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Designing qualitative interfaces: Experiences from studio education

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Abstract: Interaction designers tend to use quantification as a default to present information and a way to enable interactions with technologies. There is a notion that quantification is valued to be the most actionable and legitimate form of presentation, while our actual experiences of the world are largely qualitative. But can we design 'qualitative interfaces'? What would they be like? In this paper, we explore insights and experiences from four years of applying the notion of qualitative interfaces in interaction design student projects in two countries. We introduce, review, and compare projects across different application areas ranging from running training schemes to electricity use, and discuss questions around the relationships between the underlying phenomena and links to the ways in which they are displayed or represented, around the variety of ways in which students arrived at their designs, and suggest considerations for others interested in this kind of approach.

Keywords: qualitative interfaces and displays; interaction design; design studio education; showcase.

1. Introduction

> "What man lay on his back counting stars and thought about a number?"
> Don Draper, in *Mad Men* s07e04, 'The Monolith', 2014

Interaction design, especially in digital contexts, has tended to default to quantification to present information and enable interactions with technologies. Whether the data collected was itself natively digital (e.g. arising from within a computer), or whether analogue- to-digital conversion has happened at various stages (e.g. data about the human body, or the natural world), the presumption is often that these phenomena need to be presented,

visualised, explained to users or other audiences in numerical form. Even if done creatively, with novel forms of visualisation, physicalisation (Jansen et al., 2015) or even sonification (Serafin et al, 2011), the norm—no doubt arising from interaction design and human-computer interaction's intersections with computer science—is to value the quantitative as the 'best' form of presentation, the most actionable and comparable, the most 'legitimate'.

1.1 Engaging with the qualitative

The wider epistemological questions over the value of qualitative data in social science, and the interactions between arts, humanities and sciences, are all relevant here. But practically, in interaction design especially, it might be simply that we have not had good ways to think about qualitative data in the design of interfaces and displays, despite our actual experiences of the world being largely qualitative. As expressed in the call for papers for this track at DRS:

> "Often it's *qualities* which help us make sense of the world. From a cat's purr, to wrinkled fingertips in the bath, the feel of fabric, the crunch of fallen leaves, or a map we draw for a friend, much of our experience is qualitative rather than quantitative... Telling someone you're 7/10 happy, or 62% in love, or even that you managed 10,000 steps today, is less meaningful than a richer description of your experience."[1]

Can we design 'qualitative interfaces'? What would they be like?

In this paper, we—interaction design educators, working in different contexts—explore some insights and experiences from four years of applying the notion of qualitative interfaces and displays (Lockton et al, 2017) in interaction design studio courses and student projects in two countries. We introduce, review, and compare projects across different application areas ranging from running training schemes to electricity use, and discuss questions around the relationships between the underlying phenomena and links to the ways in which they are displayed or represented, around the variety of ways in which students arrived at their designs, and suggest considerations for others interested in this kind of approach. Because of the large number of projects and application areas included, we have summarised these in Table 2 (Appendix).

1.2 What are qualitative interfaces and displays?

Lockton et al (2017, p1845) tentatively suggested:

> "a qualitative **display** as... a way in which information is presented primarily through representing qualities of phenomena; a qualitative **interface** enables people to interact with a system through responding to or creating these qualities,"

going on to illustrate (with examples drawn from design, HCI, and real-world observations) a possible spectrum of one dimension of qualitative displays and interfaces, relating phenomena to how 'directly' they are represented:

[1] https://www.drs2022.org/theme-tracks/#01

- Level 0: The phenomenon itself 'creates' the display directly
- Level 1: The display is an 'accidental' side-effect of the phenomenon
- Level 2: The side-effect is 'incorporated' into a display that gives it meaning
- Level 3: The display is a designed side-effect of the phenomenon
- Level 4: Some minor processing of the phenomenon creates the display
- Level 5: Major processing of the phenomenon creates the display

However, while this spectrum offered some initial directions for thinking about this area—and we have applied it when discussing examples in sections 2 and 3 of this paper—it is limited in its usefulness. Other dimensions and considerations are clearly relevant, not least in terms of perspectives raised by others exploring similar areas but with somewhat different focuses in the years since. For example, Offenhuber and Telhan's (2015) Peircean semiotics-inspired work on *indexical* visualisations (e.g. smoke as an 'index' of fire), developed into an emerging body of work on *autographic* visualisations (Offenhuber, 2020), those designed to create or inscribe 'traces' of their own processes, and moved even further into the notion of the whole world as an analogue computer (Offenhuber & Parkhomenko, 2021). Lee et al's (2019) explorations of synaesthesia brought extra attention to the sensory (and cross-sensory) in designing more qualitative kinds of interface, exemplified through Lee and Balint's (2021) work on "qualitative contact" for astronauts. In data physicalisation, approaches such as Thudt et al's (2018) personal physicalisation construction and Lean's (2020, 2021) materialising data experience contribute ways of thinking about data in which qualities and properties of materials themselves—including textiles—become central to representing, sharing, and interacting with it, in some ways echoing the material-driven work of Aguirre Ulloa and Paulsen (2017) on understanding social relationships through physical use of material properties (see also Lockton et al, 2019b, 2020c). A comprehensive review of the state of the art in data physicalisation by Dragicevic et al (2021) includes theoretical positioning of, for example, material and indexical qualities within physicalisation, and reflective and artistic approaches.

Each of these developments, along with the authors' growing experience in applying the qualitative interface idea in design education, suggested that the levels in the spectrum of abstraction outlined above might not be the most useful kind of taxonomy—and we explore this further, briefly, in section 4 of the paper. But our main focus here is to illustrate and discuss what happens in practice when design students are given briefs around this topic—what kinds of designs emerge?

1.3 Where in design is this useful?

From somaesthetic design (Höök, 2018; Neely, 2019) to designing with bodily fluids (Søndergaard et al, 2020—and see 'Kalliope' in section 3.1 of this paper), the 'embodied' turn in HCI and design has offered new perspectives on sensory experience and self-tracking,

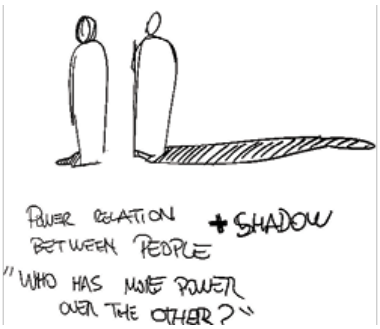
which often involves qualitative dimensions, and has emerged partially in response to the mainstreaming of quantified self-technologies and practices. As such, fitness, personal informatics, and healthy lifestyle contexts (section 3) have proven fruitful as an application area for qualitative interface thinking. We have also found that, more widely, the idea of visualising otherwise invisible phenomena (section 2), whether technological or human (or indeed ecological), and whether 'measurable' or not, offers lots of opportunities for more qualitative forms of engagement. We suggest these areas as being especially fertile for design exploration—but there are, no doubt, others.

One final point: in this paper, we describe a mixture of "interfaces" and "displays"—in some cases, student projects are prototyped as displays (i.e., one-way, output only) but if realised more fully would perhaps be two-way interfaces, interactable-with by users. The distinction is made more fuzzy where the phenomena being monitored or represented are themselves responsive to a person's input—does a runner actively deciding to take a different route to change the look of a display (see Laina, section 3.1) effectively interact, remotely, with that display? Where clarity is needed, we have explained this in the example, but we have chosen to treat "qualitative interfaces" as a catch-all term including displays as a subset.

2. Qualitative Interfaces for Invisible Phenomena

In this section we review briefly a diverse selection of student design projects carried out from 2017–20 at Carnegie Mellon University, which each responded to briefs with a 'qualitative interface' component to them[2]. The projects all attempt to make invisible or intangible phenomena engageable-with. FocusWatch (2.1) looks at sleep; Electric Acoustic (2.3) looks at electricity; while the three projects in section 2.2 take a particular qualitative interface prompt—around data materialisation and autographic displays—as a starting point, but applied to very different domains.

Qualitative Interfaces and New Metaphors



After the publication of Lockton et al (2017), the first author was invited to the Universidad del Desarrollo, Chile, to teach two groups of interaction design students how to create qualitative interfaces and displays, in workshop sessions. Since there was no specific method or obvious process, a decision was taken to concentrate on phenomena themselves, in the world—mostly natural—which might be able to be used as inspiration for non-

[2] We have excluded two families of projects, *Mental Landscapes / Tangible Thinking* (Ricketts & Lockton, 2019; Lockton et al, 2019b) and *Materialising Mental Health* (Luria et al, 2021) which, although inspired by the qualitative interface idea, involved physicalising abstract concepts rather than 'data', externalising them from the minds of the participants via the qualities of materials. The more explicitly metaphorical qualitative augmented reality approach of *Experiential Augmentation* (Lo et al, 2018) has also been omitted here.

numerical displays. For example, to visualise "power relations between people", students came up with ideas ranging from shadows, to flocks of birds. These were essentially *metaphors*, and as such an initial set of 'metaphor cards' was developed as provocations for the students to find their own phenomena; these cards subsequently, following a further workshop at [redacted] a technology company's conference, formed the basis for the New Metaphors project (Lockton et al, 2019c), moving away from the specific 'interface' context but still with a strong qualitative emphasis.

2.1 Focus Watch

Developed by Yuhan (Antonio) Song, Focus Watch was a response to a brief around autoethnography of student sleep cultures (Lockton et al, 2020d). Interested in the practice of "all-nighters", Antonio tracked his own "focus rate", as he defined it (i.e. time spent on school work) between midnight and 9AM, finding that even when "working", over 6½ hours were spent on distractions—social networking, entertainment, and retail sites—leaving only about 3½ hours of productive work time. After experimenting with different sleeping / waking patterns, and a browser extension monitoring which tabs were active, Antonio created a smartwatch app providing near-real time feedback on focus and procrastination. Given the prompt to explore a more qualitative form of display than simply showing "% focus rate", Antonio reflected on how (losing) focus felt to him like something smooth or perfect becoming damaged or dirty or broken. Sheets of paper were crumpled and smoothed out again to try to capture this feeling physically.

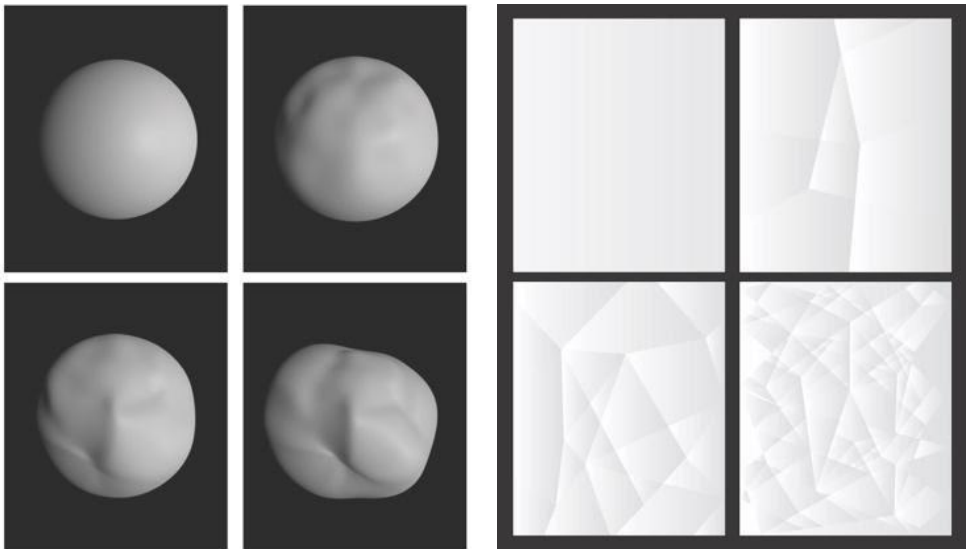


Figure 1 (left). A clay ball metaphor represents declining focus when displayed in a smart watch interface. (right). A clear sheet of crystal becomes progressively more shattered to provide feedback on focus rate.

Antonio iterated on different interface designs using a variety of metaphors (Lockton et al, 2019c), interested to see how these might provide a more qualitative and nuanced

representation of productivity and procrastination as opposed to solely quantitative feedback. The final design used two metaphors as a form of qualitative display: a **smooth clay ball** that becomes dented when focus is lost (Figure 1, left), and **a clear sheet of crystal** that becomes progressively more shattered when browsing patterns steer predominantly towards "non-productive" sites (Figure 1, right); they then become smooth and intact again when the wearer's focus increases. The intention was that these are non-intrusive, glanceable displays which do not demand the wearer's attention, but offer a gentle qualitative indicator. In the Lockton et al (2017) classification, these would be Level 5 qualitative displays—there was no actual link between the phenomenon of measuring the time spent in different browser tabs, and the clay ball or crystal representation.

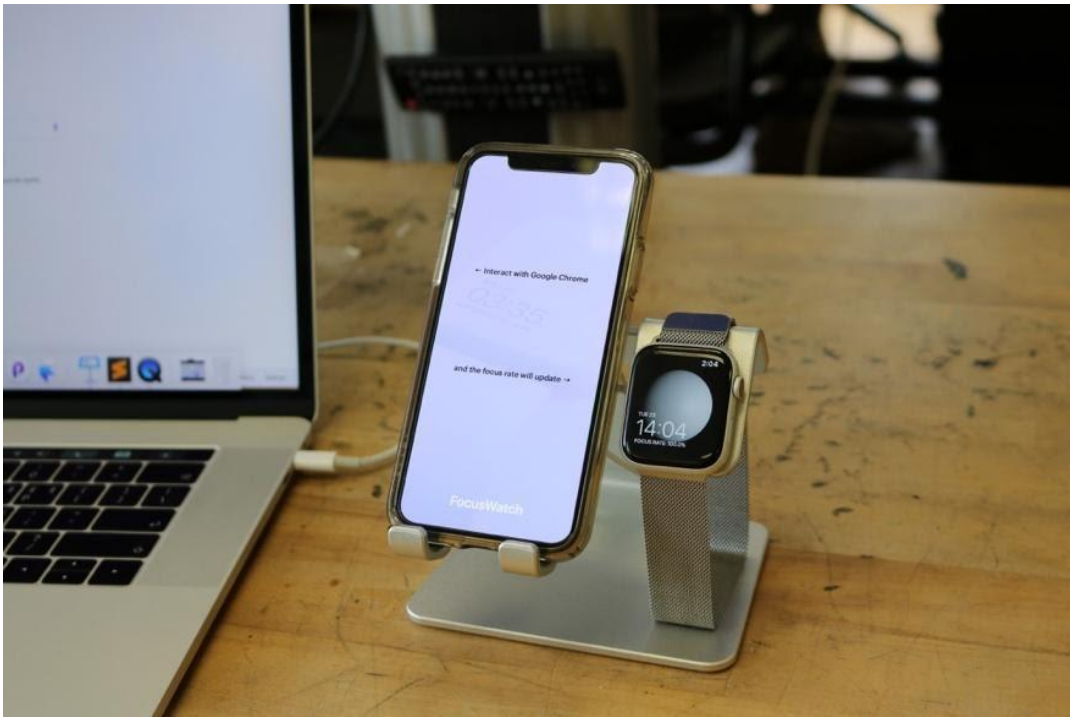


Figure 2. As the user visits websites on the laptop, the clay ball display changes in real time on the smartwatch.

2.2 Palpable Pulse, Human Vases, and A Window Into Block Play

Following a workshop on *data materialisation* (Lean, 2020)—an approach to data physicalisation (Jansen et al., 2015) in which the qualities and characteristics of materials are considered as being a vital part of the process of representing data, undergraduate students were introduced to qualitative interfaces, and specifically Offenhuber's (2020) concept of *autographic visualisations*, and examples of other designers' (and artists') work. Students were given a very open brief to create a qualitative (ideally autographic) interface, using material properties to illuminate an invisible phenomenon in human experience. The three projects we describe interpreted the qualitative interface idea in very different ways.

Palpable Pulse

In *Palpable Pulse*, Jason Zhu explored how the qualitative dimensions of human heartbeats—the patterns and rhythm rather than solely a numerical rate—could be captured and represented through a physical display, as an alternative to the quantified displays of common contemporary fitness trackers. (Pulse is an interesting phenomenon to explore in this qualitative context—see section 3 for more projects addressing bodily aspects of self-tracking). In Jason's consideration, "a physical interface, perhaps situated on one's desk, is able to embed itself as not only a more present force in one's life [than a number or graph in an app] but as a more relatable entity"—relatable in the sense that, in his vision, the interface itself would move, pulsing synchronously with a person's heartbeat. Most obviously the heartbeat of the 'user', but it could also be someone else's.

Jason experimented with ferromagnetic fluid (animated by MOSFET-controlled electromagnets) as a physical material which mapped certain characteristics of heartbeats into a tangible form, 'beating' like a heart. In a series of exploratory prototypes (Figure 3), ferromagnetic fluid suspended in oil pulsed and quivered in time to a heartbeat 'signal' which (for demonstration purposes) could be adjusted in tempo and rhythm via a light-dependent resistor sensor, but could also be driven by a live feed of a person's pulse. Another variant (Figure 4) used a 3D-printed heart with a permanent magnet inside, suspended over the same electromagnetic base, to create a pulse display which could be held in one's own—or another person's hand. In the form presented, Palpable Pulse probably fits the Level 5 classification from Lockton et al (2017), involving a major processing of the phenomenon to create the display (even if it sought to mimic something of the qualities of the original heartbeat), but being driven directly from pulse measurement itself would perhaps bring it closer to Level 4, with only minor processing needed.

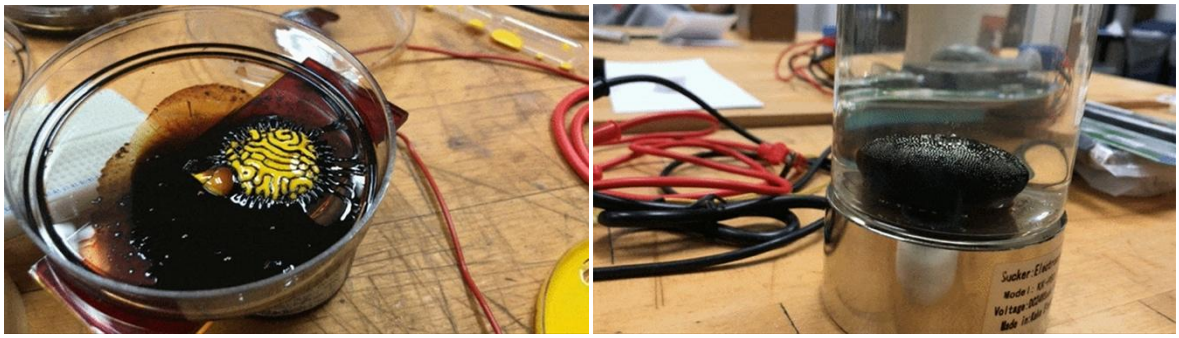


Figure 3. Two Palpable Pulse ferromagnetic experiments. Videos available at https://medium.com/@jasonlzhu/palpable-pulse-an-exploration-of-ferromagnetic-interfaces-to-visualize-personal-health-data-6c0a07eca44e

Figure 4. Palpable Pulse 3D-printed pulsing heart, by Jason Zhu, which 'beat' as it was held over an electromagnetic base.

Human Vases

Designed by students Vicky Zhou and Davis Dunaway, but produced through a process influenced by participants themselves, the *Human Vases* (Figure 5) were experimental 3D-printed vases, printed in (near) real-time while one participant chatted with a chatbot and the other acted as a "judge". The setup drew on a simplified "one-word" version of the Turing Test (McCoy & Ullmann, 2018) in which a participant's aim is to convince a human judge that they are the human (as opposed to the chatbot), with only one word to do so. Essentially, the shape of the vases, and specifically, glitches or defects in the form, were produced (via a real-time dynamic G-code generation) in response to "errors" made by the human judge—the more errors made, the more glitches the vases incorporated, which could be seen by participants during the (time-limited) session. Here, while it was possible to count the number of glitched layers in the print as a way of quantifying the errors, the pattern—how equally spaced the glitches were, whether there were runs of errors or runs of correct guesses, and how the patterns differed between participants—was intended to offer a more qualitative, and to some extent autographic, dynamic 'display' while also being a novel form of data physicalisation. Students were introduced to resources such as the Data Physicalisation Wiki[3] and also projects including Desjardins & Tihanyi's (2019) *Listening Cups*, which potentially provided inspiration in form, even though the structure and purpose of the work are very different. *Human Vases* played with notions of human and machine intelligence and fallibility in both the Turing Test aspect and the 'making' of the vases,

[3] http://dataphys.org/list/gallery/

translating errors in one domain into errors in another; very much a Level 5 approach using the Lockton et al (2017) criteria, involving a major processing of the phenomenon to create the outcome.

Figure 5. A Creality Ender 3D printer, two monitors, and a 'booth' desk constructed by Vicky Zhou and Davis Dunaway comprised the Human Vases project. More images and discussion at https://vikz.medium.com/autographic-visualizations-edc54554f2be

A Window Into Block Play

At the other end of the technology scale from *Human Vases*, Nick Marotta's project *A Window Into Block Play* took the strongly autographic Level 0/1 (or perhaps Level 2) stance from Lockton et al (2017), in which a phenomenon itself 'creates' a display, accidentally, or as a side-effect which can be intentionally designed into a display that gives it meaning. Nick's context was children's block play individually or in groups. After observing children playing with blocks on a visit to a kindergarten, Nick commented that, "When kids play with blocks, it can appear to be senseless chaos to adults, but there is a complex web of learning experience going on. Kids are taking what they've observed of the real world and modelling it in real time, trying to understand relationships, roles and responsibilities, even gaining intuition of physics and their bodies. I thought it'd be interesting to attempt to manifest some of that dynamic information in the physical structure produced by block play."

The approach here was to treat the outcome of block play—the arrangement of the blocks—as a qualitative display of the activity itself. By the simple process of dyeing wooden blocks and giving children each a different colour, their social interaction and the qualities of their collaboration (or not) in the construction of a "sculpture" would directly be visible in the outcome—the story of the interactions would be visualised. (In retrospect there are interesting parallels with 'Conway's Law' (Conway, 1968) in organisational theory, although this was not recognised at the time of doing the project). While it was not possible to get ethical approval to run a study with the kindergarten-age children, Nick produced sample structures embodying different interaction patterns, and made use of a mid-term exhibition to gather insights from (adult) visitors about what patterns they perceived in the arrangements of blocks. For example, in Figure 6, a structure with mixed red and yellow

blocks ‘collapsed’ and a blue structure intact might suggest that the blue child was jealous of red and yellow’s friendship and had collapsed a joint structure they had built. Or an intricate structure with some blocks positioned delicately, a mixture of red, yellow and blue, might suggest children who are “learning to take risks”, and “building a group” together.

Figure 6. Sample block structures embodying different interaction patterns, presented to gather insights from (adult) visitors about what patterns they perceived.

2.3 Electric Acoustic: Sonic and Vibration displays

Data sonification is usually presented in quantitative terms, finding appropriate ways to map numerical data to tones, tempo, amplitude, instruments, and so on, or more poetically, to create music from the data—while still respecting the underlying numbers. However, there are potentially interesting opportunities in more qualitative approaches to data sonification—it is often used as a way for patterns or anomalies in datasets to be ‘noticed’ more easily (Lenzi & Ciuccarelli, 2020) and as such the qualities of phenomena themselves may start to play a role in the ways in which they are sonified.

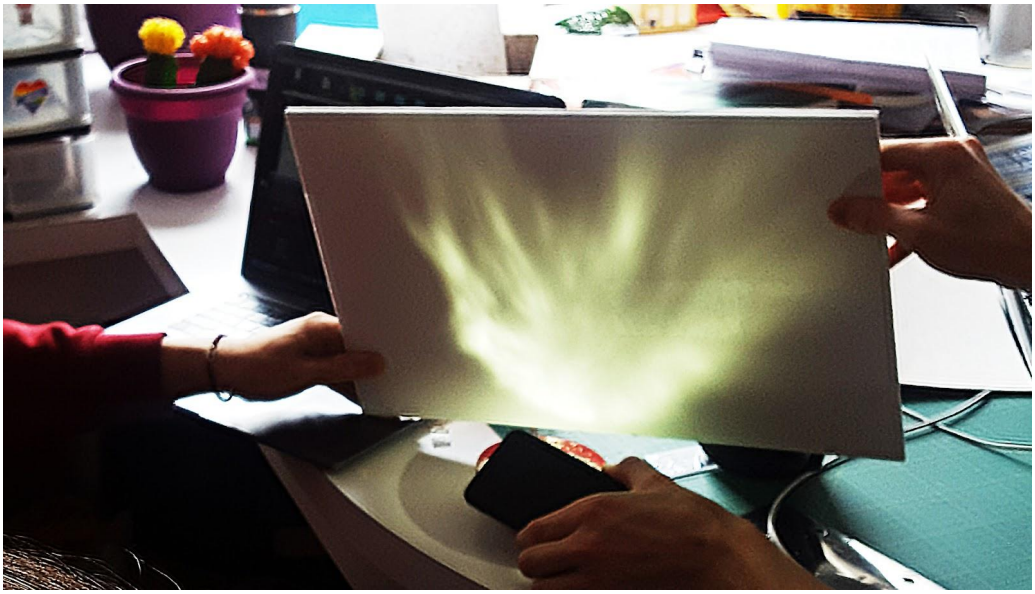


Figure 7. Initial 'vibration' experiments for Electric Acoustic. Video available at http://imaginari.es/electric-acoustic-exploring-energy-as-a-design-material-through-sonic-and-vibration-displays/

Following previous experiments with sonification of energy—specifically, electricity use (Lockton et al, 2014), using sound samples such as birdsong increasing in complexity (which already sought to offer a more qualitative way of interpreting the data, building on metaphors identified by Bowden et al (2015))—the *Electric Acoustic* project (Lockton et al, 2019d) involved students exploring more broadly what it could mean to think about designers working with energy's *qualities* instead of only treating it as something to monitor and quantify. Properties and qualities considered included energy's ability to enable things to perform actions; directly—closer to Levels 1 or 2 of the Lockton et al (2017) classification—one might imagine using electricity to burn marks on something, to electrolyse something, to create patterns (e.g. Lichtenberg figures in wood), or to shock a user (Lee, 2018), making 'electricity' visible or tangible.

Figure 8. The vibrating dish of water, positioned on top of a speaker, with light patterns reflected onto the wall behind.

While the specifics of the sonification are detailed in Lockton et al (2019d), in short, Gray Crawford, Shengzhi Wu, and Devika Singh created an ambient sound installation using three months' worth of electricity data for a building at Carnegie Mellon to trigger 20 parallel sine wave oscillators based on the magnitude of change in electricity use, so that heavy and long-term electrical draws (e.g. air conditioning) are audible as low pitched drones whereas tiny, short-term draws are audible as flickering, active, mid to high frequencies.

3. Qualitative Interfaces for Healthy Lifestyles

In this section we introduce a selection of student design projects carried out from 2019–21 at the Eindhoven University of Technology (part of the Vitality Squad, led by Carine Lallemand) which focused on qualitative approaches in the context of design for healthy lifestyles. Students were instructed to move away from the widespread quantified-self approach (Neff and Nafus, 2016) and to find ways to represent data in a qualitative and meaningful manner. We present families of artefacts to exemplify how several student groups responded to the same precise brief. Previously published examples not covered here include Ivy (Menheere, Damen, Lallemand & Vos, 2020b) and Office Agents (Stamhuis, Brombacher, Vos & Lallemand, 2021). Both projects reflect a design for debate approach to challenge the status quo of sedentary office work. For instance, Ivy (Figure 9) is an interactive office chair that represents sitting time through growing ivy strands, which will ultimately immobilize the chair after two hours of prolonged sitting. Damen, Menheere, Lallemand & Vos (2020) detail how the criticality of the design emerged from, and was supported by, the qualitative approach adopted.

Figure 9. Ivy is an interactive office chair that represents sitting time through growing ivy strands (Menheere, Damen, Lallemand & Vos, 2020b)

Figure 10. (left) With the Office Agents by Stamhuis et al. (2021), the employee engages in a speculative negotiation around optimal office conditions. (right) Dearing by Yvonne Bruin, is a collection of shape-changing wearables, designed to investigate the effect of wearing data

3.1 Exercising Motivation: Laina

Many people have positive intentions of being physically active, yet it remains a challenge to turn these intentions into exercise behaviour. A myriad of products and services attempt to motivate and support people in exercise behaviour, yet they rely on quantification and 'in-the-moment' feedback (Menheere, van Hartingsveldt, Birkebæk, Vos & Lallemand, 2021b). Students were asked to design for exercise motivation, with a qualitative interface component. A collection of nine artefacts was designed under the supervision of Daphne Menheere and Carine Lallemand.

Laina, designed by students Evianne van Hartingsveldt and Mads Birkebæk, is a shape-changing art piece that creates a data physicalization of running routes, through actuated pieces of wood. Technical details are provided in Menheere et al. (2021b). The students first explored materials that could shape-change as described by Rasmussen et al. (2012) with a focus on understanding the constraints of some materials and getting inspiration. They for instance used Living Hinge laser cutting material, origami and kirigami techniques or fluidic mechanisms inspired by Venous Materials (Mor et al., 2020). They built four low-fi prototypes to reflect on different characteristics, namely levels of density, the type of physical change in surface and different forms of restrictions in the visualization of a run.

Their main focus was to find opportunities to physicalize the runner's routes (using data from external running applications such as Strava or Runkeeper). The level of abstraction and the aesthetical effect created differed greatly according to the prototype. They eventually choose the exploration with the wooden black pins, as this system supported a certain degree of detail in the visualization while still being able to actuate.

Figure 11. Laina is a qualitative interface for running motivation, physicalizing routes and intensity (Menheere, van Hartingsveldt, Birkebæk, Vos & Lallemand, 2021b)

Routes' data is abstracted and mapped on Laina by representing pins corresponding to geolocalisation and time segments in the user's run (Figure 11). The length of each individual pin is based on the average effort on that time segment (e.g., averaging pace, heart rate). Both the number and length of pins influence the level of granularity and direct translation of the data physicalized. As pixels in a digital display, more pins would result in more precise data translation. The abstraction of the route through a limited number of pins aligned with the intended aesthetics, relying on an approximate representation supporting discovery and sensemaking. Indeed, the idea behind Laina is not only to display running routes in an artsy fashion, but rather to encourage runners to explore different types of routes in order to influence the aesthetics of their artwork. While Laina appeared at first as a qualitative display, this form of indirect and somewhat remote interaction brings an interesting perspective blurring the lines between qualitative displays and qualitative interfaces. The device is responsive to the person's input and the designers play on this mechanism to trigger a form of engagement and motivation. In opposition to the immediacy of running apps feedback, the students opted for a slow reward mechanism, where the feedback of the last run is not presented immediately, but progressively displayed over two days. The user can anticipate the changes in the physicalisation. Evianne and Mads implemented another form of interaction by allowing users to push some sticks back as a reset. In the Lockton et al. (2017) classification, Laina fits level 5, where some major processing of the data (running routes and intensity) forms the eventual display of Laina.

Five other artefacts were created by the students based on the same brief of designing a qualitative interface for exercising motivation. Reflecting on what similarities the outcomes

share, we observed that, besides objective elements related to trainings (e.g. running route, speed, frequency), qualities related to the body are often dominant in qualitative interfaces for healthy lifestyles designed as part of The Vitality Squad studio education: heartbeat (Liin), breathing patterns (Niara), or even sweat (Kalliope) were used to represent personal data around exercising practices. In the project Niara, the steam mimics the breath of the user: the steam movement (and underlying aesthetics) increases with exercising frequency. Liin uses heartbeats to stimulate exploration and reflection on the previous training. It represents balance by means of two magnetic cones which loosen up if you are not exercising.

The desire to design a multisensorial artefact which would resonate with the multisensorial experience of exercising was also a starting point for several projects, with resulting displays and interfaces using smell (Myrrhis, Àsynja), touch (Liin, Myrrhis, Laina), sound (Myrrhis) or a combination of modalities. Myrrhis is for instance a multisensorial object displaying different elements of a run: it attracts the user's attention through sounds (of steps and nature) and invites the user to interact. Its material triggers a satisfying soft touch feeling. Iron dust activated by a magnet hints at the proud feeling they experience after a run. Some projects interestingly combined multisensoriality to a theory of motivation, e.g. Àsynja (Menheere, Hilderink, Vos, & Lallemand, 2021a), which diffuses scents related to your previous run to trigger exercise imagery and remind you to go running again.

Finally, Kalliope represents a design for debate artefact relying on a paradox in sporting: one first has to go through short-term efforts (e.g. sweat or pain) before having a rewarding post-exercising feeling (Menheere et al., 2020a). Student Rani Škrabanja wondered whether we could turn these costly side effects into something more aesthetically pleasing and even rewarding? Kalliope is a poetic provocation using droplets on a display to represent the sweat during a workout. Why is it that we see sweat as something unwanted? Kalliope tries to find poetry in sweat and to translate it into a piece of art. Over the day, the artwork will dry and just like real sweat does, the water leaves stains on the work as traces of previous efforts.

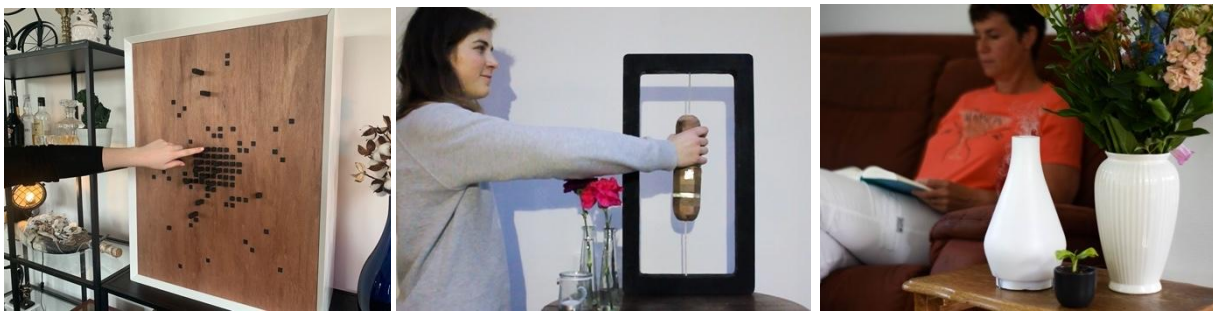


Figure 12. (left) Laina, designed by Menheere, van Hartingsveldt, Birkebæk, Vos & Lallemand (2021b). (middle) Liin designed by Ine Hikspoors, Ioana Stefanescu, Lisanne de Jonge & Naomi ter Haar. (right) Asynjá designed by Menheere, Hilderink, Vos, & Lallemand (2021a).

Figure 12. (left) Myrrhis, designed by Midas Zegers, Marleen Luijten & Floren van Barlingen. (middle) Kalliope designed by Rani Škrabanja. (right) Niara designed by Robin van Overbeek, Charlotte Meertens, Nikki Okkels.

Throughout the projects, students often went to their default mode of processing data: quantification, and thus ways of choosing elements of the design concept. We also observe that many of these projects embed a sort of contemplative element, with the concept of interactive artwork being recurrent in the production of students. Most designs remained at the qualitative display level, where the display is not always visual but mediated through other senses. In the field of healthy lifestyles, raising users' awareness through displaying personal data (typically through numbers) is usually not a sufficient trigger for motivation and change. Whether this holds true for qualitative interfaces is an interesting area to further explore. The addition of a form of friction, as proposed by the concept of Pleasurable Troublemakers (Hassenzahl & Laschke, 2015) can be a promising approach, which was also explored in several students' projects (de Haan, Menheere, Vos, & Lallemand, 2021; Menheere, Haan, Vos & Lallemand, 2021c)

Figure 13. Interactive artefacts using the aesthetics of friction to trigger exercising motivation. (left) Meria by de Haan, Menheere, Vos, & Lallemand (2021). (middle) Raya by Menheere, Haan, Vos & Lallemand (2021c). (right) Nami by Anna Merl, Emile Smeets, Jitze Orij.

3.2 Injury-free Running: Traice and the Tradeables

Despite the popularity of activity trackers, people struggle to gain meaningful insights from their personal data. Devices fail to take into account the contextual and subjective factors (e.g. injuries, fatigue, stress), and thus emit recommendations that do not correspond to the users' needs. Students from the Vitality Squad, led by Carine Lallemand at the Eindhoven University of Technology, were challenged to integrate a specific aesthetic of interaction-through-negotiation principles in order to integrate the user's perspective into the data processed by the device and its subsequent recommendations. Away from quantification, a

collection of “Tradeables” embracing tangible and embodied feedback was designed under the supervision of Juan Restrepo-Villamizar and Carine Lallemand.

Developed by student Evy Murraij, Traice is an interactive artefact supporting recreational runners in defining balanced training schemes. Traice is an interactive board composed of three areas, representing three factors at stake to prevent injuries during trainings: the distance of a run, its duration and its intensity (speed). Risks increase when the combination of these factors lacks balance, or is misaligned with contextual and subjective factors. Before going for a run, the user defines the relative value of each factor by placing a pin on each section of the board. There are four levels of intensity, which were purposively not quantified in order to be open to every runner. Based on data from the user’s activity tracker, Traice defines a recommendation per parameter.

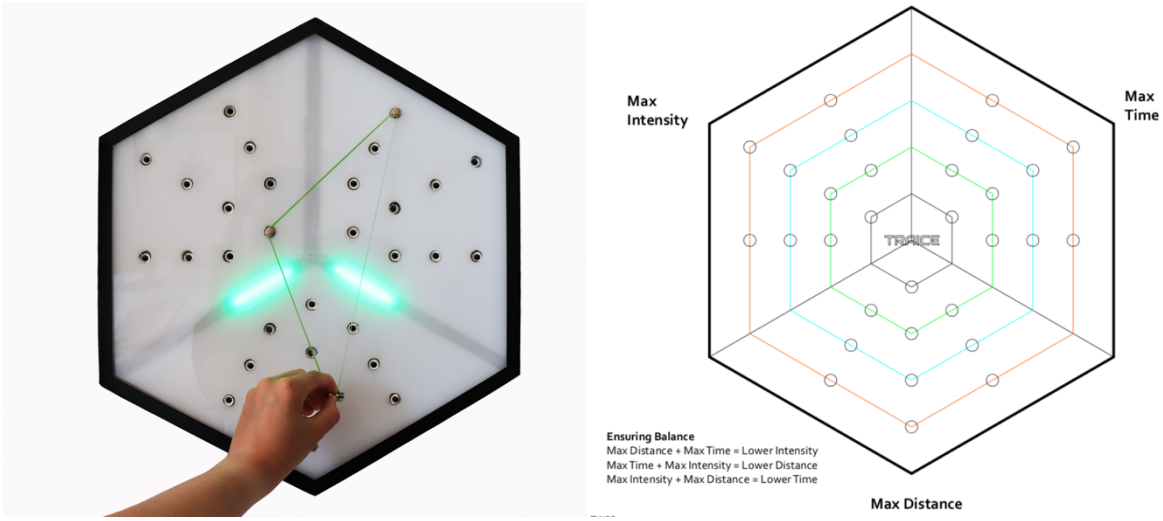


Figure 14. (left) The elastic reaches maximum tension, with two parameters defined as high (distance and duration). (right) Schematic representation of Traice.

If the pin is not placed by the user at the recommended parameter level, the board starts to flicker. It stops upon removal of the pin. The user has to consciously decide to choose the same level again or another one. At the second attempt, the board goes to the next area. The board does not necessarily want to change the user’s mind, but mostly aims to create awareness of the decisions made. An elastic rubber band ties the pins together. The more ambitious the training, the bigger the area formed and the tighter the elastic. The triangular area and underlying tension created represents the strain on the user’s body: the system does not quantify nor prescribe, yet it embodies a qualitative form of feedback. Evy used the elastic as a tangible metaphor to raise user’s awareness on the amount of tension put on your body for a specific training choice. As one places the pins and pulls the elastic, Traice forces a moment of reflection on the acceptable tension. Every training adds a new digital trace on the board. This “shadow” of the past runs provides an overview of former trainings and progression. In the Lockton et al (2017) classification, these would be Level 5.

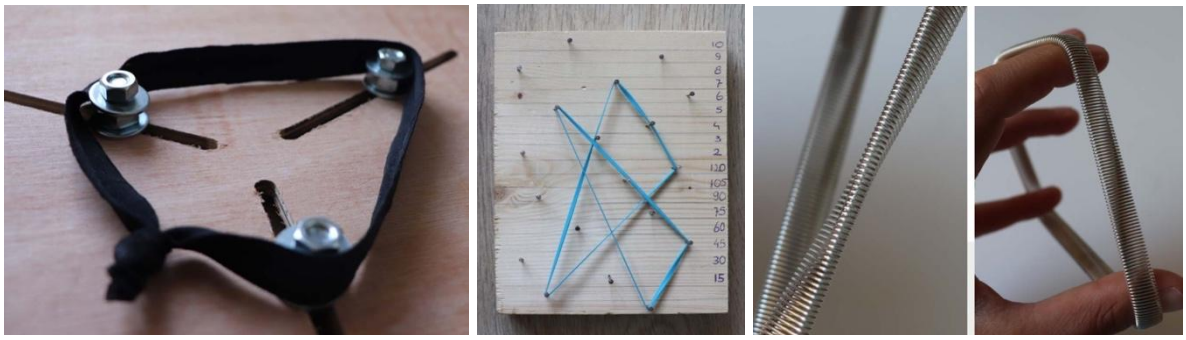


Figure 15. Material exploration around the idea of tension using different types of rubber bands.

While the Tradeables represent ten artefacts designed by different students over three semesters in a challenge-based learning environment, their respective design processes share similar trajectories. The starting point is rather traditional: understanding the users and the context. In this first step, a benchmark is conducted and triggers a reflection on the shortcomings of current quantification approaches, failing at providing meaningful feedback to users. In most systems, the more, the better. At the detriment of a balanced training, numerical feedback pushes for more steps, more distance, more intensity.

Aiming for a qualitative and tangible interface, students then typically focus on the meaning of balance and negotiation in the running context, with a definition of aesthetics of interaction principles and a broad ideation through sketching. Besides the idea of tension used in Traice, this led to numerous metaphors of (a) *balance*, such as cairns (Flib), synchronised beat (WarmUp, Hyaku) or flow (Ready-Set-Flow) (b) *negotiation*, such as turn-taking in negotiation strategies (Moirai), force feedback as embodiment of resistance (Moirai), the idea of debt and compensation (Ready-Set-Flow), (c) *reflection*, for instance the mirror in Hyaku. The tipping point where the negotiation fails is often physically represented, for instance the elastic breaking in Traice, the pile of stones collapsing in Flib, the distortion of the self-image, following by the sound and feeling of broken glass in Hyaku. In the design processes, this final stage was not always anticipated by students and usually arose during the making process and material exploration. In all but one of the devices produced, the interaction happens through the user's hands, which might seem distant from the practice of running.

Figure 16. Other design artefacts from the Tradeable family. (left) Flib by Luc Streithorst, Koen Broekema, Naomi Afenkhena, Lars Lammers. (middle) WarmUp by Ruben de Jongh. (right) Ready-Set-Flow by Dorien Brugman.

Figure 17. Other design artefacts from the Tradeable family. (left) Moirai by Romain Toebosch. (middle) Hyaku by Restrepo, Vos, Verhagen,& Lallemand (2022). (right) Tradeable board by Juan Restrepo-Villamizar..

4. Discussion and Reflection

4.1 Qualitative interfaces in design education: opportunities and challenges

The projects described above, undertaken in two countries in different design departments, largely involved a 'coaching'-style studio model in which the teachers offered prompts and directions, but students took their projects in a variety of directions.

Some observations on opportunities and challenges include:

- Students who are used to more quantitative data approaches may find it hard to start with a 'qualitative' design brief. A design process with structured brainstorming and regular 'pushback' on ideas which start to become overly quantitative again offers one way to keep this on track. Using metaphor-based challenges early in the process, including provocation, can also provide an easier route into this; another source of unblocking for some groups has been the Data Physicalisation Wiki Gallery[4] maintained by Pierre Dragicevic and Yvonne Jansen, and the new Data Sonification Archive[5] curated by Sara Lenzi, Paolo Ciuccarelli, Yuan Hua and Houjiang Liu, which, although not mainly about qualitative physicalisations and sonifications, includes sufficient variety to provide an inspirational set of ideas.
- Nevertheless, many projects still use quantitative data as (part of their) input—producing qualitative interfaces with quantification behind the scenes, to varying extents. Does this matter, or is a rich combination of numbers, contextualised through qualities, a good way forward? Qualitative-only approaches in portraying data can add a sense of ambiguity and remove the ability to explore (quantitative) details and granularity, which is presumably more appropriate for some contexts; further work could explore the effect of that ambiguity on the user experience.
- We see many installation-type 'art pieces' as a result of qualitative interface briefs, with only a few wearables, for example. Should every kind of data have its own art piece? This potentially affects the applicability of this kind of approach in industry or design practice contexts—does it mean qualitative interfaces will always stay at the 'art' end of the spectrum? How can we support students in thinking of qualitative interfaces in a different way to broaden their applicability and even business potential[6]? Or does focusing on applicability, or usefulness, inhibit the freedom of deeper exploration?

[4] http://dataphys.org/list/gallery/

[5] https://sonification.design/

[6] Perhaps learning from the ways in which, for example, Stefanie Posavec has introduced creative data visualisation techniques from *Dear Data* (Lupi & Posavec, 2016) in professional workshops:

- Material explorations can be a fascinating and rich outcome of the process, from the constraints and complexity of working with unfamiliar materials such as gallium or ferrofluids or even sweat and steam, to becoming more attuned to sensory and material qualities in more seemingly familiar contexts. This links to a thorough focus on the aesthetics of interaction, although there can also be value in the pure 'delight' of translating or embodying ideas physically rather than digitally. One downside might arise when material constraints restrict the potential to express meaning in a subtle way with the right level of granularity.

4.2 Towards an enriched taxonomy of qualitative interfaces

The examples illustrated in this paper, in their variety and complexity, have suggested some directions towards a richer form of taxonomy for qualitative interfaces, with more dimensions beyond simply how directly the output maps to phenomena in the world.

While we do not plan to develop and detail a full theory in this paper, we do want to highlight some of the possible questions and dimensions that have emerged from considering how the qualitative interface idea is realised in practice. These mainly relate to different starting points, and different intentions for the work.

Starting points

Practically, there are a variety of different starting points which can be used to arrive at qualitative interfaces. None is inherently right or wrong, but each potentially offers a different way into the design process. Some which we identified are outlined in Table 1.

Table 1 Some starting points for designing qualitative interfaces

Possible starting point	**Questions**
Material properties	What qualities does a particular medium have that would suggest its use in a display or interface?
The phenomenon itself	What qualities does a phenomenon have that would suggest trying to make use of it in an interesting way?
Bodily or sensory experience	Are there qualities which cannot be easily 'seen' but can be somehow translated or used to inspire the design?

http://www.stefanieposavec.com/workshops — or, how Lean (2021) discusses introducing her form of data physicalisation outside of the art school context in which it was developed

Quantitative / numerical data	Starting with quantitative or numerical data, but considering how it might be translated into a non-numerical output
Metaphors	Are there metaphors or analogies which seem appropriate, powerful, critical, poignant, or otherwise inspirational in reframing or translating a phenomenon? As noted above, this is often an easier way in for students who perhaps do not (yet) have deeper experiences with, for example, particular material properties.

Intentions

What does the interface or display actually (intend to) do? Some have a goal of making invisible data or phenomena visible directly; others do so more through an indexical approach (see section 1.2) in which a 'co-produced' effect of the original phenomenon is instead highlighted or made apparent; some (perhaps all?) are about transposing or mapping one phenomenon onto another; some are explicit about their use of metaphors to do this; some are something closer to a simulation of the phenomenon or model itself (compare analogue computing).

Does the interface or display aim to provide a 'record' for a user, provide an opportunity for exploration and sense-making, capture a particular feeling or sensory experience, take a critical stance, or simply offer a means for reflection? More critical perspectives on data, e.g. D'Ignazio and Klein's (2020) *data feminism*, which highlights the value of lived experience—and the politics of which data are collected in the first place—seem to offer opportunities for qualitative interfaces, but how do these different perspectives affect the design (and aesthetic) choices made? Does an interactive interface, or even a dynamic display (as opposed to, for example, a static data physicalisation) offer a different kind of sense-making? Should the aim be to move more towards interactive interfaces, than solely displays?

Traces (and *Traice*, section 3.2) and Offenhuber's (2020) notion of autographic visualisation (see section 1.2) led to us considering ephemerality and permanence: if the 'Level 0' of Lockton et al (2017) is about often ephemeral phenomena, then does 'design' suggest an intentional way of creating and presenting a permanent trace or record of this? What about intentionally-made traces, compared with those accidentally created? Is 'not cleaning up' a trace, and embracing the fact that you're leaving it, a form of 'design'—and how does that bring more artistic process considerations into interaction design?

Future work

In future work, we aim to untangle some of these questions further, with reference to other work which has explored related questions from different angles, and arrive at a framework which can be useful in interaction design (and human-computer interaction) research and education, as well as in design practice itself.

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Appendix

Table 2 *Qualitative interface projects included in this paper*

Project name	**Application area**	**Description**	**'Level'** (Lockton et al, 2017)	**Reference / Authors**
Section 2 - Qualitative Interfaces for Invisible Phenomena				
FocusWatch	Focus, all-nighters	Smartwatch app providing near-real time feedback on focus and procrastination	5	Lockton, D., Zea-Wolfson, T., Chou, J., Song, A., Ryan, E., Walsh, C.J. (2020d)
Palpable Pulse	Heartbeats	Exploration around how the qualitative dimensions of human heartbeats could be captured and represented through a physical display	4 or 5	https://medium.com/@jasonlzhu/palpable-pulse-an-exploration-of-ferromagnetic-interfaces-to-visualize-personal-health-data-6c0a07eca44e
Human Vases	Machine and human intelligence and fallibility	Experimental 3D-printed vases, printed in (near) real-time while one participant chatted with a chatbot and the other acted as a "judge"	5	https://vikz.medium.com/autographic-visualizations-edc54554f2be
A Window Into Block Play	Children's play patterns	The outcome of block play—the arrangement of the blocks—acts as a qualitative display of the activity itself	0/1 or 2	Designed by Nick Marotta
Electric Acoustic	Electricity use	*E*xploration on what it could mean to think about designers working with energy's *qualities* instead of only treating it as something to monitor and quantify	4 or 5	Lockton, D., Crawford, G., Singh, D., Wu, S. (2019d)

Section 3 – Office work				
Ivy	Sedentary office work	Interactive office chair that represents the amount of sitting time through growing ivy strands	5	Menheere, Damen, Lallemand & Vos (2020b); Damen, Menheere, Lallemand & Vos (2020)
Office Agents	Office conditions	Set of artefacts placed on the employee's desk, which capture and physicalize data about the office environment	5	Stamhuis, Brombacher, Vos & Lallemand (2021)
Dearing	Wearing data at work	Collection of provocative shape-changing wearables to investigate the effect of wearing data at work	5	(unpublished) by Yvonne Bruin
Section 3.1 – Exercise motivation				
Laina	Exercise motivation	Shape-changing art piece presenting physicalized running data through a slow feedback mechanism	5	Menheere, van Hartingsveldt, Birkebæk, Vos & Lallemand (2021b)
Liin	Exercise motivation	Art piece that visualizes the progress made after each run based on heartbeat and distance	5	(unpublished) by Ine Hikspoors, Ioana Stefanescu, Lisanne de Jonge & Naomi ter Haar
Asynjá	Exercise motivation	Scent diffuser that triggers exercise imagery by using natural scents related to previous runs.	5	Menheere, Hilderink, Vos, & Lallemand (2021a)
Myrrhis	Exercise motivation	Multisensorial device helping women to maintain a healthy lifestyle by reminding them of different elements of a run	5	(unpublished) by Midas Zegers, Marleen Luijten & Floren van Barlingen
Kalliope	Exercise motivation	Poetic provocation reminding of good post-workout feelings, using sweat droplets as a metaphor	5	(unpublished) by Rani Škrabanja
Niara	Exercise motivation	Interactive ambient display mimicking breathing patterns to trigger a feeling of satisfaction after being physically active	5	(unpublished) by Robin van Overbeek, Charlotte Meertens, Nikki Okkels

Meria	Exercise motivation	Shrinking clothes hanger using the aesthetics of friction to trigger exercise motivation	5	de Haan, Menheere, Vos & Lallemand (2021)
Raya	Exercise motivation	Tangible sports buddy aims to help women overcome the doubts experienced before getting dressed for a workout	5	Menheere, de Haan, Vos & Lallemand (2021c)
Nami	Exercise motivation	Frictional towel rack pushing people to exercise	5	(unpublished) by Anna Merl, Emile Smeets, Jitze Orij
Section 3.2 – Injury free running				
Traice	Injury free running	Interactive artefact supporting runners in defining balanced training schemes using the metaphor of tension	5	(unpublished) by Evy Murraij
Flib	Injury free running	Interactive device inspired by cairns, aimed at supporting an healthy exercising routine		(unpublished) by Luc Streithorst, Koen Broekema, Naomi Afenkhena, Lars Lammers
WarmUp	Injury free running	Interactive fitness mat using music to give recommendations to-, and negotiate with the runner		(unpublished) by Ruben de Jongh
Ready-Set-Flow	Injury free running	Connected product representing goals to support an exercising routine		(unpublished) by Dorien Brugman
Moirai	Injury free running	Interactive board helping runners to self-regulate their running routine by negotiating with them		(unpublished) by Romain Toebosch
Hyaku	Injury free running	Interactive tangible mirror supporting runners in defining a balanced training scheme		Restrepo, Vos, Verhagen & Lallemand (2022)
Tradeable	Injury free running	Interactive product supporting runners in defining a balanced training scheme		(unpublished) by Juan Restrepo