"Should We Stay or Should We Go Now?" Dis/Engaging with Emerging Technosciences

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Abstract

In this paper we focus on a special feature of science and technology studies: the trajectories of our engagement with 'emerging technosciences'. Many of us entertain close links to a particular group of scientists; our scholarly careers and identities build around thematic specialisations, trans-field collaborations and convivialities. But more often than not, such engagement does not last a whole career. With every new technoscientific hype, scholars are pressed to 'move on', to disengage from one field and re-engage with another. It thus seems warranted to explicitly reflect on the temporal patterns of dis/engagement and to look at possible ramifications for individuals, collectives, and the innovation system at large. To inform such reflection, we opted for a mixed-methods approach, tracing patterns and moments of dis/engagement across various disciplines based on scientometric analysis, individual archaeologies of engagement, a qualitative survey, and a focused discussion among fellow scholars from the social sciences and humanities as well as the sciences. Our analysis brings distinct dis/engagement patterns to the fore, relating to disciplinary affiliations as well as career stages. In our conclusion, we discuss the relevance of these findings for science and technology studies scholars and technoscientists as well as for contemporary innovation regimes more generally.

Keywords: Systems Biology, Dis/Engagement, Interdisciplinary Collaboration, Disciplinary Identity, Scientific Community, Innovation Regime.

Introduction

Practicing Science and Technology Studies (STS) comes with the necessity to bridge, in one way or another, the boundaries between social sciences and humanities (henceforth: SSH) and various science and engineering fields (henceforth: TS for technoscience).[i] Interdisciplinary cooperation between SSH and TS has consequently been an important topic of reflection. Various collaborative constellations have been accounted for, from early laboratory studies that "manage[d] to get inside the laboratory walls and show that there too was a political world of negotiated or coerced pacts to get along in the accepted ways, to see what should be seen" (Doing, 2007: 279), to the

introduction of 'ELSI research'. This research into the Ethical, Legal and Social Implications (ELSI) of technoscience came with an advisory remit. It has been followed by co-constructive 'post-ELSI' and 'Responsible Research and Innovation' (RRI) programmes, intervening more upstream in science and engineering research and education. STS scholars have extensively discussed these modes of SSH/TS interaction, considering roles and power regimes within collaborative work and methods of 'collaboration as method' in its own right. But while the overarching collaborative trends between SSH/TS have been well outlined and questions of how we collaborate (Prainsack et al., 2010) or how we should collaborate (e.g., Balmer et al., 2015) in single interdisciplinary projects have been well addressed, the overarching dynamic of engagement and disengagement represents a largely unexplored aspect of STS. How and why do individual scholars and scholarly collectives engage with a particular hyped field and, in turn, how and why do they dis/engage again?

In this contribution, we explicitly reflect on the temporal patterns of dis/engagement beyond the single project and look at their ramifications for individuals, collectives, and the innovation system at large. Other than micro-studies that mostly highlight differences between and opposition of TS and SSH, pertaining to power asymmetries, role divisions, and communication barriers, this wider horizon can serve to identify the recurring requirements of engagement and disengagement. It focusses on the potentially similar challenges for scholars from both realms and acknowledges that TS and SSH scholars ultimately collaborate within the same innovation regime, even if belonging to different epistemic cultures (Snow, 1961) or engaging with different societal functions and visions.

A discussion of TS/SSH collaboration within this broader context allows us to benefit from existing analyses of general change in academia or change in innovation regimes. Literature includes the outline of a transition from Mode 1 to Mode 2 science (Gibbons et al., 1994), from normal to post-normal science (Funtowicz and Ravetz, 1993), from academic to post-academic science (Ziman, 2000), and to strategic science (Rip, 2002) or technoscience (Forman, 2007). It resonates with diagnoses of change in university organisations and cultures in higher education research towards the 'managerial' or 'entrepreneurial' university (e.g., Slaughter and Leslie, 1997) and with findings from science policy studies. Various analyses highlight changes in funding schemes – the "transition from exclusive block funding of universities and research organisations to a split funding mode of block funding and competitive grant funding" (Laudel, 2023: 74; see also Gläser and Laudel, 2016) – and funding rationales, reassessing the relative worth of pure research, financial returns, and societal benefits (see also Wallace and Rafols, 2015). It discusses the formative power of discourse in science policy – including 'buzzwords' (Bensaude Vincent, 2014), 'big words' (Bos et al., 2014), and 'umbrella terms' (Rip and Voß, 2013) – as well as resulting hype cycles (Seifert and Fautz, 2021). General systemic tendencies point towards increased (interdisciplinary) collaboration, future-orientedness, fluidity, reactivity, and speed.

To research the temporal patterns of dis/engagement with a view to both the micro- and macro-perspectives outlined above, we chose a mixed-methods approach, targeting the empirical case of systems biology as an exemplar of an 'emerging technoscience'. Established around 2000 as a prominent field of innovation with substantial support from dedicated funding programmes (Kastenhofer et al., 2012), systems biology immediately started to attract attention from science and technology studies scholarship. This attention seems to have waned again in the past years – a hypothesis we wanted to test in quantitative terms. Moreover, with a full cycle of engagement and disengagement, the case is suited for investigating both these movements in qualitative terms, reconstructing the trajectories, experiences, and perspectives of scholars as they either embraced or distanced themselves from this field.

After a more detailed presentation of prevalent perspectives on collaboration and engagement in STS and a delineation of systems biology as an empirical case in the next two sections of this paper, we will retrace the temporal patterns of engagement and disengagement in quantitative terms, by considering topical publications

over time and per discipline. Consecutively, we will present qualitative research results that cover trajectories of dis/engagement for individual scholars: starting with our own histories with systems biology, we move on to delineate narrations collected from a broader variety of scholars. We analyse factors for engaging, staying, and disengaging with systems biology and sketch distinct narratives of dis/engagement while also discussing differences and similarities across various disciplines. In our conclusion, we more generally address the relevance of these patterns of dis/engagement for our understanding of ELSI activities and for contemporary innovation regimes.

Science and technology studies' perspectives on collaboration and dis/engagement

There are at least four ways science and technology studies scholarship can be related to engagement. Firstly, anthropologists of science have stressed the affective dimension of scholarly work and the 'engaged habitus' of academic scholarship. Being in academia comes with an expectation of also being emotionally invested. Already in 1942, Merton referred to the "passion for knowledge, idle curiosity, altruistic concern with the benefit of humanity and a host of other special motives" attributed to the scientist and sought their origin in "a distinctive pattern of institutional control" (Merton, 1942: 124). Passion and personal engagement are again on the agenda with the recent turn of STS to the affective dimension (e.g., Schönbauer, 2021; Davies, 2021). Secondly, STS has been presented as an 'engaged programme'. Sismondo (2007) builds on this notion to address "the part of STS that focuses on reform or activism, critically addressing policy, governance, and funding issues, as well as individual pieces of publicly relevant science and technology; it tries to reform science and technology in the name of equality, welfare, and environment" (Sismondo, 2007: 13). Thirdly, STS has become a 'programme of engagement' with the participatory turn in technoscience governance around 2000, aiming to engage publics in technoscientific as well as political decision-making. And, fourthly, practising STS requires a certain engagement with the technosciences, their literatures, practices, cultures, communities, institutions, and individual scientists. In the following, we will focus on this fourth variant of addressing engagement in the context of STS as it is directly relevant for our case, while keeping in mind the other three forms of addressing engagement.

Engagement with technoscience is built into the very programme of STS. For a long time, modes of engagement were mostly the topic of methodological reflections – of how to do sound laboratory ethnography and navigate between 'the field' and one's own disciplinary home. Although the early laboratory studies' epistemological aspirations had resulted in fierce debates between positivist and constructivist camps, they did not yet trigger systematic reflections about STS' relations with the technosciences. This situation changed when STS entered more public and overtly political arenas in the late 1990s and scientists and SSH scholars became more visibly juxtaposed. In the wake of the 'Sokal affair' of 1996, Hacking (1999) scrutinised the multiplicity of roles of constructivist STS scholars. In parallel, public critique of governmental response to the BSE crisis in Great Britain and public controversy regarding agrobiotechnology regulations in Europe triggered a shift in the technoscience governance paradigm. Along a new ELSI programmatic, major technoscientific funding initiatives like the Human Genome Project started to integrate research into social dimensions on a regular basis. Transparency, participatory decision-making, and scrutiny of potential side effects of technoscientific innovation became core components of responsible innovation policy. Scholars analysed the new role sets of STS when publicly entrusted with advisory as well as integrative functions, such as designers, organisers, moderators, evaluators, or commentators in public consultation exercises (Hoppe, 2005; Gisler and Schicktanz, 2009; Bauer and Kastenhofer, 2019). Overall, collaboration, "nearly always imbued with a positive connotation in the late twentieth and early twenty first centuries" (Shrum, 2010: 247), became more scrutinised by STS scholars, including interdisciplinary collaboration (Frickel et.al., 2016).

This critical view is echoed in empirical analyses of STS engagement with technoscience. Studies focus on power asymmetries between collaborating TS and SSH scholars (e.g., Rabinow and Bennett, 2012) and intricacies of scholars' political engagement (e.g., Hackett and Rhoten, 2011). As a result of engagement challenges, STS scholars now suggest the establishment of dedicated collaborative spaces for RRI (Carter and Mankad, 2021; Flipse et al., 2014) and a 'post-ELSI' collaboration agenda (Calvert and Martin, 2009; Balmer et al., 2015). Yet others focus less on the strategic and political aspects of SSH/TS collaboration. Instead, they use anthropological perspectives to delineate practices of affective companionship and care (Mol, 2008; Puig de la Bellacasa, 2011; Adam and Groves, 2011; Viseu, 2015), entanglement (Fitzgerald and Callard, 2015), and attachment (Smolka et al., 2021; de Laet et al., 2021) and thus contribute to what Law and Ruppert (2016) grasped as more 'baroque' conceptions of knowing. Two foci of this work take a prominent place in our own analysis and shall thus be highlighted here: a focus on the affective dimension and a focus on the temporal dimension of engagement.

The temporal dimension of STS work has is addressed by Felt (2016) with a view to the 'temporal choreographies of [public] participation'. Building on Mol's (2008) distinction of a 'logic of choice' versus a 'logic of care', she notes that:

> [p]olicy-makers appear to be quite attached to the idea that there is an ideal moment in the developmental trajectory when sociotechnical issues can be assessed once and for all; after that 'moment of engagement', research should be left on its own again. (Felt, 2016: 192)

Felt's analysis opposes this idea of a production-line of new technoscience certified for societal acceptance via punctual engagement exercises, while advocating for "a wider process of caring" (Felt, 2016: 192?). A recent volume edited by Vostal (2021a) further analyses rhythmic patterns in contemporary academic 'timescapes' diagnosing a "further and tighter approximation, if not a merge, of cultures/practices of variations of capitalism in academia" (Vostal, 2021b: 2), including a 'will to speed'. In this volume, Felt's chapter addresses the power dimension of "the regulation of rhythms, duration, speed, sequencing, and the synchronisation of events and activities" (Felt, 2021: 79–80), but also speaks to the deep affective/collaborative entrenchment of temporal(ised) practices via 'chronosolidarity' and moments of collectivised resistance and repair work.

This leads us to the second focus we want to briefly elaborate here: A rising interest in affects and emotions in STS analyses of scientific collaboration, furthering our understanding of the socio-psychological aspects of dis/engagement. Smolka et al. (2021: 1076) have illustrated how "attending to affective disturbances can open up possibilities for productive engagements across disciplinary divides" (see also Hillersdal et al., 2020). Scholars have highlighted the 'affective costs' of SSH/TS collaborations (Viseu, 2015) and – once again – the power dimension of 'feeling rules' (Smolka et al., 2021 in reference to Hochschild 1979). Yet others have delineated positive effects of affect, as "hot spots and hot moments" can fuel a collaborative group's scientific performance and drive a "scientific and intellectual social movement" (Parker and Hackett, 2012: 21). But overall, these scholars attended to the affective dimension of specific collaborations rather than to the affective dimension of dis/engagement beyond the single project.

To explore the temporal and affective aspects of SSH/TS collaborations, we consider a further strand of STS discourse: analyses of the contemporary innovation regime, its institutional ecosystem, and its governance practices. We particularly want to highlight the rising importance of competitive third-tier research funding and the rising share of so-called strategic or mission-oriented funding programmes. This twofold shift has influenced not only research topics and approaches but also the mechanisms and patterns of innovation in academia. In fact, it has brought about the very phenomenon of 'emerging technosciences' (e.g., Raimbault and Joly, 2021) and the related discursive logics, lobbying networks, and promissory practices (Hedgecoe and Martin, 2003; Brown and Michael, 2003; Schyfter and Calvert, 2015; Kreimer, 2022). In the following section, we shortly illustrate how these aspects of the contemporary innovation regime relate to our empirical case of systems biology.

Engaging with systems biology as an emerging technoscience

The emergence of systems biology dates back more than twenty years.[ii] Systems biology has been defined in scientific textbooks as "the combined study of biological systems through (i) investigating the components of cellular networks and their interactions, ii applying experimental high-throughput and whole genome techniques, and (iii) integrating computational methods with experimental efforts" (Klipp et al., 2009: XVII). Other texts put more emphasis on its epistemic theme rather than on the interdisciplinary epistemic practice by stating that "[s]ystems [b]iology indeed consists of a number of related, well-defined topics, […] all focusing on the mechanisms behind the emergence of functionality" (Alberghina and Westerhoff, 2008: 7) or on its paradigmatic approach, defining systems biology as an attempt "to understand at the system level biological systems that are composed of components revealed by molecular biology" (Kitano, 2001: 1).

The considerable effort invested in defining and demarcating systems biology as a distinct approach or field hints at the strategic importance of such practices. Systems biology's (stated) newness required establishing its identity and thus facilitating effective communication and collaboration within academia. Furthermore, systems biology had to be presented as a unique strand of research by demarcating it from other scientific paradigms, networks, and activities so as to secure dedicated research funds. Or, in the words of two leading systems biology proponents: "A definition can help to identify a new era of science where there is much potential for progress. It can also help direct research effort to where it should be rather than continuing to be spent on the same topics but under a new name." (Alberghina and Westerhoff, 2008: 7). Thus, the pursuit of defining systems biology was linked to distinct features and constellations of the contemporary innovation regime. Definitions served as a medium for boundary work (Gieryn, 1983; Star and Griesemer, 1989) both in a negative sense (allowing for distinguishing systems biology proper from competing approaches) as well as in a positive sense (allowing for identification and engagement of a variety of actors across science, policy, and industry).

Definitions of systems biology also relate to timelines of development. 'New' systems biology was differentiated from earlier systems-level approaches in biology (Herring and Radick, 2019). It was depicted as a quasi-logical further development of molecular biology or genomics driven by big data ('post-genomics'), as a convergence of previously isolated disciplinary approaches, or as a means to achieve specific aims, such as developing whole-cell in-silico models. Systems biology was showcased as both the result of radical change as well as incremental development, as "new and not new at the same time" (Alberghina and Westerhoff, 2008: 4), "still in its infancy" (Kitano 2001), or "still evolving" (Klipp et al., 2009: XVIII). Finally, presentations of systems biology came with distinct affective aspects, highlighting its revolutionary potential, its epistemic uniqueness (e.g., a holistic approach), and its young, open-minded and collaborative spirit, uniting 'wet' and 'dry' specialities. All these temporal and affective attributions were likely to influence engagement with systems biology for both technoscientists as well as STS scholars.

Moreover, systems biology scholars explicitly invited SSH scholars to join efforts to define and better understand systems biology, starting multi-disciplinary discussions (Boogerd et.al., 2007; Green, 2017). Dedicated systems biology funding programmes made room for ELSI research. The strong role of dedicated funding blurred customary demarcations like the ones between scientific research, scientific meta-discourse, and lobbying for science further. It also dulled the distinctions between scientists, science studies scholars, and science policymakers. All became enjoined in one cross-disciplinary and cross-sectoral scientific/intellectual movement (Frickel and Gross, 2005) that hinged on the labelling of systems biology.[iii] At the same time, new boundaries between 'systems biology proper' and 'not-yet systems biology' were established and enacted. National differences in dedicated funding resulted in in different ways of organising systems biology research (Vermeulen, 2018) and in different levels of engagement by local scientific communities (Kastenhofer et al., 2012).

Methodology

To research scales, patterns, and ramifications of dis/engagement with(in) systems biology, we opted for a mixed-methods approach that combined quantitative, self-reflexive, and qualitative experimental methods in three consecutive steps. Our first aim, to get an overview of the temporal patterns of dis/engagement per discipline, translated into a search for indexed publications that addressed systems biology. Such exercises have already been performed for technoscience publications and we could build upon that work. We added new results for publications from the social sciences and humanities. Details and results of this first empirical step are outlined in the section 'quantifying dis/engagement'.

The second step consisted of a self-reflexive exercise: in dialogue, we reconsidered both of our own histories with systems biology to establish potentially interesting perspectives we could build upon when researching other scholars' stories of dis/engagement. Results of this exercise in 'personal archaeology' are outlined in the section on 'the personal view on dis/engagement'. Based on this self-reflexive exercise, we devised a qualitative questionnaire that we then used with interviewees.

A third empirical step started by collecting potential interviewees from fields engaged with(in) systems biology. As we had already undertaken dozens of interviews with systems biologists in previous projects, we focused on adding sociologists, historians, and philosophers of science by building on the publication search as well as on scholarly networks established during our engagement with systems biology. Responses were collected and analysed with an empirically grounded approach (Corbin and Strauss, 2008) and consecutively discussed with selected scholars at a workshop held at the 2019 conference of the International Society for the History, Philosophy and Sociology of Science. The results of this step are presented in the section on 'understanding dis/engagement in qualitative terms'.

This mixed-methods approach comes with some specificities and limitations: firstly, with the quantitative analysis we opted for a keyword-based selection of publications, risking false positives and false negatives as to papers representing systems biology qua theoretical and practical paradigm rather than qua keywords, but all the better capturing discursive dis/engagement with the very label of 'systems biology'. Secondly, our sample includes some important scholars (if importance is assessed by published articles), but it does not represent the full diversity of systems biology scholars. For example, it includes scholars from diverse disciplines and career stages, but not scholars beyond Europe and North America. Thirdly, when it comes to causal theses about a link between distinct characteristics of the interviewee (discipline, location, career stage) and the experiences and positions narrated, the small number of interviewees has limitations. Therefore, we based our analysis on causalities outlined within the stories as well as on a comparison between stories and only cautiously propose causal hypotheses. Fourthly, a narrative approach has the special characteristic of not focusing on facts but on "memories of earlier events […] influenced by the situation in which they are told" and by everything that happened in between the told incident and the narration of this incident. Moreover, "the narrative takes on some independence during its recounting" (Flick, 2014: 273, 268), independence from the interviewer's own mindset, categories, or language. Finally, our 'personal archaeology' adds potential as well as limitations as it certainly comes with its own blind spots. Besides drawing our readers' attention to these issues in this sub-section, we will consider all of them in our analysis and discussion as best possible.

Tracing temporal patterns of dis/engagements per discipline in quantitative terms

Dis/engagement of technoscientists and social sciences and humanities scholars with systems biology can be outlined in quantitative terms. It can be measured by checking the term 'systems biology' in keywords of scientific publications and in the names of research groups and institutions. For the natural sciences, such quantitative analyses have already been presented in the past (Powell et al., 2007). Kastenhofer et al. (2012: 1) report that "[t]he number of publications featuring 'sys-

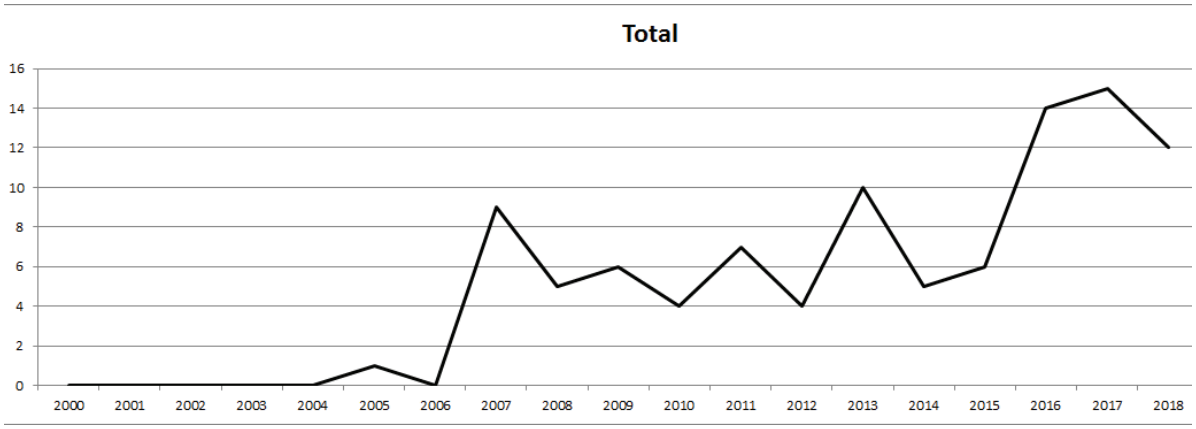

Figure 1. Philosophical, historical and sociological papers on 'systems biology' (Social Sciences Citation Index SSCI + Arts & Humanities Citation Index A&HCI 2000-2018 web of science, 'Systems biology' as topic, search 2 July 2019, Total number = 102 papers)

tems biology' as a keyword has increased steadily from four in the year 2000 to 1362 in the year 2011 (…). The relative frequency of such papers shows the same steady increase with a stabilising trend since 2011." A repetition of this search (Web of Science, 4 August 2022), reveals a flattening of the curve after 2012 from 1496 to 1129 publications in 2019. In 2021, the number only slightly recovered in absolute terms to 1248 publications.iv Although scholarly publications still refer to systems biology, the obvious historical peak was in 2012.

For this project, we performed another search in the Web of Science database, focussing on publications from the social sciences and humanities. This resulted in 102 papers from the Social Sciences Citation Index (SSCI) and the Arts & Humanities Citation Index (A&HCI) between 2000-2018, with the topic 'systems biology' and categories relating to the history, philosophy, and sociology of science (including 'social issues', 'ethics' and 'education research', see Figure 1).

The first paper had been published in 2005 and the number of papers per year was still increasing moderately. As to the disciplinary split of these papers, the largest and most clearly still rising component was categorised as 'history and philosophy of science'. Another discernible component consisted of papers on 'social issues' and 'ethics', with some peaks in 2007, 2012/13, and 2016/17 (see Figure 2).

While finalising this paper in August 2022, another search was performed to clarify the later development of this trend: the total number of papers had further decreased to 13 papers in 2019, 12 papers in 2020 and 8 papers in 2021, thus confirming a peak around 2017 and a consecutive downward slope, in line with other factors like the

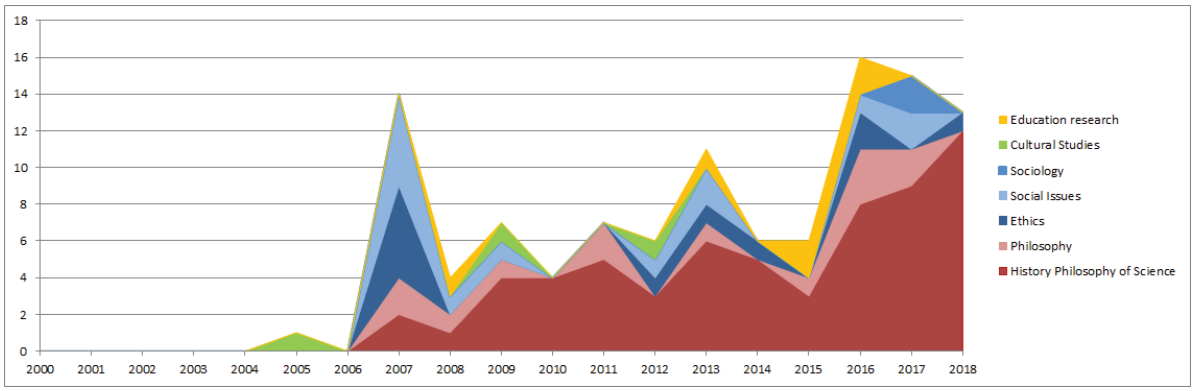

Figure 2. Disciplinary split (same search, with plural attributions slightly changing the total sums per year; 'social issues' includes 'social sciences biomedicine', 'ethics' includes 'medical ethics', 'sociology' excludes 'social issues', 'philosophy' excludes 'history philosophy')

move of funding programmes from systems to synthetic biology or artificial intelligence.

A search for social sciences and humanities publications with the keyword 'biotechnology' results in a graph with multiple peaks (e.g., in 2009, 2013, and 2018) with 'history and philosophy of science' taking the lead and 'ethics' outnumbering 'social issues' over time; a search for 'nanotechnology' results in a clear peak in 2016 with 'history and philosophy of science' as well as 'ethics' studies; a search for 'synthetic biology' reveals a later uptake and a less stable trend, starting with two publications in 2007 and meandering between 2 and 10 publications from 2012 to 2019, peaking in 2020 with 16 papers. The disciplinary split resembles that of SSH studies on systems biology, with a slight boost of 'social issues' research. The keyword 'artificial intelligence' again features a more stable presence in SSH publications, increasing from maximum 2 attributions until 2017 to 51 attributions in 2021, spearheaded by contributions on 'social issues', 'ethics', and 'education' rather than on 'history' or 'philosophy'.

Overall, these numbers confirm the hypothesis of field-specific hypes. Hypes seem to result in individual waves – with a systems biology peak in 2012 in TS and in 2017 in SSH, a synthetic biology peak in 2018 in TS and in 2020 in SSH, an artificial intelligence peak still building up in 2021 in both realms – and an overall, wave-induced irregular rhythm of engagement with technoscience.[v] Sticking with the metaphoric language: all waves taken together make for quite a heavy sea.

The personal view on dis/engagement

To further understand these engagement dynamics, we started with an analysis of our own involvements with systems biology. These involvements had triggered our interest in the topic of dis/engagement with an emerging technoscience and they also shaped how we approached it, what we were most interested in, and what we were possibly not aware of. Thus, it seemed only logical to undertake a kind of 'personal archaeology' of dis/engagement before surveying other scholars' experiences.

We had met in Vienna in 2011 when we were both already engaged with systems biology; Niki with a focus on collaboration and in the middle of a move from Vienna to Manchester, Karen with a focus on epistemic cultures based in Vienna and Hamburg. From then on, we had stayed in loose contact, exchanging our experiences, setbacks, and inspirations. In 2014, we organised a joint track on "Systems Biology: A Paradigm at Work" at the 24th International Congress of History of Science, Technology and Medicine in Manchester, gathering other scholars from the history, philosophy, and sociology of science who were interested in systems biology. In 2016 and 2017, we again joined forces in a session and workshop on a more generic theme – 'community and identity in contemporary technosciences' – at the 4S/EASST in Barcelona and later at an STS Austria event in Vienna. Being engaged for more than a decade in researching systems biology, we had started to ponder whether, when, and how we would move on to another topic like some of the colleagues we had initially met in 2014. Over the years, our engagement with the field had waxed and waned, influenced by the availability of funding as well as by our employment histories. We started discussing the various pros and cons of contin-

Figure 3. Niki's unopened boxes

uing some sort of engagement and how such a decision would tie into our epistemic projects and professional careers.

When discussing the issue of staying with or leaving systems biology as a research topic, Niki mentioned that she still had boxes with empirical material from her last research project on systems biology. They had been left unopened since she had changed places years ago, but she had not yet been ready to discard them. This image of the unopened boxes resonated profoundly with Karen as a symbol of her own state of engagement with systems biology and inspired us to collect further pictures, metaphors, and stories to test whether other colleagues were in a similar situation, possibly with similar open questions, or in different situations and possibly holding inspiring answers. The upcoming biennial meeting of the International Society for the History, Philosophy, and Social Studies of Biology (ISHPSSB) provided the perfect opportunity to discuss these issues in a broader community of scholars. We organised a workshop on staying with or leaving systems biology as a research topic or research field and invited pertinent scientists, historians, philosophers, and sociologists. Its title we derived from the song "Should I stay or should I go?" by The Clash, thereby also invoking a specific generational aspect to the issue.

Understanding dis/engagement in qualitative terms

Inspired by our quantitative findings and our bilateral reflections, we composed a questionnaire which primarily invited four kinds of personal narrative accounts: "your story/stories of getting involved in the field", "your story/stories of how you sustained your involvement in the field", "your story/stories of how you moved out of systems biology studies", and "what did you take with you or what do you see as left open or even unopened and lingering?". Participants were encouraged to address those questions that seemed most significant to them, for their own scholarly positioning, reflectionor their own scholarly positioning and reflection. In line with our narrative approach, we called the questionnaire a 'story book'.

After a successful test run, we distributed the questionnaire via personalised emails. We aimed for scholars from technosciences, the social sciences and humanities that had at some point been clearly engaged with systems biology. With an idea that experiences and views might vary with disciplinary affiliation, geography, and career stage, we aimed for a diverse sample of participants. In total, we selected twenty-three scholars: the eight most frequently named authors of the Web of Science search, thirteen further scholars who we knew were engaged with systems biology, and two renown scientists engaged in systems biology. Nine scholars reacted to our query, providing personal stories, perspectives, and opinions. Thus, we had eleven 'story books' to work with (including our own stories), volunteered from two systems biologists, four social scientists, and five philosophers (of which one also affiliated with history of science).

The story books covered between 500 and 2500 words each and were compiled for content analysis along the themes 'initial engagement', 'sustaining engagement', 'disengagement', and 'left-overs'. We analysed them in accordance with Grounded Theory (Corbin and Strauss, 2008), devising empirically grounded codes on 'what drives individual scholars', 'characteristics of the science / innovation system we are part of', 'social and cultural characteristics of our scholarly contexts', 'disciplinary differences in relating to systems biology', 'the very character of systems biology' and finally, 'a nascent discourse on dis/engagement'. The stories also included generic aspects pertaining to career patterns or the role of targeted funding. All results were presented to attendees of the ISHPSSB workshop that assembled some survey participants and other interested scholars and provided opportunity for a plenary discussion resulting in further insights. In the following four sub-sections, we first consider 'factors for engaging, staying, disengaging' and then organise our results on the three themes of 'the innovation system we are part of', 'finding one's place', and 'patterns of change'. To assure anonymity, no pseudonyms are provided; details about disciplinary backgrounds, locations or

career stages are given for individual quotes only when necessary.

Factors for engaging, staying, and disengaging with systems biology

The stories about engaging with systems biology, staying with/in systems biology, and disengaging with systems biology spoke very much to our own experiences as well to the temporal patterns coming to the fore in our quantitative analysis. Most interviewees provided such narratives of change, while a few rejected them outright (an aspect we will come back to later).

Our analysis showed how engagement with systems biology was related to contextual factors, such as discursive hypes, targeted funding programmes, and the local prevalence of systems biology; interactional factors such as the influence of supervisors and collaborators and the perceived openness of systems biology; and individual factors such as pre-existing frames of mind, generic interests, and supplementary expertise that fit well with systems biology. In turn, stories of staying with/in systems biology brought factors to the fore that allowed for an engagement with systems biology beyond a single project, including contextual factors such as discursive settlement, ongoing funding, and the local persistence of systems biology; interactional factors such as institutional support, secure positions, collaborators, and finding a place and being welcomed by systems biologists; and individual factors such as yet unfulfilled epistemic dreams and visions, a wealth of empirical material or a lack of more attractive alternatives. This step, from a single engagement to a series of projects on the same theme, marked the difference between a loose, haphazard commitment, choosing systems biology as just another empirical case, and an ongoing thematic specialisation that might well end up in being identified as a scholar of systems biology. Identification of and with systems biology were sources of ambiguity; for example, should one speak of 'systems biologists' or of 'scientists practicing systems biology'? Was systems biology a field or an approach? Could one demarcate a 'systems biology proper' from systems biology as a buzzword?

Stories about disengaging with systems biology featured mostly contextual factors such as a lack of institutional support, the end of targeted funding, a discourse that shifted away from systems biology, closing down of systems biology centres, or a lack of systems biology at a new location one had moved to due to career requirements. Thus, leaving systems biology was in many cases depicted as an involuntary act and, in some cases, a somewhat painful moment, even when scholars had successfully moved on to another promising theme. Respondents mentioned personal regret at having to leave systems biology. Many aspects were depicted as left open, with questions not yet answered satisfactorily and problems not yet convincingly addressed. There was some ambivalence about the general notion of 'leaving systems biology' or 'systems biology leaving us'; this uncertainty can once again be related to systems biology's unclear denotation as an approach, a paradigm, a field, or a community.

The research and innovation system we are part of

Transitioning from one systems biology project to a series of projects marked the transition from engaging with to staying with/in systems biology and played a crucial role in the narrated identities. However, one of the most prominent forces in the interviewee's narratives on entering, staying with, and leaving the field was public funding and its presence or absence, un/certainty, or time frames. Scholars were well aware of the consecutive waves we tracked quantitatively and our qualitative research delivered more details on the character of these waves and on how scholars navigated them. Funding was depicted as being closely connected to a science policy discourse shaped by promissory lobbying and media cycles.

Likelihood and availability of funding stimulated engagement. For example, one interviewee was told by science policymakers that systems biology was "the currently exciting topic", which motivated them to engage in its study. In turn, a postdoc wrote that "systems biology was not on [their] radar at the time. But when [they] learned of the postdoctoral position with [Y], [they] began to read up on the field and become familiar with it". Scientists engaged in systems biology

research stressed that systems biology was more dependent on targeted funding than other fields or approaches because it was interdisciplinary (and, thus, costlier) and did not fit into the usual funding schemes. This resonates with a statement published by the scientist Olaf Wolkenhauer:

> The truth is that in collaborative life science projects most experimentalists do not dare to make themselves too dependent on other labs – the risk of failure (in terms of receiving further funding and generating publications) is considered too high. A massive change in research culture is required to make real progress. Policymakers need to steer this process; otherwise necessary changes will not happen. Interdisciplinary research requires an extra effort on behalf of all sides, including strategic consideration for targeted research programmes and support for the initiation of cross-disciplinary collaborations. (Interview quote from Casini, 2011: 9)

Uncertainty around funding and its limited timelines influenced dis/engagement, with one interviewee noting that "in the very beginning (…) it also was uncertain whether one would stand a chance of getting funded". The decisive importance of funding gained most momentum in settings with a lack of institutional commitment to the topic and the researcher not holding a secure position. These combined uncertainties led to disengagement with systems biology, also influencing how supervisors advised their PhD students. One scientist reflected:

> I got my PhD in [a related field]. When I wanted to switch to systems biology, the director of the institute and other senior colleagues worried that I would ruin my career with such a focus on biological questions. Now I do not have to worry anymore, because I am lucky enough to have [a secure position]. Now I have the freedom [to choose].

Another early career scholar specified that "the project [they] joined … was funded for five years by the [funding organisation]", thus shaping the timeline of their career, their dis/engagement with systems biology, and their professional identity options.

The importance of intense multidisciplinary and multi-laboratory engagement in systems biology and its discrepancy with expectations held by funding agencies was pointed out by one of our interviewees:

> "If you change the way your experimental partner designs his/her experiment, this is a great success [within systems biology] but not so easy to communicate with a funding body as a big story."

Changing the experimental set-up accounted for an essential innovation in the eyes of the systems biologist (as "a systems approach is a way of thinking, a rational approach to handle complexity") and hinged on intense and costly mutual engagement, while it represented no worthwhile news as such to the science policymaker waiting for marketable technological breakthroughs. Along such lines, scholars assumed that continued funding to engage with systems biology would simply not happen in the highly competitive innovation system. Thus, the innovation regime's definition of desired innovation co-determined the right level of engagement that should be sustained.

Moreover, with continuously changing innovation hypes and topics of targeted funding, the next buzzword at play fostered disengagement. Synthetic biology became an alternative funding target in many countries and when scientists began to move that way, some STS scholars moved with them. Artificial intelligence (AI) was also mentioned several times as a potential successor in attracting targeted funding. With no additional money in the funding pipeline, a new hype equated the likely end of an older one: as AI "[came] along with stunning results from image analysis, published on a weekly basis in top journals", people already "[saw] an end to systems biology as a consequence". However, there was also reluctance to change horses. In some cases, scholars uneasily felt that switching fields had neither been a personal choice nor an epistemic necessity. One interviewee concluded that

> "if you can swing some of that [AI] and machine-learning funding in [systems biology's direction] and you want a[n X] scholar [like me] to tag along, you have my number!"

Continuing engagement depended on the availability of dedicated funds both for systems biology research and for investigating its sociological, historical, or philosophical aspects. Switching from one field to another was not a choice based only on epistemic motivations, but also hinged on this very field and its community persevering over time. This high dependence on dedicated funding also led to a discussion on scientific freedom during the workshop. Certain aspects of the contemporary innovation system were seen as challenging scientific freedom.i

Finding one's place

Especially for the phase of sustaining engagement with systems biology, SSH scholars mentioned that feeling welcome in systems biology or being welcomed by systems biologists was one important factor in finding one's place and deciding to stay. This comprised being invited to joint activities (meetings, preparation of project proposals and co-authored papers), staying in contact over a longer period, making friends, and co-shaping a field's very conceptions and practices. Differences in the individual stories corelated with different disciplinary affiliations. Philosophers of science mentioned most often that they had been invited into the field of systems biology as illustrated by this comment:

> I have been pleasantly surprised by the interest from the scientists in talking to philosophers of science. Some of them even attend philosophy of science meetings and publish on philosophical topics. Thus, systems biology for me is an area where engagement with the scientific practice has been welcomed and where there is a great openness to thinking out of the box. This means that there is also a potential for philosophers of science to not only analyse the practice but also actively take part in it and shape it.

Likewise, the systems biologist Olaf Wolkenhauer stated in an interview that he

> "would urge philosophers of science not to wait until [they/the systems biologists] have died, to only then analyse the work done and where we got it wrong" (Casini, 2011: 10).

He specified that his

> "interest in the philosophy of science and epistemology stems from the fact that scientific explanation in biology is hampered by complexity and uncertainty. (…) Philosophers can help [them/systems biologists] with this." (Casini, 2011: 9)

In sum, philosophy of science – mostly in the form of epistemology – had become a welcome means to support systems biology in its quest to develop and demarcate its own, distinct epistemic approach and paradigmatic position. Historians engaged with systems biology considered the emergence of systems thinking in biology and addressed issues of identity, continuity, and change (Drack et al., 2007; Morange, 2009; Herring and Radick, 2019). Because systems biology reflects contemporary trends, histories of systems biology converged with more sociological approaches in discussing the emergence of systems biology and its novelty.

Sociologists of science also addressed the issue of being welcomed, but in the context of leaving systems biology for other fields like synthetic biology or artificial intelligence. These fields had extended invitations with a view to fix problems with societal acceptance and/or acceptability:

> The [synthetic biology] scientists approached [y] for some social scientists to do ELSI work on a grant they were putting in, and [z] asked me if I would be interested in being part of it. Being approached by scientists to be on their grants wasn't something that had happened to me before. […] synthetic biology seemed to provide more opportunities for collaboration and intervention, because it was perceived to be contentious in a way systems biology wasn't and therefore required social scientific input.

The social scientist also noted that they

> "got more wrapped up in the field and its development than [they] had been in systems biology, where [they] had adopted a traditional detached social scientific researcher role."

Thus, the character of the engagement changed fundamentally with the intensity and rationale of being welcomed by the scientists. With synthetic

biology, sociologists ended up focussing mostly on potential societal issues, whereas systems biology was mostly discussed as an exemplary case of a so-called 'emerging technoscience' (Bensaude Vincent, 2014) or of biology becoming a more collaborative science (Vermeulen, 2009; 2016).

Being welcomed was also an issue for systems biologists themselves. They recounted not having been welcome in the beginning (in the scientific community, at their research institutions, or with their funding applications). The situation had changed only after intense lobbying work, discursive acknowledgment, institutionalisation, and practical habitualisation of interdisciplinary collaboration between physicists, biologists, medical researchers, engineers, computer scientists, bioinformaticians, and mathematicians. What had not met with much approval at first was then (almost) normal.

Adding to the issue of being welcome or not, the issue of 'who knocks on who's door' came to the fore. Olaf Wolkenhauer recounted that "[i]n the first years, [he] as a modeller had to approach the biologists – in the beginning without success." (Bergs and Terstiege, 2016: 66, translation by authors), but over time this changed:

> In the very beginning, collaborations of medical scientists and biologists with us modelers were still high risk. (…) But with time the individual disciplines converged within systems biology. Now, we do not have to argue anymore that it makes sense to build mathematical models. In many projects the scientists know from the beginning that the collaboration will prove fruitful for both sides.

In contrast, for STS scholars the transition from one collaborative project to the next seemed quite bumpy, suggesting that sustained collaboration came less naturally between STS scholars and scientists than among systems biologists. With a lack of institutionalised forms of collaboration, social ties figured strongly in decisions to keep researching the field, next to availability of recurring funding and unsolved epistemic issues: Staying in contact with systems biologists after the completion of a joint project was mentioned as a central factor in thinking about re-engaging with systems biology.

Patterns of change

Just as scholars from different disciplines had been welcomed differently in systems biology, we also found differences pertaining to the general storylines of engagement and disengagement. In this sub-section, we delineate the storylines of engagement along four (partly nuanced) motifs: firstly 'continuous journey', secondly 'going with the flow' / 'being caught by an undercurrent', thirdly 'switching fields', and fourthly 'systems biology ending' / 'systems biology dissolving'.

When a scholar's engagement with systems biology was depicted as part of a continuous journey, then switching fields was not in the picture and change less of an issue. As a philosopher of science stated:

> I don't really see myself as having worked on systems biology at some point and then deciding to stop doing so. I have been working on a whole range of [biological] questions for many years, and at some point, I wrote, or co-wrote, one or two things on systems biology. It was a major topic of discussion […] in the mid-2000 and seemed a natural topic to think and write about then. But I never made a conscious decision that this was what I was working on, beyond deciding to write a particular paper, and I certainly never decided I was finished with the topic.

This account related to a secure, senior position with less likelihood that a shifting funding environment would have an impact on the interviewee's decision about what to work on. It reverberates with a refusal to 'jump on a bandwagon' or to go with the hyped 'buzzword of the day' and does not necessitate the existence of a distinct systems biology place, community, or field. Younger scholars in less secure positions described their engagement and disengagement along pictures of 'going with the flow' or 'being caught by an undercurrent'. In our sample, these also stemmed from philosophers of science, but accounts came with a more instrumental flavour, (not) working on systems biology was depicted as a necessary career choice:

> After these two years, the fact that I had built up expertise in [x] from studying [systems biology] led

> to opportunities I wouldn't have had otherwise. At the same time, I used [x] as a channel to engage with the [y] community here and this has been successful. […] I have moved more deeply into [z] issues, forming a group of philosophers interested in [z]. Again, [x] and [systems biology] have served as my basic entry point.

Junior philosophy scholars also recounted continuity, but seemed more concerned about strategic career building, or basically keeping their career alive.

In contrast, interviewees with a sociological affiliation built on a storyline of 'switching fields' altogether or even 'being switched to another field'. One scholar recounted that "[i]t was synthetic biology that took me out of systems biology." After working on both for a couple of years, they had found that they "couldn't sustain them both" and had stayed solely with synthetic biology as it seemed to provide more opportunities for collaboration and impact. The motif of 'switching' seemed to be specific to ELSI researchers performing applied social research, following a general notion that more or less the same approach could be applied to different technosciences. A change of topics was motivated by ceasing funding, loss of public interest in a topic, and/or the topic being judged as comprehensively analysed. For ELSI researchers, 'switching' meant to build up new collaborative networks and new topical as well as contextual expertise. Another kind of switching was referred to by scholars who switched to a more generic level of analysis, like interdisciplinarity or the general logics of emerging technosciences. They switched from analysing 'a field as such' to an orientation towards analysing a field as 'an example of'.

Finally, we came across the motif of 'systems biology ending' or 'dissolving' in both scientific and SSH accounts. This sentiment aligns with announcements of 'deaths' of specific fields or approaches in the literature (see also Morange, 2008). 'Death of' stories seem to depict a genre in their own right. They can be interpreted as a logical companion to accounts of emergence or radical innovation: because of limited resources (scientific personnel, media attention, funding, etc.) the emergence of new fields must correlate with the demise of existing ones; radical innovations are meant to render existing approaches obsolete. Larry Moran, emeritus professor in the Department of Biochemistry at the University of Toronto, commented on the topic of "Genomics Is Dead! Long Live Systems Biology!" in his blog in 2007:

> I still remember when recombinant DNA technology was going to change the world. Then it was developmental biology and evo-devo. Along the way [we] were told with a straight face that sequencing the human genome would cure cancer and everything else. After a while it all got very boring. We put up with the hype on the grounds that it was good ~~spin~~ framing for the general public. If it brought in lots of money, then what's the harm? Well it turns out there was some harm done. We scientists are losing our credibility. (Moran, 2007)

Moran distinguished between rhetoric and practice; he argued that radical scientific innovation and the new labels that went with them only existed in science lobbying. His own account resonates more with the 'continuous journey' motif than with a 'death of' motif as "Most scientists are already tired of these fads masquerading as revolution".

From our questionnaire material, we reconstructed two main storylines on scientific transformation that determine the mode of engagement: a 'death of' narrative, denoting the substitution of systems biology by another emerging field along the next revolution, and a 'normalisation' narrative, rendering the need for a special label obsolete after systems biology's approach had become ubiquitous. The 'death of' narrative was applied to discursive as well as practical change; it fit well with a funding context in which labels undergo a specific hype cycle. The 'normalisation' narrative depicted gradual change in scientific practices and communities and a discourse that reacted to this change. Both narratives could also be merged as illustrated in the following statement by a scientist:

> I am observing that people already speak of the end of systems biology, which makes me sad. (…) I kept saying that I don't mind if the term systems biology disappears — when mathematical modelling and systems approaches are so well

> established in the life sciences that we all are just doing biology, medicine, using these approaches. We are however far from having firmly established these approaches, nor are they widely accepted. A key problem is a lack of appreciation of the complexity of living systems and the urge for quick results.

Again, discursive patterns, funding logics, the urge for quick results in a competitive innovation system, and specific characteristics of systems biology – its time-consuming, heterodox, and interdisciplinary character – combined in a distinct way and interacted with dis/engagement. Last but not least, this last quote also hints at the emotional aspects of dis/engagement, although it does not become clear if the sadness relates to the announcement of the end of systems biology as a label, a vision, or an approach. In any case, we interpret it as a sign of engagement and identification with the field and as an illustration of how engagement with an emerging technoscience can run deep in contrast with a mere strategic and temporary move. The negative emotions triggered by the potential demise of a field might also help explain why disengagement and demise are so seldomly addressed in the context of contemporary technosciences, which are mostly depicted as exciting, promising, and prospering.

Discussion: the irregular rhythms of technoscientific dis/engagements

Although TS/SSH engagement has indeed met with some interest in STS on the level of single projects, longer lasting engagement or its opposite, disengagement, seem to have stayed "hidden in plain sight" (Gläser et al., 2016). This observation can be linked to different causes: Gläser et al. (2016: 26) note that "the study of [emerging] fields is in danger of neglecting generic governance structures and processes for the simple reason that these appear to be always already there". In addition, our analysis shows that the study of such fields simply ceases when they are no longer in the spotlight, without consideration of a farther-reaching rationale for disengagement. Disengagement is seldomly advertised and theorised in explicit terms; rather, it is tacitly effectuated if deemed warranted or even beneficial by relevant actors. Disengaging from science and science policy hypes has only recently been an issue and only in strategic terms, such as a plea to not blindly 'jump on band-wagons' and thus buy into potentially empty promises. Thus, it is fair to say that long-lasting engagement, as well as disengagement, continue to represent blind spots in contemporary analyses of science, technology, and society.

With our quantitative appraisal, we have provided a more robust picture of temporal and disciplinary patterns of dis/engagement with emerging fields. Our results corroborate a single-wave pattern for the medium horizon of two decades of SSH interest in systems biology. But whereas the social sciences present a rather unstable publication pattern and thus enforce the wave-like pattern with research on social and ethical issues, history and philosophy of science publications present a much more stable quantitative development. Moreover, we found a succession of waves for SSH engagement with various emerging fields such as systems biology, synthetic biology, or artificial intelligence, thus extending the diagnosis of single waves to that of a wave-like rhythm or a 'heavy sea'. Every rise corresponds to SSH scholars newly engaging with an emerging field, every decline with their disengagement.

It is interesting to note that only dramatic rises of TS publications are followed by peaks in SSH publications, with a time lag of five years in the case of systems biology. The fact that the wave-like pattern for SSH publications on systems biology especially corresponds to publications on social issues, supports the impression that SSH are meant to assess "sociotechnical issues … once and for all" at "an ideal moment in [a technosciences] developmental trajectory" (Felt, 2016: 192). It also supports the thesis of a "co-construction of the empirical object 'emerging field'" not only directly by science policy, but also indirectly by "policy-led science studies" (Gläser et al., 2016: 26). It can be assumed that this mechanism is even more pronounced with policy advisory (and thus, policy-led) fields like technology assessment.

A better understanding of how rhythms of dis/engagement are (co-)produced by contemporary innovation regimes also allowed us to reflect on further implications of these entanglements. Most

notably, we have seen the rise (and fall) of systems biology, synthetic biology, nanotechnology, and, most recently, artificial intelligence. How deep these rhythms run, whether they only pertain to funding rhetoric, or also correspond to transformations of theoretical conceptions, paradigmatic approaches, and technological potentials, is still to be discussed. Depending on one's concept of innovation, they can be perceived as features of a highly successful innovation machinery or as mere window dressing. Assessing the productiveness of wave-like patterns thus also necessitates a critical appraisal of the kind of (science-based) innovations we are striving for in our societies – and the timelines needed to accomplish them.

When scrutinizing effects these waves have on individual scholars exposed to them, it makes sense to also consider other formative aspects of the contemporary innovation regime.[ii] Laudel (2023: 74) notes that "most researchers [are now forced] to actively construct a match between resources – their funding portfolio – and their research portfolio". Our research on patterns of dis/engagement with emerging technosciences helps to better understand how scholars handle this challenge which requires constant re-orientation – on the technical level, but also on the epistemic, affective, and social level. Doing science therefore includes the constant re/building of social ties, the constant re/establishment of one's place within scientific communities as well as paradigmatic landscapes and constant processes of de/identification (see also Kastenhofer and Molyneux-Hodgson, 2021; Kastenhofer and Bauer, 2022). All these processes are subsumed in the notion of dis/engagement and play a role in how scientists and STS scholars accounted for dis/engagement with systems biology.

Furthermore, our analysis highlights how across disciplinary accounts, dis/engagement with systems biology is closely linked to projects, funding opportunities, science policy, and innovation regimes. In addition, our focus on social and affective dimensions showcases the importance of networks, colleagues, friendships, being welcomed and finding one's place. Finally, engagement seems to be also linked to specificities of the field: in the case of systems biology, the paradigmatic interest in complexity rendered collaborations with epistemologists more attractive; in the case of synthetic biology, the publicly perceived ethical, legal, and social implications made collaborations with social scientists and ethicists more called-for and even a sine-qua-non in specific funding programmes. Many of these factors resonate with more general aspects of our current innovation regime, such as projectification and funding rationales, which make long-lasting engagement and identification with one field and/or label dependent on the continuous acquisition of project funds or require flexibility to switch strategically between fields. This can be detrimental for individual scholars as well as whole research ensembles: not only might 'the bubble burst' before it even 'delivers' (cp. Kastenhofer, 2013b: 16), but also researchers must rebuild their identity and network, re-establishing expertise and reputation with every switch to a new label.

Interestingly, our own discussions on dis/engagement with systems biology from an SSH position were equally relevant to scientists engaging with systems biology. From previous studies, we know that some scientists consciously opted to call themselves systems biologists while others saw themselves as central in furthering systems biology but abstained from labelling themselves as such (Vermeulen, 2009; Kastenhofer, 2013a). This diverse pattern can be linked to the diversity of local funding environments. In some (trans)national contexts, systems biology was specifically funded as an emerging research field; in others, it was financially supported as an emerging research community; in yet other contexts, it was perceived as an approach not needing dedicated funding – rendering deep engagement and identification difficult, costly, and risky (Kastenhofer et al., 2012; Vermeulen, 2018). Thus, patterns of identification can converge along shared geographies (and funding regimes) rather than disciplines. Moreover, the similar exposure of both TS and SSH scholars to hype cycles and dis/engagement waves makes room for enacting 'chronosolidarity' as suggested by Felt (2021).

However, modes of dis/engagement were also co-determined by disciplinary affiliation and career stage in our sample. When support and

funding for systems biology started to wane, senior scientists working in systems biology could move back to their original discipline, or move along to the next wave of funding, sometimes literally changing their identity from systems biology to synthetic biology. In contrast, scientists early in their career, still being trained and socialised in(to) the emerging field, were less prepared to transition to a new label or a more stable, traditional field. Within the social sciences and humanities, we saw senior scholars opting for looser engagements with the new label, determining engagement on their own terms. Early career scholars dependent on third-party funding had to disengage with a new post-doc project on another topic or a teaching job that did not allow much time for research. Overall, this pattern resonates with the power dimension inherent in the exposure of scholars to shifting hypes and funding priorities as addressed by Felt (2021): the less secure a scholar's institutional and social position (as determined by work contract, scholarly reputation, and networks), the less power they hold and the more effort they have to put into engagement and identity work, resulting in more difficulty to later disengage and disidentify.iii Recurring exposure to this dilemma may well lead to more cynical takes on engagement and identification over time, to practices of staging engagement and rites of choreographing one's scholarly identity.

How these power dimension of dis/engagement fare in relation to place-based, centre-periphery dynamics, we could unfortunately not cover adequately in our current empirical analysis. Such a discussion has been well prepared by other scholars like Pablo Kreimer (2022) or Liscovsky Barrera (2022) and should certainly be extended. For systems biology, a centre-periphery constellation can be assumed not only for the global context, but also among European countries with different scales of dedicated funding. In this paper, we focused not on geographical centres and peripheries but on the dynamics related to career stages and disciplinary hierarchies. Interestingly, we not only saw different trajectories of dis/engagement between scholars at different career stages and scholars from TS and SSH fields, but also among the social sciences and humanities scholars. These differences were closely related to different role expectations. Philosophers were engaged by systems biologists to help with epistemological issues, and this was also how they depicted their role themselves. Sociologists were contracted to help address societal issues and concerns, but when it turned out to be quite hard to determine what these issues would be in relation to systems biology, the sociologists concentrated on better understanding systems biology as an emerging field. We identified differences in dis/engagement that show the importance of reflection on the relationship between different SSH approaches and the type of engagement they engender. As dis/engagement comes in different forms, it can be a rich source of mutual learning in STS, SSH, and beyond.

Finally, the dynamics of engagement and disengagement have implications for our own identity as STS scholars and our own community. While we study topics and themes that are valid and relevant across scientific fields (such as controversies, regulation, public engagement, etc.), many of us are entertaining a close connection to a specific discipline or a particular group of scientists, even when developing broader theories on knowledge creation and governance. Careers are built through engagement with specific scientific disciplines or groups. In some cases, the scientific area of study even corresponds to a scholars' initial academic education. In-depth knowledge of a particular (sub-)discipline through intensive immersion is an asset for STS research and also a crucial aspect of scholarly identity (Schönbauer, 2019). The closer the link, the stronger the identification between an STS scholar and 'their' scientific field. Consequently, the faster the labels or 'gravitational centres' in technoscience change, the more these dynamics are likely to substantially affect individual scholars and their careers, networks, and community. As such, rhythms of dis/engagement influenced by innovation regimes are affecting the type of work we (can) do, as well as the careers and communities we (can) create. It is therefore not only important to ask how we dis/engage, but also on what terms and to which lengths and depths. We thus hope that this contribution fosters more discussion on the dynamics of dis/engagement in STS and beyond.

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Notes

i In this text, we are interested in science and technology studies including social, cultural, historical and philosophical studies of science. We follow an aggregated perspective (social + cultural + historical + philosophical studies of science) in our quantitative analysis and a more integrative perspective (STS as a field, programme, movement, or community in its own right, e.g., Sismondo, 2007; Felt et al., 2017) in our qualitative analysis and discussion (see methodology section of this paper).

ii Systems biologists refer to earlier scholars, like Ludwig von Bertalanffy or Robert Rosen, who formulated central epistemic approaches and theoretical concepts of biological systems thinking and modelling already in the mid-20th century. However, the establishment of modern systems biology is commonly attributed to the beginning of the 21st century.

iii Kastenhofer (2013a) reports on scientists' critique of the use of 'systems biology' as a buzzword; Kastenhofer and Torgersen (2016) critically discuss social scientists' uptake of new technoscientific labels and expectations as 'jumping on the band wagon'.

iv As the total number of publications and Web of Science entries keeps increasing each year, a slight increase in absolute terms can equal stagnation or even decrease in relative terms.

v Moreover, Collins and Evans (2002: 240) in their analysis of paradigmatic waves within STS hint at the diverse ways waves can succeed each another: "The relationship between Wave One and Wave Two is not the same as the relationship between Wave Two and Wave Three. Wave Two replaced Wave One [while] In this strange sea, Wave Two continues to roll on, even as Wave Three builds up."

vi This position presupposes that there was a kind of ideal situation, free from non-epistemic influences like lobbying, mission orientation, career requirements, or scientific routines – a presupposition that warrants further discussion in its own right.

vii Whereas on the aggregated and mid-term level, we can possibly speak of a co-construction of hypes and waves, on the level of the individual scholar and their daily routines, speaking of exposure to such phenomena seems more adequate. Individual perceptions of levels of exposure may still differ, as our qualitative material shows.

viii However, we assume that radical epistemic disruption also poses a challenge to established scholars, which might result in some caution in acknowledging and embracing such change.