cyborg played a role for their ability to secure external research funding, most informants responded negatively. On the contrary, one interviewee thought the initiative's communication could pose risks to approval by ethical review boards and by extension also risks to future funding:

> [I]f I am perceived, or one of my colleagues, again from a neuroscience perspective that we are actually doing something that may push ethical barriers, we may not be able to have a license to work with the neurons we are working with. That might actually limit our chance of getting funding in the future. Because sometimes misconceptions may be enough to […] somebody sitting at [The Research Council of Norway], read something where it makes them feel that whatever we do it is a bit outside, or in a grey zone, in opposing some ethical boundaries. […] They will say 'OK, I can't be bothered, next application or next project' (Researcher in neuroscience).

As this quote shows, ethical considerations around neuroscientific work influence how audiences might perceive or judge communication from NTNU Cyborg, and institutional mechanisms such as licenses and grant review processes may present barriers for conducting research. Communication, then, was deemed particularly risky for this group of researchers, perhaps contributing to the urgency with which they raised concerns about visual representation and nomenclature within the NTNU Cyborg initiative. The structural elements of the cyborg's affordances in communication settings outlined above – in particular its *requesting* attention, *encouraging* experimentation with different expressions, and *discouraging* alternative starting points for communication – can be read as interrelating to create a particularly volatile and unruly communication tool for the neuroscientists in the initiative, when considered in light of the model's relational elements. Neuroscientists in NTNU Cyborg not only lacked the *dexterity* to manipulate the communicative possibilities offered by the cyborg, but also risked losing *cultural and institutional legitimacy* through their association with the cyborg, insofar as communication risked triggering institutional sanctions against their research and careers. For this reason, when the cyborg is seen to *encourage* experimentation in communication forms for cyberneticists, it may be more accurate to say that what is being *encouraged*, for neuroscientists, is risk-taking.

Although informants did not think the cyborg helped them secure external research grants, they did acknowledge a role for the cyborg in the initiative's ability to secure local institutional support at NTNU. NTNU Cyborg was described as being about: 'institutional profiling where NTNU appeared as working on hairy problems and as an exciting community' (Initiator and research director). The cyborg's communicability helped make NTNU Cyborg a 'flagship project for NTNU' (Researcher in neuroscience), and something that could 'affect internal strategies at the institution' (Associate professor in computer science and former project coordinator). One interviewee thought the cyborg's popularity was helpful for administrators at strategic levels of the organization: 'If we get hose newspaper stories, it means that the work of [Initiator and research director] and the people at the [college] where money is channelled through, their work is made easier' (Associate professor in cybernetics). Another interviewee expressed a

sense of responsibility towards the university: '[it] has to do with reputation, both for the project and of course NTNU [and its strategic initiatives]' (PhD student in cybernetics).

The cyborg *allowed* synergistic activities such as institutional profiling aimed at student and faculty recruitment, aligning research goals with organizational visibility and strategy. But the cyborg, as a mechanical object, also *demanded* significant resources in the form of person-time, equipment, and expertise, in order for its affordances to be utilized in these ways. Over time, NTNU Cyborg received funding through a number of strategic support mechanisms at the university level and from participating departments and schools. Mechanisms included resources from NTNUs strategic research areas, as well as 'discretionary funds […] from the college' (Professor in computer science and project coordinator), and 'PhD fellowships that […] NTNU has funding for from the Research Council' (Professor in computer science and project coordinator). These internal support efforts allowed the nascent research community to take initial steps towards bigger research efforts that eventually proved competitive and secured external funding:

> [W]e have been acting locally. To secure funding in the different departments, for sub-components of the project. Cybernetics, computer science, neuroscience, and so on. And when we had this group of people up and running with internal resources, we could create proofs of concept of this project. And then apply for external funding (Associate professor in computer science and former project coordinator).

> The SOCRATES project which we received from the Research Council of Norway, that is a project with external and internal [partners], and in the order of twenty million crowns. […] And that project would not exist without the Cyborg project (Professor in computer science and project coordinator)

NTNU Cyborg's ability to generate media attention was described by informants as instrumental for the initiative's ability to secure support from within the organization. The purchase of the off-the-shelf humanoid Pepper robot in 2017 (bottom right in figure 1 above), for instance, which offered no research advantages but arguably a more visually appealing reference point for communication than earlier iterations, was financed in this way. 'Obviously, attracting that public attention made a difference for the, relatively modest but nevertheless important internal funding at NTNU' (Initiator and research director).

The alignment between research communicability and institution building appeared to be recognized within the organization. Research communication, according to (Head of communication), is something that 'your management becomes aware of it […] the management at the college and NTNU love to brag about these kinds of projects. […] and then NTNU can bask in that glow, and the rector is satisfied as well' (Head of communication).

> I do not think it makes you into a full professor any sooner, but I think it may make a difference in salary negotiations, and I am positive that it makes it easier for you to secure strategic funding at the institution, funding for scientific equipment (Head of communication).

Individual salaries and strategic funding appear to reward communicable research. Research communication and university representation is routinely orchestrated at campus tours for delegations of policy makers, businesses, or other important visitors, for the benefit of the organization.

> [T]he researcher stands there speaking about their project in a good and entertaining way. That is kind of the package that we offer. And then we use the occasion to have management be part of those meetings [and to] bring attention to themselves and the organization (Head of communication).

Returning to the specific affordances of the cyborg, however, we see that the above dynamic of intertwining research objects with organizational appearances might amplify the risks of research communication as well, thus illustrating the importance of attention to the *interrelations* between mechanisms. One interviewee recalled how the rector (a physician by training), after reading a press article, raised a potential concern with the interviewee's head of department. While the interviewee's account suggested that the rector's comments were made in a jocular manner, to them it still served as a reminder of the risks associated with NTNU Cyborg's visibility:

> [The rector] coincidentally met my head of department, and he said 'But are you actually, are you having a brain connected to some cyborg? There are many ethical issues here.' […] And we have had also, rather, disagreement or at least discussions about why this is not acceptable from a neuroscience point of view. So, I will say there has been at least a risk of actually cutting down this activity for us. Because if my department head has said 'I don't want you to continue' I have no choice (Researcher in neuroscience).

This episode was widely known and discussed among the collaborators, and one PhD candidate described the experience as a wake-up call about the implications of attracting media attention: 'It is taken seriously, definitely. […] it brings home the seriousness of the situation' (PhD student in neuroscience A).

Building collaboration

A third dimension explored in interviews was whether the cyborg affected the formation and cohesion of the NTNU Cyborg collaboration, which 'is really about different things for different groups' (PhD student in neuroscience A). Interviewees gave different accounts of this topic.

> [M]y interest in the project is actually the interface [between biological neural networks and a cyborg, and] whether you can have a closed-loop communication between the two, where learning processes can be transferred based on behaviour either of the neural networks or the cyborg. And the interest I have in this is […] possible applications in the clinic. Like for example neuromodulation, or bio- or neuro-prosthetic devices (Researcher in neuroscience).

> [O]f course it is the dream of us computer scientists to have, so, different computers, like brains for example, or the components of the brain, like neurons, and it is the dream of neuroscientist to have the algorithmic skills to analyse their data and use machine learning to train models to make sense of it (Associate professor in computer science and former project coordinator).

> But really when we talk about the research interests we have here, no one are really concerned with the cyborg […] I think that none of us have that as a main research focus. […] It is all overlapping Venn diagrams. Which say that here we can make a cyborg and even be in the newspaper. […] Yes, we all have our primary interests, and then they overlap in something that […] allow us all to reach our goals (Associate professor in cybernetics).

For one interviewee the cyborg had been the main attraction: 'It was critical. That was why I joined the project. […] the basic idea, essentially. It was incredibly exciting' (PhD student in neuroscience B). Interviewees also considered disciplinary research to be strengthened by their association with emerging research agendas in other disciplines:

> [The cyborg] brings it together. Something that can take all the different research agendas that do not actually align. Actually, bring them together, and say that if we give it this name, it becomes meaningful for us to work together. And for [PhD student in cybernetics], their publications are strengthened tremendously by having backing from the hospital. Benefitting from the technological or conceptual or whatever it is, from [the cybernetics and computer science partners]. That there are synergies here, where we all come out stronger (Associate professor in cybernetics).

In structural terms, the cyborg not only *allowed* group formation, but also *demanded* a degree of interdisciplinarity given that a cyborg by definition merges biological with synthetic elements. As the latest quote implies, the cyborg may have *encouraged* participating researchers to associate themselves with others in the initiative. One interviewee thought NTNU Cyborg only expedited collaboration that would have emerged sooner or later: 'in either case we would have taken contact across campus, to actually seek those collaborations which we lacked a couple of years ago' (Researcher in neuroscience).

As earlier sections show, the cyborg certainly influenced how and when the need for shared and coordinated nomenclature arose within the group. The use of the word 'brain' in newspaper articles prompted internal discussions and a transitioning from improvised communication to more consistent terms and narratives: 'computer scientists refer to artificial brains as a kind of set of even twenty neurons. […] So, this is also possibly a little bit our fault. [Then, after internal discussions] we were very careful [to] not mention the word brain at all' (Associate professor in computer science and former project coordinator). Only some of the contributing researchers appear to have felt *encouraged* to use this particular language when communicating about a cyborg, however.

Communication experiences also brought other differences between the research traditions in NTNU Cyborg to light:

> [We] work with rat neurons, but the neuroscientists work with human neurons [to better understand] ALS and Parkinson's and similar diseases. […] And in one of these interviews […] they stated that, and we received a bunch, a burst around it being human-like. [..] Suddenly it was human brain cells, and they were extremely excited (Professor in computer science and project coordinator).

As this quote shows, the use of human-sourced neurons changed the dynamics of media attention into something previously unfamiliar to the computer scientists in the initiative. The neuroscientists, presumably more experienced with bioethical implications of research, might have been more habituated into considering the public reactions to and institutional sanctions against their work, thus (relationally) *perceiving* risks associated with the cyborg in situations where computer scientists and cyberneticists *perceived* opportunities for exploration and spectacle. Nevertheless, reflecting on how the cyborg had influenced the collaboration, one informant described it as a model for interdisciplinarity:

> [A]s of now the cyborg is one of our role models for how we have stimulated activity across disciplinary communities who would not otherwise interact. […] the deans who are involved also see this. Definitely. But this is what is so difficult, namely to find the 'what's in it for me'-component so that a collaboration like that does not simply, does not only work when money are steadily trickling in, but that it is self-driven because people recognize that they can stimulate their own careers and their own research agendas by contributing to shared tasks. That there is sufficient scientific fodder, epistemological fodder there for each discipline to advance, so that they do not need to abandon their own disciplinary goals by joining the project (Initiator and research director).

Reflecting on a recent meeting with representatives from different disciplines, one researcher stated 'there we were actually able to speak with each other. And I think that can be attributed to [NTNU Cyborg] which established that common language' (PhD student in neuroscience B). Another researcher stated that '[people] sitting across tables, different disciplines, and actually trying to understand each other's language […] was very important' (Researcher in neuroscience). The cyborg, to these interviewees, *demanded* that each collaborator articulate their research agendas and priorities in relation to it, thus ensuring a common focus for and *encouraging* collaboration.

The interdisciplinary collaboration in NTNU Cyborg initially sought to include ethicists and social scientists, in anticipation of the initiative's interest to the public and in recognition of the ethical and societal questions raised by its topic. As one informant stated while reflecting on the questions the use of the word 'brain' might evoke:

> [I]t is nice to be aware of these things, and discuss, and when we can't find the answers, actually, seek interaction with other people, and see what they think. Like for example people who are working with ethics, perspectives et cetera (Researcher in neuroscience).

Interviewees stated that early ambitions of including ethicists and social scientists in the initiative fell short, partially as a consequence of the initiative's reliance on a myriad of sources of internal funding of person time and equipment from within departments and strategic pots of money at NTNU, which directed acquisition-efforts towards technical units. We might see this as an instance of interrelating mechanisms of affordance; the cyborg's affordances as an object of communication helped activate institutional support based on the promise of a material cyborg aligning technical research and organizational strategic aims, thus directing efforts towards technical equipment and expertise rather than systematic ethical and societal reflection.

Discussion

Returning to our research question (*how does the cyborg afford particular outcomes of research communication, and how do its affordances manifest for different members of the interdisciplinary team?)* we can now describe the affordances of the cyborg in relation to different outcomes of research communication (Table 3).

The cyborg can be seen to *request* attention insofar as its very existence and visual expression is designed as spectacle. The cyborg *allows* for institutional profiling or student recruitment – depending largely on the context in which it is being put to use. The ease with which different avatars, sounds, lights and other parts can be added or adjusted also means that the cyborg *encourages* tinkering and experimentation. What it *refuses*, on the other hand, is to serve as a direct representation of what the participating

Table 3. Mechanisms of Affordance: How Do Artefacts Afford?

	The cyborg …
… requests	Attention
… demands	Resources, visual representation, 'management' as communication object
… encourages	Tinkering, exploration, and improvization, institutional support, risk-taking
… discourages	Alternative starting points for communication, the (internal funding of) inclusion of social scientists and ethicists
… refuses	To enact or directly represent technical research
… allows	Institutional profiling, interactivity, student recruitment, communication and mutual understanding between fields
Mechanisms and their interrelation	Technical resource demands more urgent than including ethicists and social scientists, the refusal to serve as a direct representation of research, requires 'management', attention amplifies risk

researchers consider to be their primary or substantive research objectives; instead, as interviewees report, computer scientists and neuroscientists alike, are forced to manage communication settings and segue from audiences interest in the cyborg towards what they consider to be more significant content. The cyborg in this sense also *discourages* alternative starting points for communication, since its very availability as a tool or prop for communication settings, dissuades researchers from relying on other aids in their external communication. As a material assemblage it also *demands* resources for maintenance, parts, and skilled operators.

When one considers for whom, and under which conditions, the cyborg affords (Table 4), there appears to be variability between the NTNU Cyborg participants in terms of the benefits and risks of using the cyborg in communication efforts.

Here, the cyborg affords broader agency to computer scientists and cyberneticists than to neuroscientists. Risks of damaging reputations or triggering organizational sanctions that prevent important research, on the other hand, are more keenly felt by neuroscientists. Both the risk and the autonomy around communication around the NTNU Cyborg initiative thus appears to be unevenly distributed. The emergence of mutual understanding and coordination between the contributing fields around word-choice and narratives over time, can be interpreted as a developing sense of responsibility towards each other as collaborators and to the host institution, in ways that are directly influenced by the connotations and affordances of the cyborg. These observations have implications both for RRI and for science communication.

For RRI, on-going efforts to institutionalize reflexive and societally oriented capacities at research-performing organizations through mechanisms that motivate and reward communication and outward-facing initiatives, may do well to let the selection of communicable topics for flagship-type initiatives itself be subject to systematic scrutiny and deliberation, acknowledging the distinct opportunities and risks that such choices may open up. This would also enable greater intentionality within the fragmented landscape of mechanisms supporting public communication and engagement-related activities at

Table 4. Conditions of Affordance: Affordances for Whom and Under What Circumstances?

Perception	Computer scientists, cyberneticists see ways to explore and improvise
Dexterity	Cyberneticists manipulate the cyborg
Cultural and Institutional Legitimacy	Legitimate signalling of technical innovation for computer science and cybernetics Ethically questionable and risking organizational sanctions on neuroscience research

European research institutions (Neresini and Bucchi 2011). In our case study, public visibility has been gained less by organizational mechanisms designed to encourage communication in a generic sense, and more by the specific features of the cyborg and their manipulation by certain members of the NTNU Cyborg initiative.

For science communication, the material analysed here shows that scientists' motivations for engaging in public communication may be both more instrumental and more opportunistic than what current research on strategic science communication appears to suggest. In the current study, researchers seem attentive to the ways in which the cyborg affects journalists' expectations, and adapt to what they consider to be the expectations and interests of different audiences in order to manoeuvre between getting attention, segueing towards preferred topics, and performing in ways that align with the priorities and norms of collaborating colleagues from other disciplines.

Neither the initial choice of the cyborg as a reference point for communication, nor the early experimentation with communication, were subject to systematic planning, deliberation or consideration, and the ethical and societal implications of 'propping up' the NTNU Cyborg initiative could have benefited from more systematic reflection – particularly, perhaps, about the stakes for contributing disciplines. This is a potential area where future attention towards organizational mechanisms for RRI may be directed. As university flagship research initiatives emerge to showcase research communities' claims to societal relevance, the choice, packaging, and implications of objectification and visualization of research efforts may be a fruitful focus for RRI methodologies and institutionalization.

Conclusion

The cyborg, we argue, has contributed to a shared sense of community and focus across disparate research groups while aligning with organizational strategic priorities for branding and student recruitment. Yet, the cyborg's affordances vary in their availability to participating researchers, and the risks of foregrounding it are unevenly distributed within the initiative. Its intentional use as a reference point for communication has been continuously experimented with, evaluated, and adapted over time. The early choice of the visual and material cyborg as an outward-facing reference point for the initiative, largely escaped critical questioning by the participating researchers, despite their awareness of and interest in ethical and societal implications associated with constituent technical fields such as artificial intelligence, genetic engineering, and humanoid robotics.

In the case presented here, the 'prop' and its affordances as exerted in relation to organizational contexts, logics, and support mechanisms have significantly influenced the ways in which NTNU Cyborg emerged as a broad interdisciplinary research effort with high public visibility. Further research and attention to the dynamics of university flagship research initiatives and the interplay between individual researchers' motivations, organizational factors, and the particular affordances of objects of research communication, may be helpful to realize RRI's ambitions for early and meaningful public engagement.

Notes

1. A counterpoint to what Wynne (1992) calls the *deficit model* view of the public as in need of expert guidance.
2. This receptiveness contributed to the conception and funding of the project on which this publication reports.
3. NTNU's campus includes natural science facilities at the campus area Gløshaugen, but also laboratory and department space in buildings operated by the nearby, institutionally separate St. Olav's University Hospital.

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Notes on contributors

Mads Dahl Gjefsen is a Senior Researcher at the Work Research Institute, OsloMet – Oslo Metropolitan University, and a researcher at Ruralis Institute for Rural and Regional Research. Gjefsen's research background is in Science and Technology Studies, and he has held non-research positions related to innovation and intellectual property management. His research interests include technological promise-making as well as theories and methods of participatory processes.

Knut Jørgen Vie is a PhD student at the Work Research Institute – Oslo Metropolitan University. His main resaerch interests are research ethics and research integrity from an organizational perspective, and responsible research and innovation.

ORCID

Mads Dahl Gjefsen http://orcid.org/0000-0002-8862-7582
Knut Jørgen Vie http://orcid.org/0000-0002-8228-6078

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Appendix: Semi-structured interview topic guide

- General introduction to the project and its history, getting started
- General overview of attention and communication
- What types of dissemination activities, broadly defined, have been carried out, aside from media appearances?
- How was contact with the media been established? Who initiated it?
- Did they think journalists conveyed what the researchers themselves saw as the most important research objectives?
- Has the media attention influenced research in terms of choices of topic or methods, or its quality?
- How has dissemination been discussed internally? Process and reactions, what has worked and what has not?
- What has the collaboration been like with NTNU's communication staff during the course of the project?
- What has motivated the research dissemination activities within the project?
- What do the project managers consider to be the most important questions of societal and ethical interest within the project? Why is the project important?