

Respect for Numbers: Lively Forms and Accountable Engaging in Multiple Registers of STS

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Abstract

This paper explores an episode of numbers appearing on a screen and being read/spoken, looked at and received *as numbers*, by people who work together to achieve a particular goal. The events happened in Singapore, in 2012-2013, as part of periodic reporting on diabetic retinopathy screening in the context of efforts to innovate such screening. I tell of two parties at odds over how to engage numbers accountably. This question of 'engagement', of what can and should be *done* with numbers to secure their participation in organizational affairs, is worked out in how numerical forms are performed and sustained as working numbers. Using three STS analytics to analyse the episode – Helen Verran's (2001) work on number as a relation of unity/plurality, John Law's (1994) work on modes of ordering, and Steve Woolgar and Daniel Neyland's (2013) work on mundanity and accountability – I argue that numbers are brought to life in very different ways, each mobilizing a certain recognition of what numbers *are* and what it takes to respect this. In the conclusion, I comment on the article's use and juxtaposition of these STS analytics, using the metaphor of a kaleidoscope.

Keywords: numbers, accountability, engagement, symmetry, STS theory

Introduction

In the midst of fieldwork on eye images, in January 2012, I witnessed an exchange over numbers that put me on the path of writing this article. This happened in Singapore, in one of the meetings of the interdisciplinary group whose work with retinal images I was following. 'Prof Xu', the group's leader, and PI for most of its projects, expressed dissatisfaction with the progress numbers being reported for its flagship project. The project meant to pave the way for a significant public health innovation: a new model for the delivery of diabetic retinopathy screening. So these numbers were important. But in the meeting, the professor did not like what he saw and heard.

A 'grader', about whose role I will say more below, had flashed up a PowerPoint slide with a numerical table, and had read out the totals-to-date flatly and matter-of-factly. The numbers had 'floated' into the room as self-contained utterances and notations on the screen, needing no elaboration. The professor wanted to see them *worked* more: in and through these numbers, he wanted to see where the project was headed; he wanted to glimpse projections into the future. He asked the graders to engage their numbers differently, to engage them *properly* so as to provide more insight. And yet, in subsequent meetings over the course of the following year, graders

reported their numbers in the same way. Numbers were sent into the room, only to be met by the request to be 'done' differently – and then the same thing happened again in the next meeting.

I was intrigued by these moments of 'disconnect', which added an element of tension to the meetings but also made the numbers central to them *strange*. When I say that numbers were sent into the room, that they were floating, I am choosing my words with care, to convey a sense of that strangeness, almost opaqueness, of the forms presented. Helen Verran (2001: 102) has reminded us that *numerals* – the spoken utterances or written shapes we use to denote numbers – and *numbers* – the entities that participate in practices of enumeration – are not identical. When we buy five oranges in a market or read about a 1% inflation forecast, our encounter with numerals immediately sets in motion familiar rituals of enumerating. For practical purposes, there is no distinction and we do not even notice numeral becoming number. In this fieldwork episode, however, the distinction was brought into focus. In what sense were these 'floating' numerals failing to come alive as numbers? In what sense were they indeed brought to life, but in a way that differed from what was recognized by the professor?

For those of us interested in pursuing an empirical philosophy of numbers and their relations, this number situation provides an opportunity to revisit the question of what numbers become in differing engagements. It provides for an investigation into the enacted ontologies and accountabilities that constitute numerical agency and organizational relations. What numbers are made out to *be* entails stipulations for how to accountably engage them. Vice versa, accountably engaging makes numbers consequential, brings them alive, by specifying their participation as numerical entities in particular ways of acting, being, and relating.

Using the grader's floating numbers as a provocative starting point, I will pursue a narration of the relationalities in and through which the parties in this fieldwork episode were 'doing' numbers *differently* and demonstrating how to do them *properly*. My analysis follows the lead of three STS analytics: Helen Verran's (2001)

work on number as a relation of unity/plurality, John Law's (1994) work on modes of ordering, and Steve Woolgar and Daniel Neyland's (2013) work on mundaneity and accountability. There is family resemblance between these analytics, all of which see the properties of entities as not fixed but as relational and emergent, and all of which have an interest in how we may interrogate that which has congealed. At the same time, they offer different approaches to what we take as the number object and its performed properties in the episode under consideration. By bringing together the episode and these three analytics, I show how narrations of accountable engagement can recover liveliness in seemingly unanimated forms. This broadens into a more general point about how numbers are constituted as things to be reckoned with in engagements that mobilize a certain recognition of what numbers *are* and what it takes to respect this.

In the conclusion, I take these points forward in reflecting on the article's use and juxtaposition of STS analytics. In using my fieldwork episode as a 'comparison engine' (Beaulieu et al., 2007) for the analytics, the differences between them come to stand out by enrolling them as tools on the 'same' job. Doing this allows me to multiply the stories about agency, work, and taking care with numbers that I tell with my materials – much in the way a kaleidoscope presents an ordering of its pieces that is different with each turn, creating different patterns. Like Lippert (2018) who compares qualculation (Callon and Law, 2005) and Verran's (2001) juxtaposition of ontics and ontologies, I too see such a comparative exercise as a way of working *in* and *on* the analytics that are our shared STS heritage. Just like numbers, these analytics become things to be reckoned with in and through ongoing attempts to use them, faithfully and generatively. The article's specific contribution to STS scholarship on numbers and numbering is then also accompanied by a broader message regarding ways of doing STS.

Lively numbers: Inscriptions and enumerated entities in STS

By way of situating the theoretical question of how numbers come alive in our engagements

with them, let us revisit how the agency of numbers has been described in other STS literature, particularly in approaches associated with actor-network theory and post-ANT. Treatments of numbers as ‘inscriptions’ and as ‘enumerated entities’ each teach us about the relational configurations in which numbers emerge (or fail to emerge) as effective and properly utilized.

In understandings of numerical forms as inscriptions that help to produce reference and action-at-a-distance, the agency of numbers is part and parcel of the process of translation. This is facilitated by what Bruno Latour (1999: 49), in “Circulating reference”, an account of a field expedition into the Amazon, calls “empty forms”. A grid superimposed on the forest, tags attached to specimens, the protocol whose steps are followed in sequential order for the collection of earth samples, a filing cabinet that classifies as well as shelters materials – these methodological-material devices are empty until, as a result of their practical use in the field, they get filled. In the practical action of choosing and filling them, something is preserved and something is left behind. This is what ‘circulating reference’ means: the *movement* along a chain of translations, so that, in this case, a question about the behaviour of forest and savanna becomes answerable. Empty forms “are set up *behind* the phenomena, *before* the phenomena manifest themselves, *in order* for them to be manifested” (Latour 1999: 49, emphasis original).

Numbers play a crucial part in the work with empty forms, to the extent that these forms are set up to receive only or mainly numerical information. Latour leaves this implicit, but the point is made explicitly in Rolland Munro’s (2001: 479) piece on budgets as accounts: “inscriptions in the form of budgets arrive on a page *as* numbers, not narrative” – thereby materially specifying what an account (in respect of the budget) can contain, and what is excluded from it. The spreadsheet is an empty form that *calls for* numbers. The numbers entered into it obtain their relevance and appropriateness from the way they are presented as form and as substance: because they are formally right, they can become empirically significant. In a similar vein, Paolo Quattrone (2009) writes about *figuring* in the accounting practices of the

Jesuits as powerful by its emptiness. The empty form of the ledger, which calls for numbers to fill it, structures the thinking and creative practice of accountants: “its content may be absolutely evanescent, while the form appears to be clear” (Quattrone, 2009: 112).

Returning to Latour’s work on circulating reference: once a form is filled with actual numbers – location nr. 234, sample nr. 3 – empirical faithfulness becomes an important thing to preserve: “If I were to tear down these [numbered] tree tags, or if I were to mix them up, Edileusa would panic like those giant ants whose paths I disturb by slowly passing my finger across their chemical freeways” (Latour, 1999: 32). So numbers can be thought of as ‘working inscriptions’ if they do their part to keep the chain of reference intact. In this way, they participate in producing the possibility of faithful representation and power, of ‘action at a distance’. The chain breaks, however, when numerical inscriptions’ function to *preserve* is severed from their function to *translate*. This is what would happen in the imaginary scenario of mixing up the number tags. It is also how we can read social psychologist Diederik Stapel’s account of messing with survey numbers: a pivotal moment in the research fraud he committed. When in the privacy of his office he “changed an unexpected 2 into a 4; then, a little further along, [...] changed a 3 into a 5” (Stapel, 2012: 102), reference could no longer circulate.

Related accounts of failure appear in studies that attend to the practical difficulties and contingencies of getting numbers-as-inscriptions to facilitate action-at-a-distance (Asdal, 2011) or produce an influential account (Neyland, 2012). These studies understand both success and failure in more situated terms, yet retain from Latourian studies of science-in-action the sense that numbers’ agency as inscriptions is a function of their participation in and connection to a chain of translation across which objects of knowledge or concern are transported.

Training our attention on a specific set of numbers rather than the entire chain – ‘freeze-framing’ them – is, on this view, not helpful. However, another body of literature treats numbers as entities and asks after their agency or participation in situations of numerical sense-

making, thus ostensibly ignoring this proscription. Helen Verran (2012: 66) understands numbers as “lively material-semiotic actants” – where “lively” relates to the way they work as signs, in practice. Verran argues that numbers can work in inventive ways by shapeshifting. Or, arguably, by shifting everything *but* their shape: they may look the same but are different in their way of “materially expressing formal relations” (Verran, 2010: 173), in how they *generalize*. Attending to the ‘liveness’ of numbers here means understanding and being able to interrogate how numbers participate in ordering and valuing, and it means keeping number-facts connected to the epistemic practices through which they are generated. Being specifically concerned with the relationship between knowing and policy-making, Verran (2012: 68) argues that numbers are no longer ‘lively’ when they “have zero temporal extension”, when they no longer can be taken forward or revisited as active participants in knowing and governing. For example, a proprietary quantitative assessment deployed to fortify a government decision in relation to a dying Australian river, can be critiqued in understanding its functioning as a “solidified value icon” (Verran, 2012: 68).

Dawn Nafus (2014), writing about the numerical data generated by sensors, uses the term ‘liveness’ (adopted from Lury, 2012) to articulate something similar. ‘Live’ here captures a sense of “numbers-in-production” or “in the making” (Nafus, 2014: 211), of becoming that carries possibility and the capacity for surprise. The other side of this is the uncertainty as to whether numerical data will attract the kinds of labour that bring and keep them alive, whether “calculative infrastructures” will “cohere” or whether these numbers that are “free for the taking” will “more likely [...] betray, fall flat, or find dead ends” (Nafus, 2014: 221).

Making numbers as entities the point of entry for analysis, and using the affective language of liveliness and its antonyms, provides a fresh take on ways in which numbers make a difference or fail to do so – in other words, on the politics of numbers. In this and related work, two qualities are associated with lively numbers: they are able to *effect* – that is, to be taken into account, to be taken seriously in relation to an action or decision – and they *remain open to*

interrogation – that is, are not solidified, reified or naturalized in ways that obscure how they are made to signify. They live in the paradox of stability and instability, being stable enough to effect, yet unstable enough to be interrogated. Tjitske Holtrop (2018), in her article on the number 6.15% in Dutch foreign policy interventions in Afghanistan, captures these two sides aptly:

Importantly, numbers are caught in an oscillation between evoking referential doubt and evoking confidence or action (until they don't anymore and someone or something throws the numbers back into a pool of questions and uncertainty, demanding clarification, and so on). Rather than weakening the power of numbers, it is in this contradictory oscillation, as interface, that numbers are generative. (Holtrop, 2018: 86)

Substantively, at least in my reading, this paradox or oscillation retains a version of Latour's dual emphasis on preservation and translation in articulating what makes numbers work. At the same time, methodologically, the shift from considering numbers as inscriptions to numbers as ‘lively material-semiotic actants’ expands the possibilities for analysing numbers’ relational agency in knowledge-practices. By positioning numbers as protagonists in our ethnographic stories, we are not confining them to one role or way of being. When numbers are spoken of as ‘participants’ (Verran, 2012), as attractors of human labor (Nafus, 2014) and as entities that “have a form and a way of life that can be explored ethnographically” (Holtrop, 2018: 78), this brackets the assumption that we already know what numbers are or what they do. Such methodological agnosticism works from the position that we will never fully know our numbers, fully pinpoint or control their participation in our collective affairs, or successfully reduce them to one thing. It retains the capacity for surprise, for engagement to unfold in surprising ways.

This literature on numbers as inscriptions and on numbers as enumerated entities has paved the way for understanding numbers’ agency as the upshot of practices of producing reference and action-at-a-distance, and of rituals and practices of enumeration. Importantly for the purposes of this paper, it has also paved the way for under-

standing number forms as needing activation so that they do not fail or fall flat. In what follows, I build on this heritage and language to narrate fieldwork materials as multiple forms of accountable engagement with numbers. In achieving faithfulness to numbers as particular kinds of entities, such engagements secure their participation and liveliness in organizational affairs.

A note on materials and methods

The flagship project I studied as part of my fieldwork on eye images between 2010 and 2014 aimed to make eye screening for diabetics in Singapore into a more streamlined and centralized endeavour. To do this, the appraisal of screening images was shifted from family physicians in local polyclinics to dedicated technicians called ‘graders’ in a grading centre. Graders, most of whom were hired fresh out of polytechnic education, were trained on the job for this work. Centralized grading by graders was projected to improve the reliability, speed and cost-effectiveness of screening services (Bhargava et al., 2012; Nguyen et al., 2016). This could then extend the reach and uptake of such services, meeting the needs of a population in which diabetes and its vision-relation complications were on the rise (Goh et al., 2015).

The project started by having graders take on the screening load of two polyclinics, and then gradually expanded. As the number of graders increased, the grading manager began to assign specific individuals the job of reporting progress numbers. At the heart of my account below are four meetings in 2012 and 2013 during which such reporting was done. My understanding of the graders’ relationships with numbers is further based on two visits (in June 2013 and January 2014) to see the graders process numbers and hear them talk about what they were doing; and on two presentations of my own – one to the graders and one to the management team – in June and July 2013, in which the reporting of numbers was surfaced as a side-matter for discussion.

The mutual puzzlement with which the graders and the professor regarded each other’s orientation to numbers, features centrally in my analysis: I use it as a path into articulating two quite distinct

worlds organized around accountable engaging with numbers. The episode invites this, in that it brings to the fore a difference between the graders’ actual way of doing numbers and the PI’s preferred way for the graders to do numbers. In other words: the difference between ‘doing it this way’, and ‘doing it that way’ was a topic in these meetings – the ‘proper’ approach was at stake. At the same time, it’s important to stress that my reason for dwelling on this is philosophical and methodological; it is not to give it special descriptive importance in the overall trajectory of this team’s work. In terms of that trajectory, there is no reason at all to fixate on a set of meetings and reporting practices that have long since been reorganized, by now probably multiple times over.

What the ‘disconnect’ provides for us here is a provocation regarding what qualifies numbers as alive in our engagements with them. Is it possible to approach the graders’ and the professor’s expressed relations with the progress numbers as alternative ways of ‘doing’ numbers properly, and if so, what might that look like? By engaging three STS analytics in this work of symmetrical redescription, different aspects of accountable engagement are brought into view. At the same time, the episode of the disconnect helps to make these analytics comparable, and brings out the uniqueness of each by providing common ground for putting their symmetrical redescription capacity to use. As with all comparisons, “[a] unit for comparison has to be constituted, and features for comparison have to be specified, if this approach is to yield interesting insights” (Beaulieu et al., 2007: 677). This then is the particular way in which analytics and empirical materials are mutually elaborated in this article.

A disconnect

The progress meeting on 5 March 2013 attracts more people than usual. The room at the Institute is far too small for the thirty people who are trying to fit in it, so another room is found. Even here, people barely fit as we wheel in chairs and arrange ourselves in two tight rows around the conference table. A copy of a set of PowerPoint slides with numerical tables is distributed as a handout. Some lunch food is passed around.

The graders know what is expected of them: when it is their project’s turn, they will present a progress update, in numbers. Their audience is a heterogeneous and shifting group of people that includes: the scientists who oversee the research grading, the grading manager and other administrators involved in the operations of the image analysis centre, the centre’s IT staff, one or two business development managers, two or three computer scientists from a local university who are working on the automation of image analysis, and myself, a sociologist from the same university. The key audience for the graders’ accounts is, however, ‘Prof Xu’, the clinician-scientist who heads the centre and is the PI on most of its projects.

Today, the flagship project, a pilot programme that centralizes and streamlines screening for diabetic retinopathy, is first in line. ‘Khim , a grader who has been at the centre for a year and a half, is tasked with the progress presentation. When the corresponding PowerPoint slide appears on the screen, Khim reads out the numbers:

In total we have seen **nineteen thousand one hundred twenty-seven** patients, of which **four thousand five hundred ninety-five** were referred and **one thousand nine hundred fifteen** were rescreened.

While Khim reads the numbers, everyone looks at the table on the screen (reproduced as Figure 1). Her reading directs us to three numbers in the table: 19,127, 4,595 and 1,915 in the last row..

These are ‘total’ numbers of patients, first the overall total (*nineteen thousand one hundred twenty-seven*), and then the breakdown by

outcome of the screening examination. This outcome takes one of three possible forms:

- **Referral:** patient referred to a specialized eye hospital for further tests and/or follow-up care (*four thousand five hundred ninety-five*);
- **Rescreen:** patient asked to come for another round of screening in six months’ time there are signs of diabetic retinopathy, but these do not warrant acute follow-up (*one thousand nine hundred fifteen*);
- **Annual:** patient assigned to continuous routine monitoring via annual screening, eyes look stable. (not read out)

Patients are assigned to one category or another based on so-called referral criteria.

In the progress meeting on 5 March 2013, Khim’s way of presenting the numbers is recognizable to other participants as the typical way graders present their numbers. In the short silence after she concludes, people wait to see if Prof Xu will comment on this presentation.

For over a year now, Prof Xu has been intervening in the graders’ presentations. These interventions are fairly explicit. When he says, addressing the grading manager that “We need to train the graders to find trends in the numbers, so that they don’t just give us the raw numbers” (in the meeting of January 2012), it is clear that he wants something different than is being offered. He is indicating that the graders’ numbers do not make see-able or appreciable what he wants to see or appreciate. Numbers are made present, but no story is told with or about them. All the numbers in the table are presented as if on the

Pilot DR Screening Service - Polyclinic Figures

Year	No. of Patients	Referral	Rescreen	Annual
2011	10,618	2,906	1,143	6,569
2012	7,799	1,577	771	5,451
2013*	710	112	1	597
Total	19,127 (100%)	4,595 (24%)	1,915 (10%)	12,617 (66%)
*Until 31 Jan 2013				

Figure 1. Progress update for the project.

Year	No. of Patients	Referral	Rescreen	Annual
Total (2011)	10,618	2,906	1,143	6,569

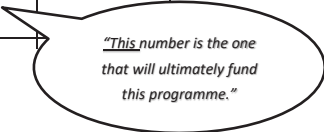


Figure 2a. Emphasizing the Rescreen number.

same plane – nothing is highlighted or singled out. And the graders are usually reticent to engage with follow-up questions. It's as though the graders present their numbers without an understanding as to what they are really for, or about.

A more extensive flashback to January 2012. After sitting through a reading of graders' numbers, Prof Xu walks up to the projection screen and points to the total for 'Rescreen' (Figure 2a). Tapping it with a finger he declares: "This number is the one that will ultimately fund this programme." His demonstration brings texture to a previously flat display, lifting out one number at the expense of others.

Prof Xu ties *this* number to the story of the flagship project, to its rationale. The Rescreen category is a key innovation within this new way of doing screening. It is a monitoring category, allowing patients who do not need immediate follow-up to be called back for a repeat screening in six months' time as opposed to one year ('Annual'). It gives screeners an option in-between referring someone to specialist care and having them continue routine annual screening.

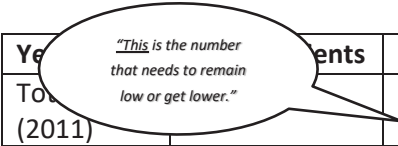
'Rescreen' has been introduced to take some pressure off the 'Referral' category, allowing the system to reduce unnecessary demand for specialists' time and resources. In his demonstration at the screen in January 2012, Prof Xu also points to the Referral number as deserving special attention (Figure 2b):

This is the number that needs to remain low or get lower. I don't mind if the other two numbers stay large; it doesn't matter whether it's six months or twelve months, as long as it's not referral.

By singling out some numbers rather than others, Prof Xu elaborates the relation between numbers in a way that connects them to the aims and objectives of the pilot programme. The Rescreen and Referral numbers are crucial in building the case for this programme.

Back to March 2013. After Khim has read out the total counts as of 31 January 2013, Prof Xu asks a question. Looking at the screen, he asks: "Why was there a drop for the Rescreen category in 2013?". The question hangs in the air, is for a moment met by silence. It has a similar effect as his earlier gesturing: it singles out one number. From being invited to take in *all* numbers on the same plane, our attention comes to be directed to *this* number: the number '1' in the Rescreen column (Figure 3).

Khim offers, in a low voice, that "it was because of a change in the referral criteria". This exchange, again, goes back a long way. The referral criteria are decision criteria that create cut-off points between the categories. In the previous year, a committee in which Prof Xu took part revisited these criteria and decided to make them more



Year	No. of Patients	Referral	Rescreen	Annual
Total (2011)		2,906	1,143	6,569

Figure 2b: emphasizing the Referral number

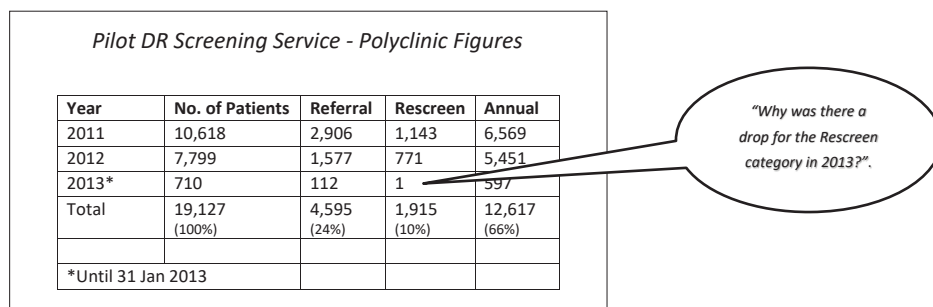


Figure 3. Singling out the Rescreen number for 2013.

conservative. The shift of the work of screening from doctors to graders made the committee nervous about false negatives, so it put safeguards in place to avoid cases that needed intervention ending up in the six-months rescreen category. Some patients who would have previously qualified for 'Rescreen' now had to be assigned to 'Referral'. This change in the referral criteria would naturally make it harder to achieve the project's projected savings of resources.

Prof Xu wanted to see the impact in the numbers' presentation. He had already requested this once before, saying in September 2012 to the grading manager:

You need a slide to compare the numbers before and after the moment when the referral criteria changed. The graders are not presenting the right stats. They don't know how to ask the right questions. It's not their fault but it is a problem, because these stats won't drive change.

The exchange between Khim and Prof Xu on 5 March 2013 ends with, as far as the latter is concerned, the matter still unresolved. The change in the referral criteria has not been marked in the numbers' presentation.

When I asked the graders on a separate occasion what they made of Prof Xu's persistent questions and comments about their number reports, one said: "We hear that he wants something, but we are not clear on what he wants." Coming up with an adequate response to the issue was considered hard: "It would be good to think strategically about what he asks, but this requires a lot of time and coordination." Another grader, in a one-to-one conversation about his work with the progress numbers, ventured a guess about what

the professor might be after, but also expressed limited interest in it:

Maybe our referral rate is high? I'm not very sure. In any case, we don't think about it when we grade. Not to say that it's not our concern. But we have to grade without bias.

Another added: "You don't want to present something that's not correct."

We now turn to our three STS analytics to elaborate the relations of accountable engagement that make for two such different ways of doing numbers properly.

With Verran: Number as unity/plurality relation

In *Science and an African Logic* Helen Verran (2001: 94) teaches us to become attuned to the 'doing' of number in particular ways, to attend to "what numbers are in terms of here-and-now routines of practice, [of] ongoing collective acting". In this material-semiotic approach, which focuses on the forms of generalizing numbers take in practice, a key emphasis is on their enactment as unity/plurality relations. The story of the Reverend Alexander Akinyele's method to achieve an accurate census count of inhabitants of a town in Yorubaland in 1921 provides an illustration of this. Akinyele's method was to ask the headman plus one man and one woman from each community to *name* every man, woman and child in each household, to *represent* each name by a stone, and then to *count* the stones afterwards. He proposed this to the British colonial government as a workable way of enumerating the community: a series of translations designed to produce a census count accord-

ing to what the British understood such a thing to be, yet also faithful enough to Yoruba practices of enumeration.

As Akinyele tells it, first there was the repeated making of a *unity*: a person steps forward, or a name is uttered, and a stone is placed. The routine is repeated until the set of people is exhausted. Persons are translated as pebbles. Second, a *plurality* is made as the stones are taken as a collection, which like collections in this way of numbering is taken to exhibit the quality of numerosity to a particular degree, a degree that can be represented with a number. Third, this number is rendered a *unity*: the population of a compound entered as an object into its place in a chart. Fourth, a further *plurality* is made as the numbers from many compounds are collected, to enable a fifth step, a further *unity*, the population of Ibadan, and so on. (Verran, 2001: 99)

In Akinyele's method, persons and populations are constituted in and through the alternating movement of making unity (categories) and making plurality (members of categories). Elaborating such "banal material practices" (Verran, 2001: 101) reminds of Latour's writing on chains of reference with their consecutive translations (small 'jumps') from matter to form (Latour, 1999: 49). But in Verran's tracking of units and plurals, the emphasis is as much on making *numbers* as it is on making reference. It is on doing numberliness in and through "routines of gestures and utterances [and] ritualized repetitions" (Verran, 2001: 100). In the momentum that makes units out of plurals and plurals out of units, numbers come to acquire their distinct capacity to generalize.

How does this work for the diabetic retinopathy screening numbers? Their journey up until their presentation by graders in the meeting, may be broken down into four moves of making unity and plurality. The 'making' relies on graders' actions amidst an infrastructure that includes computer hardware and software, a flow of images from polyclinics to the centre, and a number of organizational devices such as patient identifiers, protocols, and electronic logsheets. In stylized form:

- Graders make referral decisions out of their work with retinal images. This is the first move: producing decisions as *units*.
- At the same time, graders gather these decision-units into types ('Referral', 'Rescreen', 'Annual'), so that now each single decision is a member of a collective named after that type. This second move produces *plurals*.
- Graders add up the referral decisions within each collection to a category count: the total for 2011, 2012 or 2013. Thereby, the plurality of members is converted into a singular degree of numerosity. This is the third move, producing *units*.
- Graders gather the counts for the categories of 'Referral', 'Rescreen', 'Annual' into a new collection, that of 'progress figures' for 2011, 2012 or 2013. This is the fourth move, producing *plurals* again.

With the next move, the graders and the professor part ways. With Verran's emphasis on how numbers come to generalize, we can pinpoint how, during the meeting, numbers are enacted in two different ways.

- Graders convert the plurality of 'Referral', 'Rescreen' and 'Annual' for the years 2011, 2012 and 2013 into grand totals of singular numerosity (hence, new units) for the project-to-date, as of 31 January 2013.
- But the professor also wants them to make a different fifth move, which is no longer about adding but about comparing. He wants the plurality of 'Referral', 'Rescreen' and 'Annual' for the years 2011, 2012 and 2013 to be converted into units of relative share out of 100.

The difference lies in how units and plurals are made to stand in relation to one another. By putting all numbers on the same plane – treating them equally – in the table, and by reading out the grand totals for the project to date, the ritual set in motion by the graders is one in which the numbers in the table are recognized as *category counts* within the here-and-now *volume of work* produced. The 'whole', as the sum of its parts, stands for where the project is *now*, which is a different number from what it was three months or a year ago, or will be three months or a year from

now. The total volume is a momentary snapshot of the extent of work the graders have presently delivered for the pilot service. (Note that percentages are added in the same cells as the sums, perhaps in response to Prof Xu's earlier requests, but these are not elaborated in the presentation.) The graders have done their numbers as tallies, have configured themselves as tally-keepers, accounting in real time for how their work adds up.

When the professor asks questions, makes comments and uses gestures to highlight certain numbers in the table, he sets in motion a different ritual: one that recognizes the numbers in the table as (relative) *weightages*. This is done by indicating that it is the *relation* between numbers in the different categories that matters: "This is the number that needs to remain low or get lower. I don't mind if the other two numbers stay large; it doesn't matter whether it's six months or twelve months, as long as it's not referral." It is also done by comparing that relation in the present to that relation in the past ("Why was there a drop for the Rescreen category in 2013?") and in the future ("needs to remain low or get lower").

The professor has performed the graders' numbers as would-be trend numbers in a ritual that produces difference with the graders' own enactment on multiple counts. This ritual is faithful to numbers by imagining the whole before the parts: "a vague general whole that allows articulation of specifiable parts" (Verran, 2007: 181; cited in Guyer, 2014: 159), the 100% against which clear parts, as proportions, can be outlined. The 'whole' is what provides for the relative weight of the member categories to be calculated and projected into the future. That future is one in which the project will be assessed for achieving cost- and other benefits in the way it delivers screening. It is the future in which the Rescreen number, relative to the Referral number, "will ultimately fund this programme". The professor's number ritual not only produces a different temporal orientation to the numbers on the screen than the graders' ritual does. It also produces a different normative regime in which numbers are reckoned with as 'good' or 'bad' via the monitoring of their internal relations over time. What is more, it produces the requirement for the telling and retelling of these

internal relations in relation to the project's aims, and for the graders to perform such telling.

Juxtaposing these two ways of making plurals into units, of relating unity to plurality, shows different ways of reckoning with numbers in taking stock of progress. One – the professor's – sets the stage for attaching consequence and possible action to these numbers, while the other – the graders' – makes this less central, being an accounting for the work that has been completed. This, by the way, is not to suggest that the graders were never moved to action by their numbers. One grader, 'Shawn', showed me how he scrutinizes his monthly totals to keep an eye on the 'ungradables' – images whose quality is too poor to be graded. The ungradables do not produce a decision and therefore do not end up in the specific progress statistics presented at the meeting. In relation to these images, Shawn said: "I find it most disturbing if I have a lot of ungradables. I sometimes need to reach out to the nurses, [remind them] how they should use the system. Show them what's ungradable." An increase in *that* number was something he looked for and acted on, by contacting the nurses (with whom he had developed a good working relationship) and trying to get them to produce better-quality images.

Using Verran's analytic, which describes multiplicity in how numbers are made to generalize, we can discern in the 'disconnect' two different ways of doing number, characterized as different unity/plurality relations. These make for different temporalities (past work vs future-oriented aims) and different forms of accountable engaging on the part of those responsible for the numbers.

With Law: Numeracy and discretion in different modes of ordering

In *Organizing Modernity* (1994), John Law uses the term 'modes of ordering' to refer to material-semiotic arrangements that "tell of the character of agency, the nature of organizational relations, how it is that interorganizational relations should properly be ordered, and how machines should be" (Law, 1994: 20). Modes of ordering, in other words, help describe how material relations and forms of agency are mutually constituted. In an

example that implicates numbers in the work of management, Law (1994; 1996; 1997) shows how spreadsheets participate in producing managerial discretion, because they enable a way of 'seeing' the organization. At the same time, they also circumscribe such discretion, because the shortfalls manifested in and through the spreadsheet need to be attended to.

Two of the four distinct modes that Law (1994) formulated, based on the talk, action and material organizing he encountered in his ethnography of the management of a scientific laboratory, are especially salient to my analysis: 'enterprise' and 'administration'.¹ Each mode envisions the world of the organization differently, and in doing so provides for particular ways of sense-making and normative assessment of action and situations.

Graders, when asked how they prepared for the progress meeting, said that the most important thing was to provide "an overview" of the project. Providing an overview is what the graders understand themselves to be doing as they extract the case records from the log sheet, filter them by month and referral decision made, add up totals for the year, and enter these into a table on a PowerPoint slide. As I watched one grader work with numbers to complete this last step, she commented: "I am just keying them in." It sounded almost like an apology, as in "sorry I can't show you something more interesting". But this indicated straightforwardness and simplicity is also the point: nothing else is done other than faithfully passing on what was found in the records.

With Law, we can say that these comments, these actions, this way of organizing work enact both graders and numbers in the mode of *administration*. This is a bureaucratic mode that heralds a strong emphasis on (due) process and on *correctness*. 'Correct' was indeed the term used by one of the graders when I asked for her response to the professor's requests for different numbers: "You don't want to present something that's not correct." Correctness is about ensuring accuracy: the grading manager checks the numbers before the meeting (and in other work of compiling numbers, graders apply checks and balances to avoid making any calculation errors). It is also about staying within one's remit and not getting creative: "I am just keying them in." Constituted in

relations of administration, graders are 'correct-overview providers', faithful to their 'correct-overview numbers'.

A physician, a scientist, a managing director, Prof Xu must strategize and negotiate, make decisions, write papers, prepare keynotes, see patients. He often joins the meetings late, rushing in after his last appointment, and, afterwards, rushing to the next. He wants to keep things moving. As progress reports are being presented, he listens to determine whether there is a need to intervene. Does this project need help of any kind? Does a sluggish collaborator need prodding, a new data analysis strategy formulating, a new source of funding finding? Should they pull the plug on a project that no longer interests people, no longer pulls in investments of money or time? His organizational world and he himself as a decision-maker are 'made' in the relations of enterprise. The mode of enterprise, as Law (1994: 75) describes it, "tells of deploying resources, of adaptability, and of riding with the punches". Acting in this mode involves seizing opportunities and staving off threats in the process of moving forward.

In the mode of enterprise, numbers become organizationally salient as materials in and through which opportunities or problems are ascertained. When the professor singles out specific numbers as being of special significance and asks to see 'trends', he enacts numbers in the mode of enterprise. In and through the numbers, the professor is looking for indications of whether the flagship project is bearing fruit. The progress numbers on the screen are possible sites for intervention, a "place of discretion" from which to see and act (Callon and Law, 1995: 494).

A way of presenting that places equal emphasis on every number is not satisfactory in the mode of enterprise. Instead, in his gestures and elaboration, the professor enacts the 2013 Rescreen number as "too low", as prompting the team to strategize on what to do next. In the mode of enterprise, numbers need to be displayed in such a way that threats and opportunities become visible. In this mode, the progress numbers presented in the meeting are elaborated as 'drive-change numbers' – a phrase taken from the professor's comment that the graders' stats "don't drive change". If the stats do not show the impact of the change in

referral criteria on the relative proportions of Rescreens versus Referrals, they do not support corrective action. These numbers need to indicate possible trouble, for, in the mode of enterprise, “failure is a practical matter – something to be put right by trying again. For there is no such thing as absolute failure. Rather, there are setbacks and strategic withdrawals.” (Law, 1994: 75)

Comments like “it’s not their fault” and “we need to train them” constitute the graders as learners who can progress; they also chart a particular kind of future. By “present[ing] the right stats” and “ask[ing] the right questions” graders can constitute both their numbers and themselves in the mode of enterprise. In and through their numbering, graders have the chance to make their value visible: both their value as diagnosticians for diabetic retinopathy (who work faster, more accurately, and more cost-effectively than generalist-doctors) and, at the same time, their value as enterprising subjects. The professor calls it “moving us all up the value chain.”

Indeed, the stakes of being able to engage numbers in the mode of enterprise become clear in the context of nation-wide initiatives that have sought “to entrench a culture of productivity and continuous learning and upgrading in Singapore”.² These foreground a particular kind of “thinking people” (Teh, 2012), in constant search of opportunities to ‘add value’, as exemplary employees – a model that extends to those, like the graders, in entry-level jobs.³ By enacting the progress statistics as ‘drive-change’ numbers, the professor holds these up as a prime site (though not the only one) for the graders to cultivate themselves as ‘thinking’ persons, to participate in seeing and showing opportunities and threats, to help make the case for the pilot service. Graders who engage numbers in the mode of enterprise thereby also indicate their own staying power in the world of work, even as developments in automation or artificial intelligence may put them out of their primary job.

So the mode of administration and the mode of enterprise operate with different values to anchor accountability: correctness in the first and opportunity/threat/action in the second. By having their numbers critiqued in the meetings, graders are asked to straddle the two. Juxtaposing

the two modes in relation to the concerns that animate the project also allows us to bring into view another aspect. Remember how Shawn cared about the number of ‘ungradables’, those images whose quality was too poor to be graded? He kept watching this number in case it prompted him to talk with the nurses about better use of the retinal photographic camera. Shawn could not see how he might develop a similar relation to the progress numbers prepared for the meeting, which, as he said, “to me don’t mean much”. He took a guess at the professor’s concerns – “maybe our referral rate is high?” – but he also drew a clear line: “Not to say that it’s not our concern. But we have to grade without bias.” Working with these numbers in terms of what the desired outcome might be, something Shawn was motivated to do for the ungradables, he saw as problematic for the progress numbers. Grading without bias is a matter of correctness and of vocational pride: Shawn seemed to take pride in not caring about these numbers, not going beyond ‘correct overview’, because doing so might interfere with his ability to do the work of grading at the core of his job. Here being ‘correct’ has a hint of the moral high ground as well as asserting a relation of accountable engaging marked by self-imposed disinterest in what these numbers “mean”.

Recourse to the analytics of modes of ordering has made it possible to examine the co-constitution of numbers and calculating subjects in how things get done and accounted for in organizations. In the different ‘modes’, numbers become organizationally salient as ‘correct-overview’ numbers or ‘drive-change’ numbers – with their respective ways of delineating appropriate actions and demeanours for calculating subjects. By allowing us to attend to both the organizational positioning of and the normativities inscribed in number work, modes of ordering provide a sense of the stakes and obdurances of the disconnect.

With Woolgar and Neyland: The self-evidence of numbers

The third and final analytic we will bring to bear on this case comes from Steve Woolgar and Daniel Neyland's (2013) book *Mundane Governance: Ontology and Accountability*. The way in which ontology and accountability are brought into double focus in this book provides another opportunity to articulate features of the disconnect. This approach is interested in "the accomplished ontology of entities" (Woolgar and Neyland, 2013: 51), the temporal fixation and distribution of identities. It has a particular focus on how such fixation and distribution is part and parcel of enacting moral orders.

An example is the case of the woman who sued MacDonalds for serving hot coffee, aggrieved after she had spilled the coffee on her lap (Woolgar and Neyland, 2013: 35-6). Was that an absurd action, or was it justified? The authors argue that precisely such evaluations are provided for in how the ontology of hot coffee is accomplished in accounts of the case. Characteristic of much of the media portrayal of the case is the following understanding:

The apparent absurdity of the case stems from the common sense assumption that, after all, coffee is (surely) meant to be hot. If you opt to purchase a coffee (from MacDonalds), you might expect it to be hot and so should take all normal precautions when handling hot coffee. (Woolgar and Neyland, 2013: 35)

Such an account performs a particular moral order in the relations and contrasts it makes available. It simultaneously achieves an understanding of (1) hot coffee at MacDonalds as self-evidently what it is (*just* coffee); (2) normal people as those who know how to relate appropriately to the hotness of this (and any) coffee; and (3) people who see cause for holding a vendor accountable for serving hot coffee as 'absurd'. Accountability relations are thus articulated in relation to achieving the object at the centre of the case as perfectly mundane – evoking readers' agreement that this is indeed what everyone knows about coffee. However, the hotness of MacDonalds coffee is respecified in legal commentary on the case. In this

respecification, the coffee "is no longer just hot, it is '30-50 degrees hotter than other restaurants', it is at a temperature that 'doctors testified...only takes 2-7 seconds to cause a third degree burn'," (Woolgar and Neyland, 2013: 36). The authors continue:

By contrast with the initial common sensical reaction – how on earth could someone really try and sue McDonalds for providing hot coffee – the subsequent version achieves the kind of hotness of coffee for which McDonalds becomes appropriately accountable. The revised ontology of the coffee performs new accountability relations. (Woolgar and Neyland, 2013: 36)

This approach allows us to explore the awkward exchanges between the graders and the professor as a contest between two different ways of articulating both what numbers *are* and what the graders are supposed to do with them. In their reading out of the numbers on the screen, in the reticent way they respond to questions, in talking about "providing an overview", in "just keying them in", etc., graders display an orientation to the progress numbers as mundane and self-evident, as *just* counts of cases. This is not, of course, to say that counting is self-evident or unremarkable *per se* (see Martin and Lynch, 2012). It is to say that – in their actions to prepare for the meeting, in their performance in the meeting, and in their comments on these meetings – graders accomplish numbers as speaking for themselves, as needing no elaboration. The self-evidence of the progress numbers is achieved through the way the graders act towards them, and it reinforces the *rightness* of this way of acting towards them.

This is further outlined in the observation that the professor's critique of the graders' presentation – his holding them to account for improving what they present – involves challenging the achieved self-evidence of numbers as obviously and recognizably 'just counts'. Instead, the professor, in his response to the numbers, the questions he asks, the gestures he uses to lift out certain numbers, the requests he makes, his exasperation at not getting through, etc., orients to the graders' numbers as "just raw numbers". Note the different connotation the term 'just' has here, compared to the graders' enactment of numbers as 'just'

counts. In the professor's contestation of what the graders are doing, the numbers are characterized by what they are not-yet. These "raw" numbers are trends-to-be-realized. With this as reference point for "temporary imputations of moral orders of accountability", the graders' numbers are frustratingly non-insightful: they do not support the meeting's participants in making sense of where the project is at. Just as the lawsuit did for the hotness of the coffee, the professor's intervention challenges the accomplished ontology of the read-out numbers as 'just' counts. His way of acting towards the numbers draws on accomplishing their nature as not-yet-trends, which in turn reinforces the rightness of his critique of what he sees.

The achieved ontology of numbers is thus intimately implicated in the question of whether the professor's request to the graders is or is not reasonable. This is not a contest over what the numbers 'mean': what the professor does is not an ironic second-guessing, saying that what the numbers actually show is different from what graders suggest they show. It goes, instead, to the question of what a number properly should be taken to *be*. To illustrate this, we can point to the imputations of lack and excess that symmetrically characterize each party's response to the other's enactment of numbers. In the professor's orientation, the graders' numbers offer too little: 'raw' information, words floating in the air, marks deposited in a table, devoid of investment in how these can really be made to speak. In the graders' orientation, the professor asks for too much to be made of these numbers: the request is difficult to place ("we are not clear on what he wants"), hard to achieve ("this requires a lot of time and coordination"), even illegitimate ("we have to grade without bias"). In all these ways, the graders construe the request as something *over and above* the self-evident ways in which counting referral decisions and reporting on progress is part of their job.

What this analytic contributes, then, is a way of investigating what counts as accountable engaging in relation to how numbers are enacted as nothing more or less than what they are. The imputations of 'too little' (professor to graders) and 'too much' (graders to professor) show account-

able engaging as the flipside of the accomplished ontologies of numbers.

Conclusion

By drawing together a fieldwork episode of a 'disconnect' in organizational work, and three STS analytics, this article has offered three ways of symmetrically describing varieties of accountable engagement with and of numbers. This question of 'engagement' is at the same time one of constituting numbers as what they *are*, and of detailing what those responsible for them can and should *do* with them. It is a question of what brings numbers alive, what sustains and secures them in their numberliness, and about the performance of organizational relations.

Helen Verran's (2001) work sensitized us to the multiple ways in which the numbers were done as a unity/plurality relation, a relation in which numbers become 'counts' or 'weightages', instantiated in ritualized repetitions that involve gestures and utterances. The professor's lively numbers specify engagement as a *whole/part* relation, one of percentage – thereby taking stock of progress by envisioning the project's trajectory into the future. But graders, to the professor's frustration, do not reckon with them in this way. They are doing numbers as a *one/many* relation, thereby taking stock of progress by adding up completed units of past work.

John Law's (1994) work sensitized us to the way numbers and appropriate behaviour towards them are delineated within different modes of ordering. In the mode of administration, 'correct-overview' numbers come to life in the following of procedure and avoidance of bias; in the mode of enterprise, 'drive-change' numbers come to life in the showing and telling of opportunity and threat in graders' orientation to both the project and their jobs. The professor wishes for *both* number-relationalities to be sustained, for numbers and graders to switch between one and the other. But graders stick with the mode of administration and do not sustain the 'drive-change' numbers beyond the professor's efforts at animating them in the meetings.

Steve Woolgar and Daniel Neyland's (2013) work sensitized us to how enactments of 'self-

evidence' become part of accountable engaging. The moral order made available in the professor's numbering features numbers as *needing to be probed and textured* so as to bring out trends and insights from inter-number relations and comparisons. By implication, the graders' numbers are 'raw', and graders' efforts in presenting them 'too little'. Conversely, the moral order made available in the graders' numbering features numbers as *needing to be left alone*: they are self-evidently what they are. By implication, the professor's request for different numbers is 'over and above', doing his bidding would involve treating numbers unaccountably.

What do we gain from this threefold sensitizing? Firstly, the symmetries produced in the threefold analysis show the graders' numbers to be 'proper' and alive in their own way, as a particular unity/plurality relation, within a particular mode of ordering, and in terms of a particular moral order. Graders may not be skilled with numbers in some ways, but they are in others. They sustain the lives of numbers in and through particular relations of respect, by accountably engaging according to what numbers' properties are taken to be. In three different ways, the graders' orientation to numbers has been rehabilitated, not by invalidating the professor's, but by telling stories of difference that are also stories of competence.

Secondly, we have charted a path into an empirical philosophy of numbers in STS that begins from the familiar strangeness of seemingly unanimated, 'floating' numbers. This is significant for making the question how *numerals* become *numbers* part of our repertoire. Empirical situations where parties are at odds over accountable engaging may touch on that very question, may instantiate it in number-relations as they are performed and contested. My hope is that the episode examined in this article will stand as one example of the possibilities of examining *already-made* numbers, in a field that methodologically has been drawn to studies of *numbers-in-the-making*. Perhaps this distinction is overblown: numbers-in-the-making are in another sense already pre-made (in the sense that they are conventional) and the showing, seeing, speaking and hearing of already-made numbers continues to 'make' them, as the threefold analysis above

has shown. However, the familiar strangeness of numbers is given additional play by starting from the agnostic treatment of encounters in which the proper treatment as well as liveliness of numbers *qua* numbers is at stake. The three analytics sensitize us to the trails we can follow from such a starting point and could yield interesting analyses of other instances of demonstrations and presentations of number-forms, including engagements with (big) data (see also Nafus, 2014).

Thirdly, the abovementioned points can be taken forward in reflecting on the article's use and juxtaposition of STS analytics, in regard to the 'doing' of multiplicity, difference and contribution. The use of the analytics has multiplied the stories to be told of my fieldwork episode. Much in the way a kaleidoscope presents an ordering of its pieces that is different with each turn, each analytic organizes its symmetrical description according to a different concern, creating different patterns. For Verran, it is how (and with what consequences) the numberliness of numbers is manifested, for Law, it is how numbering co-constitutes the relations out of which organizational agency emerges, for Woolgar and Neyland, it relates to the conditions of possibility for treating numbers as self-evident. What can we do with such an observation? Rhetorically, in terms of how journal articles are often written, it feels difficult to leave things there, without a stronger statement of implications. Should I argue that it is only with Verran that the analysis is truly specific to numbers? Only with Law that the labour conditions under which the numbers emerge come into view? Only with Woolgar and Neyland that the lack of elaboration by the graders of their numbers turns from a lack into a constitutive element of the situation? Does this give us a basis to choose one over the others, in certain situations or for certain analytical purposes? Such a case could perhaps be made, but I would like to end on a note that leaves greater openness and that also, in parallel with lessons learned from STS analyses of numbers, shows greater regard for the work in and through which such analytics are sustained.

I say this in recognition of the fact that the episode 'works' the analytics as much as the analytics 'work' the episode – work that in each case produces relevant distinctions. The analytics

have produced graders' numbers as distinct from the professor's numbers by thickening what emerges as a disconnect in the meeting with ways of narrating relations of accountable engagement. Yet the episode, as a 'comparison engine' (Beaulieu et al., 2007) has also produced certain elements of the work of Verran, Law, and Woolgar and Neyland as number analytics that are *distinct* from one another, by enrolling them as tools on the 'same' job. Like the numbers they describe, the analytics have attracted labour (mine) to help coalesce and sustain them, and mull them over (see also Kenney, 2015). Again like the numbers, they become and remain things to be reckoned with in and through efforts to use them, respectfully and generatively. This acknowledges the creative intellectual work of furthering this particular corner of the STS field – work that entails doing empirical philosophy and wielding with precision the instruments we have available for doing it. It also suggests that we can commit to such work without the presumption of fully knowing, specifying, pinpointing, exhausting, or subordinating others' work *qua* analytics. With a capacity for surprise. The patterns and distinctions that show up in this way are worth noticing for the 'life' they contain and transmit. You may prefer one over the other, but the point is to have them show up in service of expanding and renewing our collective repertoires for how to think with what we encounter.

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Notes

- 1 Law cautions that modes of ordering do not stand outside their practical enactment; they may be usefully 'imputed' but have no driving force. In a later piece he adds that a mode or logic of ordering is meant to denote "a coherent and persistent feature of social relations. One test of that coherence would, I think, be their recursive propensity: that is, their tendency to reproduce themselves" (Law, 1996: 303, note 15).
- 2 <https://www.mti.gov.sg/MTIInsights/Pages/Research-And-Development.aspx>.
- 3 A telling example from the campaign to increase productivity is how one employee working in the housekeeping and linen management team of a hospital "realised that older workers sorting linen often had trouble differentiating one garment from another, so she made mini samples of each type of garment and put them up for easy reference to speed up sorting. Another seamstress working with her sews butterflies over small holes in hospital garments, reducing wastage. "It may be small, not big money, but the point is that we hope every employee, whether in cleaning, or the kitchen, or linen department will think about how to make things better and safer for patients," Mrs Chew [the CEO] says." (Teh, 2012: 11)