An optimal environment for our optimal selves?: An autoethnographic account of self-tracking personal exposure to air pollution

Sarah H. A. Tan[1] and Thomas E. L. Smith[1]

[1] Department of Geography & Environment, London School of Economics & Political Science, Houghton Street, London, UK.

ABSTRACT

This paper presents an autoethnographic study which tracks the experience of routinely monitoring personal exposure to air pollution, using Plume Labs' 'Flow' device. While conventional air quality data is provided by static monitoring stations, this paper seeks to understand how new intimate data from portable sensors can influence decision-making and induce behavioural change. This is explored in relation to self-tracking and the 'Quantified Self' (QS) movement, recognising that the environment is intrinsically part of the self and the body. Through autoethnography and reflecting on experiences in London and Kuala Lumpur, this paper explores the practicalities of using Flow and its potential as a transformative tool to facilitate societal consciousness and change towards 'the optimal self' with minimised exposure to air pollution. Through personal experience and interactions with others, this paper finds that individuals' willingness and ability to attempt to minimise exposure to air pollution is subject to a combination of factors within and beyond one's control. However, whilst self-tracking does not necessarily translate into attempts to minimise exposure, choosing to be exposed to higher levels of air pollution in certain circumstances becomes an active decision. Whilst some maintained their scepticism of Flow's potential, and others remained apathetic towards air pollution, Flow was found to be particularly effective in cultivating curiosity and consciousness through its facilitation of conversations about air quality. Flow's provision of otherwise absent information and its potential to create a network of better-informed individuals is exciting but uncertain. This paper raises important questions about the role of the QS and such sensor devices in addressing urban air pollution and creating a sense of collective accountability to the environment, moving towards a new goal of 'the optimal environment for our optimal selves'.

ABBREVIATED ABSTRACT

This paper presents an autoethnographic account of routinely monitoring personal exposure to air pollution using a portable sensor, while reflecting on self-tracking and the 'Quantified Self' (QS) movement's objective of 'the optimal self'. By exploring how this otherwise absent data may induce behavioural change and encourage individuals and their networks to minimise pollution exposure, this paper raises important questions about the role of the QS and such monitoring devices in addressing urban air pollution and creating a sense of collective accountability to the environment.

1 INTRODUCTION

Extensive research has shown that air pollution negatively affects human health. This is particularly apparent in urban environments with per capita mortality attributable to air pollution estimated to be roughly 50% higher than in rural environments in 2010, with the difference increasing to nearly 90% under a business-as-usual scenario by 2050 (Lelieveld et al., 2015). Population exposure to urban air pollution has been measured largely using ambient air monitoring stations. However, these do not adequately capture personal exposure to air pollution which is highly variable temporally and spatially across microenvironments. Experiments conducted to capture this individual-scale effect can be rendered limited in their ability to reflect actual lived experiences of air pollution and monitoring personal air pollution exposure in urban environments.

With the evident "expansion of sensors beyond laboratories into relatively affordable, easily obtained consumer devices" (Nafus & Sherman, 2014, p. 1790), we believe there is merit in exploring how this new form of citizen sensing feeds into discussions around the 'Quantified Self' (QS) movement. The QS movement is premised on the belief that self-measurements allow for increased "self-knowledge through numbers" (Wolf, 2009), setting individuals on paths towards 'the optimal self' (Gregory & Bowker, 2016; Lupton, 2016). This paper hopes to expand on the QS literature, recognising that the environment is not just external but also an intrinsic element of the self and the body. Hence, acknowledging the quantification of environmental factors, in this case – personal air pollution exposure, as a quantification of self. The QS movement is motivated by self-improvement through an accountability to the self and

the body. In a similar manner, this paper seeks to explore the potential for these new sensors to foster a shared accountability to the environment amongst users and the network of conscious individuals it cultivates, working towards the more ambitious target of 'the optimal environment for our optimal selves'. The 'environment' here is in reference to the air we share. This paper explores how technology can act as an enabling medium in influencing daily decision-making processes and inducing behavioural change, whilst cultivating curiosity and consciousness. Through an autoethnographic account, this paper tracks the lead author's (Tan's) personal experience of routinely monitoring personal exposure to air pollution, assuming the role of 'the citizen' in this citizen sensing project.

2 METHODS

Exposure to air pollution permeates the everyday lives of every individual. Hence, whilst typically applied in anthropological and sociological studies, autoethnography presents the perfect tool to account for personal experiences of routinely monitoring personal air pollution exposure. Through a process of self-reflection, autoethnography recognises writing as a method of inquiry to better understand social phenomena (Adams et al., 2015; Ellis et al., 2011; Crang & Cook, 2007). By placing an understanding of self within the wider social context, insight into social experiences provide a basis for which others can make sense of similar experiences (Mayan, 2016; O'Reilly, 2012; Butz, 2010); acting as a means to facilitate social consciousness and societal change (Adams et al., 2015). The application of autoethnography to air quality studies has been limited. Using autoethnography, Zolnikov (2018) describes lived experiences of personal exposure to air pollution from cooking in Kenya's rural villages; and travelling on heavy

traffic-laden roads in urban Nairobi. Building on Zolnikov's (2018) work, this study focuses instead on the experience of monitoring personal exposure to air pollution.

Related literature on citizen sensing, specifically Gabrys' 'Citizen Sense' project uses a participatory and community-based approach, focusing on experiences of community residents monitoring air quality. 'Citizen sensing' is "a practice of monitoring environments that is in many ways structured as an individual pursuit [and]… the terrain of one political subject using a device to monitor her or his environment to take individual action" (Pritchard & Gabrys, 2016, p. 354), much like the QS. Where citizens operate as 'a node or data point', the combined "contribution of many, individual citizen nodes is meant to produce collectives and collective data that are meaningful and actionable" (Pritchard & Gabrys, 2016, p. 358). However, the validity and accuracy of citizen-produced data is often questioned. Hence, Gabrys and Pritchard (2018) use the concept of 'just good enough data' to address accuracy issues and highlight the rich value of trans-local experiences, collective insights and approaching environmental issues from new perspectives. We believe autoethnography extends this, offering a different dimension to the experience of monitoring personal pollution exposure by assuming the role of 'the citizen' in this citizen sensing project. Autoethnography is able to reveal insights into the personal experience of self-tracking personal exposure to air pollution, beyond merely the production of numeric data (Figure 1).

This study uses Plume Labs' 'Flow' device, marketed as "the first environmental sensor of its kind to be this small, this portable, and this personal" (Plume Labs, 2019). The device measures real-time concentrations of PM2.5, PM10, NO_2 and VOC, making

use of smartphone location services to track changes in air pollution exposure temporally and spatially. 'Flow' lights up in four colours indicating different levels of air pollution exposure, according to the US AQI (EPA, 2014). 'Flow' syncs with a smartphone app, sending data via Bluetooth and presenting data visualisations. This was supplemented by regularly contacting Plume Labs to obtain 'raw' datasets and processing this data to produce daily cumulative exposure plots, for comparison with WHO and EU exposure limits (Figure 2).

Active routine monitoring of my pollution exposure using 'Flow' was carried out over 12 weeks, from 26 November 2018 to 17 February 2019, during which time I reflected on my experience using the device and how it informed my daily decision-making. I kept a journal to note my observations, thoughts and reflections throughout each week. As an international student, observations were made primarily in London but also across geographies with two weeks at home in Kuala Lumpur. By conducting fieldwork in both cities, it became apparent that the experience of monitoring personal pollution exposure, and the resulting effects, shifted across geographies, even with the same user.

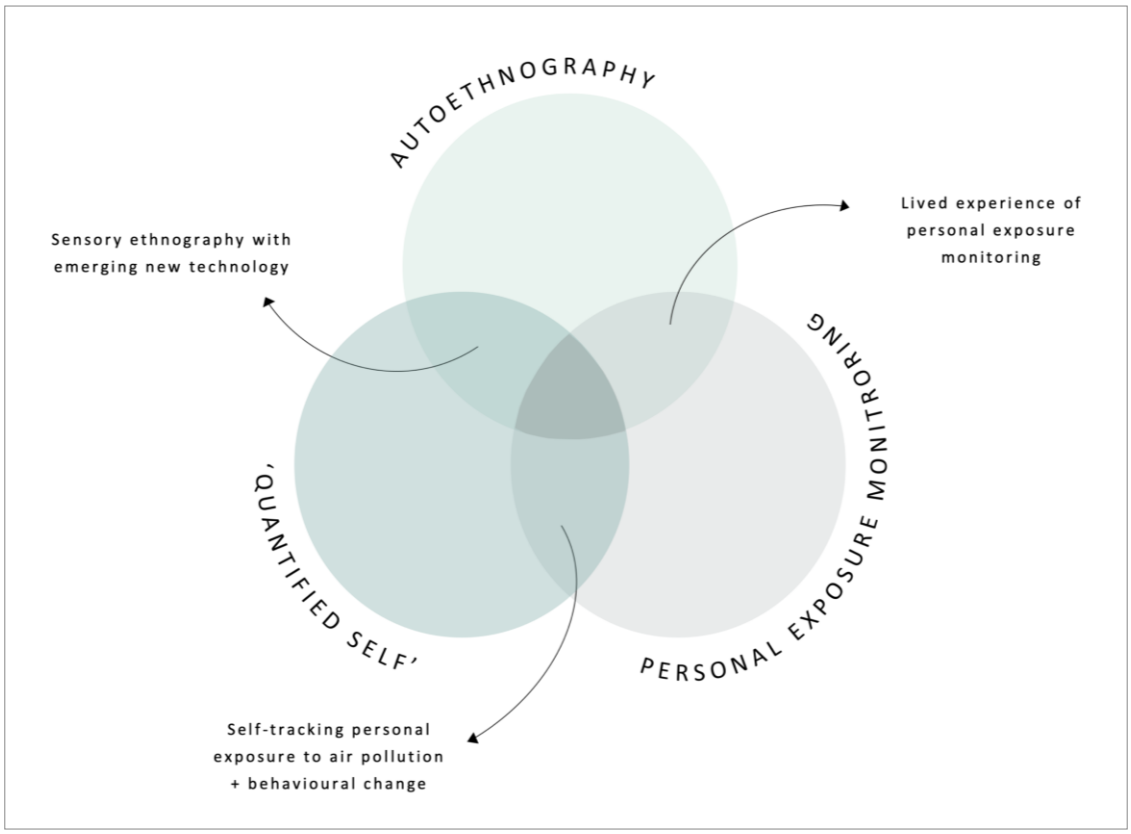

Figure 1*: The areas of overlap indicate our novel approach to exploring PEM and QS through an autoethnographic account.*

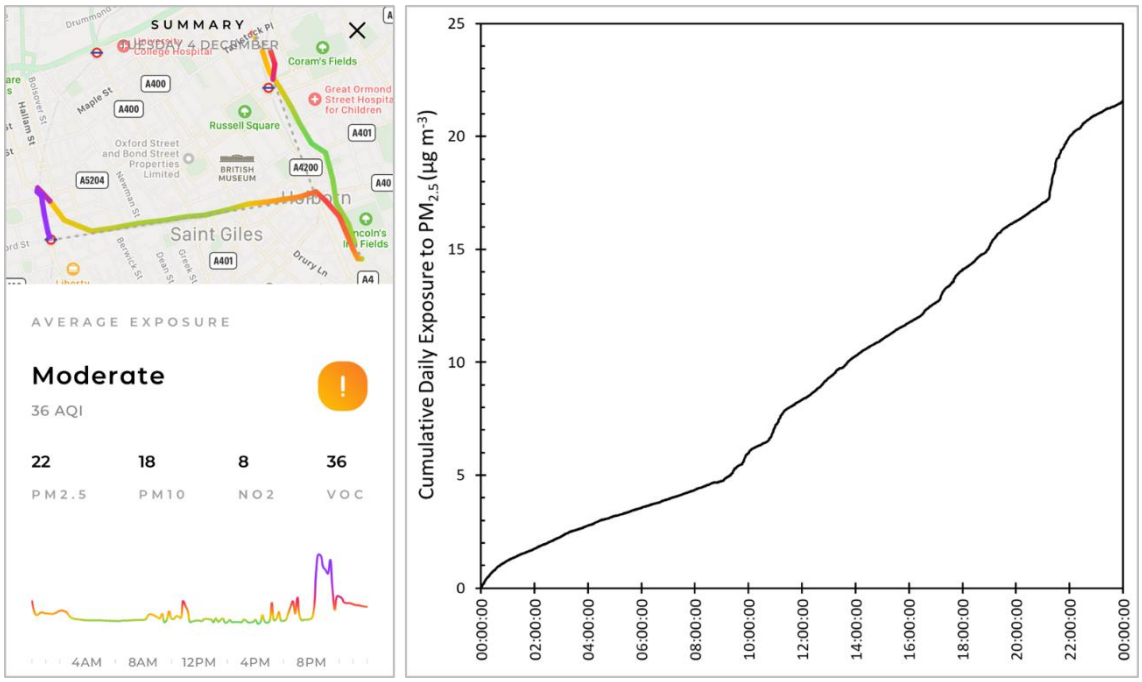

Figure 2: *(left) Screenshot of a daily summary in the Flow mobile phone app for 4 December 2018; (right) Flow data from the same day processed to calculate cumulative exposure over a 24-hour period.*

3 FINDINGS & ANALYSIS

3.1 The Quantified Self

Lupton (2016) notes that digital data on 'the self' significantly influences people's behaviours, sense of self, social relationships and potentially their life chances and opportunities. This study explores the extent to which this is true for personal air pollution exposure. By presenting individuals with the opportunity to set quantifiable goals, these devices act as "pedagogical and motivating agents" (Nafus & Sherman, 2014, p. 67) to agitate social change, as the perceived tangibility of such goals improve. Flow's different colour indicators were particularly motivating initially. Purple translates to very high exposure, red to high exposure, yellow to moderate exposure and green to low exposure. I found myself disappointed with 'purple' days and excited about relatively 'green' days. Acknowledging that 'green' days are not free of pollution, limitations to understanding our data in relation to permissible limits set by bodies of authority are recognised. "Threshold limits assume that ecosystems and bodies can assimilate a specific amount of toxicant before harm occurs" (Liboiron et al., 2018, p. 335). This establishes structures which systematically and legally allow a specified amount of toxicants in environments and bodies. Furthermore, embedded within these "experts' standards" are a set of claims about pollution and health (Ottinger, 2010).

Tracking introduces intention into everyday activities (Nafus & Sherman, 2014) resulting in a goal-oriented QS. The purposeful collection of data allows individuals to review their conduct of life and determine how best to make changes for self-

improvement. Where data is often seen as a 'window' into people's lives, the QS movement urges us to instead consider data as a 'mirror', in which reflections are to be made and personal insights to be revealed (Wolf, 2010 as cited in Nafus & Sherman, 2014). Moreover, self-tracking and the resulting new information on the self allows for the reconfiguration and redistribution of expertise. Hence, individuals are able to actively participate in the process of knowledge production, in which invisible power structures are typically embedded.

Wearable sensor devices like Flow have been understood as 'technological exosenses' (Swan, 2012 as cited in Lupton, 2016) or 'prosthetics', extending the body's sensory capabilities. This then makes explicit the quantification of the environment, in this case – air pollution, as an extension of self. Relatedly, the use of metaphors in self-tracking discourse portraying the body and self as a machine-like entity, in which 'inputs' and 'outputs' are readily measurable and quantifiable (Lupton, 2016), assumes the QS' control of their 'inputs' that affect progress towards the optimal self. However, when considering the environment as an extension of self, some 'inputs' or factors that determined my air pollution exposure were not entirely, if at all, within my control. This is where this research departs from existing QS literature. The QS here adopts a different role as a member of a shared environment, exposed and subjected to certain 'inputs' beyond the remit of the bounded self. Where the QS tends to look inwards in its monitoring of 'the self', self-tracking personal pollution exposure involves focusing outwards on other people and processes in understanding these effects on the self.

For example, in rainy weather, my overall exposure tended to be lower than on dry days, even if I walked the same route to and from university. Similarly, during a period of assignment deadlines, I spent many hours in the same indoor spaces. However, as indoor air quality typically correlates with outdoor air quality, it was evident that pollution exposure in specific spaces succumbed to temporal variability. As such, it became difficult to assume 'safe spaces' based on previous AQI readings.

While Flow presents new intimate knowledge that affected my behaviour and decision-making processes, it is important to recognise other determinants that work to inform my choices, whether conscious or subconscious. A central concern that emerged from my observations and interactions with people was the feasibility of attempts to minimise personal pollution exposure whilst simultaneously completing day-to-day activities. In understanding better the circumstances in which I would subject myself to higher exposures of air pollution, I was willing to adapt my behaviour and attempt to limit my exposure, only when it was convenient to do so. My willingness to minimise my pollution exposure by walking a different route or avoid taking the London Underground, was highly dependent on time I had and whether an attempt to reduce my exposure was easy and identifiable.

Flow explicitly presents the health risks associated with high personal exposure to air pollution that may be "indiscernible at ground level but manifests in chronic health effects" (Kelly & Fussell, 2015, p. 632). Barr (2003, p. 230) notes that "the threat posed by environmental problems… can have a significant impact on the degree to which individuals are motivated to change behavioural practices". However, when confronted

with multiple risks, decisions tend to be made on the basis of averting the perceived greater risks. In many incidences, pollution-associated health risks were deemed less detrimental to self than other perceived risks. In determining what posed the greatest risks, I found that these choices were linked to wider factors like time of day, perceived security of route and personal factors like age, gender and race. As a young female Malaysian student in London, I felt more vulnerable alone at night. Whilst I would happily walk the back roads to university in the day, I intuitively walked the main road home at night. Although the use of Flow did not always necessitate or directly translate into attempts to minimise my pollution exposure, choosing not to reduce my exposure in itself becomes a conscious and active decision, being aware that I am exposing myself to higher levels of air pollution for that specific journey. This may then encourage me to compensate for this increased exposure when next given the opportunity to do so. As noted by Payne (2013 as cited in Lupton, 2016, p. 65), tracking makes way for "self-awareness into previously invisible aspects of your life". Hence, Flow provides users with otherwise absent information.

Outside the CBD, Kuala Lumpur is not the most walkable city. As walking is often framed as a desirable option health-wise and environmentally, I assumed car commutes in Kuala Lumpur would increase my daily pollution exposure more than walking in London. Instead, I found that recordings on car commutes were almost always of 'low to moderate exposure'. This is consistent with Rivas et al.'s (2017) findings that whilst car commuters are the least exposed, they simultaneously tend to be the worst polluters. Ironically, Gulliver and Briggs (2004) found that encouraging people to take short journeys on foot to reduce car usage may inadvertently increase overall air

pollution exposure. This is inevitable "unless the achieved reduction in traffic volumes is sufficient to provide compensatory reductions in ambient pollution levels" (Gulliver & Briggs, 2004, p. 7). Hence, this emphasises the need for collective and systematic change to address urban air pollution, but also raises interesting questions on the role of personal exposure monitoring and the QS.

Where there is a tendency for the QS to look inwards, focusing on individual behavioural change to alter outcomes, we arrive at a fundamental question of whether Flow encourages users to alter their behaviour to reduce personal exposure by *avoiding* air pollution to the best of their abilities, or acting to *reduce* urban pollution levels. Alternatively, does Flow simultaneously encourage both forms of behavioural change? As users become more conscious about the multitude of ways in which air pollution is intertwined with their everyday lives, individual-scale change and its resulting network of conscious individuals may further encourage collective change. If Flow is to encourage individuals to become more 'environmental', does this relate to simply being conscious about the environment and how it may affect oneself, or being environmentally-conscious with the intention to improve it? As highlighted by Neidell and Kinney (2010), avoidance behaviour is the current impetus behind air quality warning systems globally.

It is important to consider the extent to which individuals are not only willing, but able to reduce their air pollution exposure. My dislocated knee cap temporarily made walking long distances not feasible. This limited my mobility and significantly reduced the number of potential alternative routes to minimise my pollution exposure, raising

some important questions. Firstly, what and how many options to reduce personal exposure to air pollution are available, and to whom? And secondly, does consciousness about air pollution exposure matter if options to minimise this exposure are not available? In such cases, the QS is unable to make necessary changes to their behaviour to make progress towards the optimal self. Evidently, the ultimate goal of shaping 'the optimal environment' is then bounded by the capacities of people who inhabit the environment, recognising that the capacity of every individual differs.

3.2 Cultivating curiosity and consciousness: interactions with people across geographies

I came to realise that Flow's influence extended beyond myself as the sole user of the device. Whether warranted or not, the perpetual physical presence of Flow began to impact people around me, explicitly cultivating curiosity and consciousness about air quality issues and personal air pollution exposure. I consistently observed that people were quick to notice the device on my backpack, questioning what it is, how it works and their own personal exposure to air pollution as an immediate response. Flow presented opportunities to converse about air quality and the ways in which it pervades our everyday lives with people who otherwise do not think about air pollution. Public awareness of environmental matters and participation in decision-making is tightly related to available environmental information (Haklay, 2002), where a cleaner environment and healthier population can be fostered through increased awareness about air quality issues (Kelly & Fussell, 2015). As I shared anecdotes about what I learned using the device, friends began to wonder how polluted their routes to class

were, or where on campus air quality was best. Inevitably, my exposure to this new information about myself and the environment around me as an extension of self led people around me to question their pollution exposure and the air quality of spaces they inhabit.

As the public become more informed about air quality issues in communities, they become better-able to converse about it and develop community-based strategies with more complete understandings of personal pollution exposure (Snyder et al., 2013). For example, during a hospital visit for a knee injury, the device caught the attention of my doctor and my physiotherapist more than my limping. My physiotherapist was very curious and shared that her patients' remarks that her therapy room felt stuffy and uncomfortable led her to buy an air ventilator but had yet to set it up. I checked her room's air quality before and after the ventilator was switched on. Reduction in pollution levels over the two hours encouraged her to use the ventilator at all times. My doctor was immediately excited about the potential of such devices in regulating the air quality of patients' room.

Flow's impact on the behaviour of people within my network was most apparent in observing the changing routines of my flatmates. Living with me, as someone actively monitoring their personal exposure to air pollution, meant that they were made aware of their personal pollution exposure in our shared living environment. When I first used the device in our flat, the immediate readings were of 'Very High Pollution'. The app noted that exposure to these levels of pollution had an "*immediate impact on health*". This was alarming to all of us, having not ventilated our flat for three months prior.

Whilst my flatmates continued to complain about having to live with a geographer, they obliged and we began to open the window when cooking, and routinely ventilate our flat. Our pollution exposure levels quickly came down as a result. However, upon returning to London after the Christmas break, my flatmate made the remark of, “Oh no! We have to start ventilating the flat again.”, admitting to neglect ventilating the flat the entire time I was gone. Evidently, reducing our pollution exposure was seen by my flatmate as a chore rather than something personally advantageous. Thus, consciousness about air quality and the benefits of reduced air pollution exposure was directly linked to the presence of myself and Flow around my flatmates.

It is important to note that not all external interactions with the device resulted in positive responses, where people’s receptiveness to this new information varied. It became obvious that some people are uncomfortable being made aware of the high air pollution level they expose themselves to regularly, preferring to bask in their ignorance for the sake of convenience, especially when alternative decisions to minimise personal pollution exposure are not easily identifiable. Others are potentially apathetic towards air pollution, immune to the shock of being made conscious of their pollution exposure. Having accepted the fact that Central London is polluted, any attempt to minimise pollution personal exposure, when one will inevitably continue to be exposed to air pollution, is deemed futile and unproductive.

One possible explanation for these varied responses to personal exposure data is that people’s previous environmental experiences influence their interpretations of environmental problems. Due to what Edelstein (2004 as cited in Altman et al., 2012)

terms as one's 'eco-social' history, different histories potentially work to filter and inform responses to air quality data. Having experienced episodes of haze growing up in Malaysia, where air pollution and its effects were very visible, I am potentially better positioned to fully grasp air quality problems and its related risks compared to some of my university friends who do not share this specific eco-social history. However, this can alternatively work to strengthen the influence of air pollution visibility in driving people's perception of the air quality they are exposed to. A common response to a high air pollution reading from Malaysian friends and family was, "but there's no haze". Evidently, if air quality was not extremely or explicitly compromised, there was a tendency for people to assume air pollution was absent and air quality at healthy levels.

My siblings were particularly sceptical of Flow's potential as a transformative tool. Perhaps, as my siblings, they were more opened to sharing their honest thoughts and concerns. They noted that as a geographer, I would be more sensitive to environmental issues like air pollution, being familiar with the context. This supports Kelly and Fussell's (2015, p. 641) assertion that "individuals may choose not to concern themselves about air quality owing to a poor understanding of what is undoubtedly a complex science", hence are content being apathetic to air pollution. Where I would regularly process and analyse my 'raw' datasets to better understand my personal cumulative exposure to air pollution, against WHO and EU limits, it is not possible to expect everyone to do so. Whilst Flow's colour indicators and thresholds are based on WHO's daily and annual exposure limits, relating instantaneous readings to these other timescales can be complicated as the app does not provide cumulative data. Cumulative exposure plots can be particularly useful in encouraging long-term positive behavioural change to

highlight the true contributions of short peaks in exposure against prolonged high exposure to air pollution, in relation to one's lifestyle (Figure 2).

In a study of women's responses to data on personal exposure to chemicals found in their homes, Altman et al. (2012) found that participants tended to identify information gaps, requesting additional info about whether results signalled problems, what defined an 'acceptable' exposure and recommendations for action. Similarly, data presented on Flow's app may imply a problem without presenting a direct solution. Users have to be creative and independently find ways to reduce their exposure. This process takes time and users may not be motivated to do this. Moreover, I found it difficult using Flow to minimise pollution exposure in unfamiliar areas, as I simply would not know which alternative routes will have lower exposure. The app's latest update includes new street-level pollution maps (which are yet to use Flow data) in London and Paris. However, Flow has yet to suggest pre-established routes where users can expect to minimise their exposure. For example, between King's Cross and Euston stations, the 'Wellbeing Walk' with 50% less pollution than the Euston Road route encourages people to minimise their personal air pollution exposure (Urban Partners, 2019). Evidently, external support is needed to meaningfully interpret the data produced by Flow, and make it actionable for individuals, creating new publics in the process.

Where data accuracy is a common concern raised within QS literature, the robustness of air quality sensor data (Austen, 2015) and our ability to derive meaningful information from such datasets remains questionable (Snyder et al*.,* 2013). But does data accuracy matter? This is dependent on the ultimate objective of devices like Flow.

If routine personal exposure monitoring is intended to encourage behavioural change, in an effort to minimise overall air pollution exposure because of its associated health risks, then would the spread of consciousness about air quality issues not be more important than how accurately the device measures pollutant concentration? Hence, if the data produced by Flow is able to effectively deliver these intended outcomes of consciousness and minimised exposures to air pollution, would it not be considered sufficient for this purpose? This supports Kelly and Fussell's (2015, p. 641) assertion that "attitudes and behaviour can be driven by a person's immediate locality and understanding rather than accurate data". However, this data has the potential to spur change beyond a mere individual's behaviour. The data produced by Flow combined with the insights and anecdotes from experiences of a monitoring individual can be meaningful and empowering as 'just good enough data' (Gabrys et al. 2016). These outputs can have political implications if used by communities to lobby for change, or to hold governments accountable in working towards 'the optimal environment' for the health of its citizens.

In recognising the potential for these devices as transformational tools, it is important to also recognise the technological inconsistences apparent across geographies and question its universal applicability and the preconditions required for these devices to function optimally as such. Where maps in Kuala Lumpur were less detailed, I was better positioned to make sense of my personal pollution exposure spatially in London.

Finally, new detailed knowledge on air pollution exposure may not be welcomed, or appear to be culturally insensitive, even if with best intentions in mind. When visiting my grandfather's home in Kuala Lumpur, this was an obvious barrier to cultivating curiosity and consciousness. As a Taoist, he has a prayer alter with burning incense indoors at home. This meant whilst at a family reunion dinner, I was unable to minimise my personal air pollution exposure. It would be disrespectful of me to expect air quality to be a bigger priority than his religious and cultural practices. Hence, in certain circumstances, Flow's influence on inducing behavioural change and creating consciousness may prove to be somewhat limited.

4 CONCLUSION

In conclusion, Flow provides me with otherwise absent information about my personal air pollution exposure to make better-informed decisions. Whilst behavioural change to minimise exposure is not guaranteed, I found that Flow made me and the people I interact with far more conscious about the nature of air quality. Hence, in the long run, I will be better equipped to converse about air quality and better positioned to lobby for community-scale change in reducing urban air pollution. Where policymakers may respond better to the numeric data produced by Flow, stories and anecdotes might be powerful compelling tools to engage other community members in the dialogue around urban air pollution. As foreseen by Snyder et al. (2013), this more complete understanding of personal exposure to air pollution through sensors welcomes a key role for governments to provide guidance on how to interpret this new data. But more importantly, in using this data to develop and implement effective air quality management policies. The QS approach and new sensors like Flow are able to

create a sense of accountability to self. How then can we extend this accountability to the environment? Where the QS movement has been fixated on self-improvement through self-initiative, associated with an excitement for potential and positive change, how can we instead channel this spirit into the bettering of the environment, as an intrinsic element of self? For Flow to be a truly transformational tool, it needs to move beyond merely encouraging avoidance behaviour to minimise personal exposure to air pollution, and towards creating a network of informed and environmentally-conscious individuals to tackle the root problem of urban air pollution. Hence, this community-centred approach calls for a clear shift from progress towards 'the optimal self' to the more ambitious target of 'the optimal environment for our optimal selves'.

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