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The re-mediating effects of bio-sensing in the context of parental touch practices

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ABSTRACT

This article investigates the remediating effect of bio-sensing technology on touch practices in the context of parent-infant interaction. We examine how the entry of a biosensing technology into the social, sensory and technological ecology of family homes interacts with the ways in which parents and babies know each other and communicate through touch. The paper centres on an exploratory case study of the Owlet Smart Sock (OSS), a bio-sensing baby monitoring device. We bring the social critical and experiential lenses of multimodality and sensory ethnography to studying the OSS as a socio-technological probe across a range of research encounters, including focus groups, home visits and video re-enactments with parents. In doing so, we provide an account of the ways in which the technology affects how babies and parents' bodies are (re)imagined, assessed, controlled, interrelated, experienced, and cared for and move beyond generic social debate around the quantified-objectified baby and fears of touch deprivation in contemporary digital culture.

Introduction

In this article, we employ a baby smart monitor, the Owlet Smart Sock (OSS), as socio-technological probe, in order to explore its role and social implications in the context of parent-infant touch relations. Our exploratory case study focuses on how the technology interacts with the ways in which parents and babies communicate, know and experience each other through touch. We emphasise a social orientation to touch, beyond a purely technological or physiological orientation (Jewitt et al., 2020), in which touch experiences and practices are understood as being remediated, in the broadest sense, by biosensing.

We use biosensing practices to refer to practices related to sensor generated data and its interpretation: a narrower definition than that of Nafus which refers to '*any* practice that uses information technology to understand something about bodies or the environments in which they live' (2016a, p. xiv). Biosensing technologies alongside the practices that they are embedded within, are a social tool that mediates the body through uncertain

knowledges, in this case those that circulate around parenting and touch, in doing so they shape new socio-technical practices (Nafus, 2016a). On the one hand, the smart sock involves direct touch contact, that is skin contact with babies' feet, and impacts on the physicality and comfort of the baby. On the other, it enables the wireless transmission of physiological data to parents' smart phones in ways that reconfigure (disrupt, change, produce new) touch experiences that are interpreted by parents as a form of remote digital touch in the context of the wider embodied diagnostic touch practices parents employ. This enables us reflect on how baby biosensing monitors impact on the shape of tactile interaction (e.g., the manufactures promise of reducing negative touch and promoting positive touch).

The use of biosensing technologies, is contingent on the social, sensory and material contexts of family life in the home, and on parents' wider multisensorial caring and bonding activities of which tactile sensing and interaction are a part. The study engages with the way in which digital objects, such as OSS, can become central to people's social relationships, and the diverse ways in which their introduction into the home can disrupt everyday practices within the domestic sphere (McDonald, 2015, p. 18). In this way, we explore parent-baby touch practices in the context of the 'complexities of entanglements between human sensory embodied experiences' (Maslen & Lupton, 2019, p. 12) encounters between parents, partners, children and babies, and the digitally-mediated experiences provided by OSS with attention to how these intersect to disrupt, reduce, 'replace', re-orientate or reconfigure touch.

This article explores Owlet as part of the environment of parent-infant touch relations and practices, with attention to the contexts of parenting and bed-time routines. We ask what contexts, relations, routines and discourses are at play in parent and baby touch communication, and how these are shaped by the introduction of biosensing technologies and practices. We address the question of how the OSS intersects with parents' tactile understandings and experiences of bodies, both their babies' and their own. The study is based on focus group and focused ethnographic encounters with parents of babies up to 1 year of age. First, we contextualise our study in relation to existing work on parenting, touch and communication, and the emerging landscape of touch technologies that are shaped by and mutually shape (Madianou & Miller, 2013) parent-infant touch relations.

Parent and infant touch, and communication

Touch is often described as our first and perhaps most immediate sense (Fulkerson, 2014), gaining maturity in the womb before other sensory systems become functional (Lickliter, 2011). The mother's movements, her heart beat, the vibration of her voice and the baby's own movements are all part of foetal tactile experiences. While beyond the scope of this paper, biotechnologies play an important role in the construction of the contemporary foetal body and its meanings (Lupton, 2013). Once a baby is born, touch is integral to how they are cared for, fed, cleaned or comforted, and how their temperature is regulated. Touch between caregivers and children is at once a 'mutual, proximal and frequently multisensory' (Crucianelli et al., 2018) a shared embodied experience, a functional given, a medical, developmental and psychological necessity (Field, 2002), and a social encounter of meaningful interaction (Cekaite & Kvist Holm, 2017). Interactions that are mediated to different extents by a variety of technologies – from clothes to digital devices.

Touch in this context has been demonstrated to convey emotions and aid bonding (Hertenstein & Campos, 2001), reduce pain and stress in children (Feldman et al., 2010), and aid cognitive and emotional development. Few studies focus on the everyday socio-cultural contexts in which tactile interaction happens, or the role of touch as a mode of communication.

Research that takes into account the sensory-experiential and embodied dimensions of parent-infant touch has pointed at the 'blurring of bodily boundaries and selfhood' (Lupton, 2013, p. 40) that are involved in the touching, near-touching or 'skinship' (Tahhan, 2008) of bodies. Lupton discusses the pleasures and challenges of 'interembodiment' in such practices as breastfeeding and co-sleeping (2012), and notes the lack of literature that explores the ways in which babies' bodies 'in western societies are experienced ontologically by their carers' (2012: 40). Co-sleeping, while actively sought out in Japanese society, is often a source of worry and conflict in societies where issues of safety, co-dependence and risks of abuse dominate the discourse. The interconnectedness of caregivers' and babies' bodies is shaped by socio-cultural contexts of which the politics of touch are a part. Parent-infant touch is immersed in moral and political debate, and questions of touch are deeply bound up with notions of what constitutes good and bad parenting (O'Malley Halley, 2009). The global market of baby products reflects and reinforces the tensions between on the one hand enabling parent and infant contact (e.g., baby slings), or on the other, creating varying levels of distance (e.g., cots and monitors).

While baby monitors and parenting apps are not new (Lupton & Pedersen, 2016), this 'next generation' of baby smart monitors presents a different relationship to the body via the use wearable biosensors on babies' skin (Greenfield, 2013). These varyingly track the baby's movement, breathing, sleep patterns, or determine physiological changes (e.g., temperature). Information and alerts are sent to parents' smart phones via connected apps, and alarms on base stations, or 'nudge' babies into rousing if detecting a lack of movement. Medical professionals have criticised such monitors for heightening or creating unnecessary parental fears, leading to unwarranted, invasive testing (Bonafide et al., 2017). Yet little social research exists on their actual use in the context of parent-infant touch or interaction.

Our research is sensitive to the above conceptualizations of 'touch', 'bodies' and 'communication', and sought routes to exploring touch in relation to the sensory, material, social and technological contexts in which the OSS would enter, shape, and become meaningful.

The Owlet

The OSS is a wearable baby smart monitor which detects babies' heart rate and oxygen levels during sleep times, and alerts caregivers if readings fall outside the norm. Its sensor-embedded fabric sock, wrapped around the baby's foot, connects to a base station via bluetooth. The base station sounds a red beeping alarm when readings are higher or lower than expected. Alarms indicate a loss of connection between the sock and the base station. Notifications, real-time heart rate and oxygen level readings, and access to historical analytics/trends are also sent to parents' mobile phones via the Owlet app. Owlet has been sold in the US, Australia and Canada since 2017 and the UK since January 2019 (after our fieldwork).

We relate the OSS to three primary technological histories: existing baby monitors (medical and domestic); personal self-tracking and wellness devices (e.g., FitBit); and emerging touch technologies designed to enable touch communication between parent and child (e.g., Huggy Pajama, Cheok, 2010). (For a detailed review see Jewitt et al., 2020). Domestic baby monitors are a relatively recent phenomenon which normalises parental anxieties (Nelson, 2008). Similarly to self-tracking devices (cf. Lupton & Maslen, 2018), they potentially change caregivers' skillsets and sensory perception as parents 'learn to interpret their children's needs through the medium of the flashing lights; and instead of communicating comfort with their presence, they rely on oral communication' (2008:, p. 530). With the OSS, the availability of physiological (bodily) data adds a further dimension to this apparent reconfiguration of parents' skills and senses.

We are aware of one other qualitative study of the Owlet in use for a short trial periods, in the UK (Wang et al., 2017) which raised notions of a 'cyborg baby' and attending to virtual (representations of) babies. Our case study differs, in its ethnographic approach, and focus on how touch practices between parent and infant, and how biosensing remediates the touch communication and sensory-social meaning-making.

Study design

Our study design is guided by the combined theoretical-methodological lenses of multimodality (Jewitt et al., 2016) and sensory ethnography (Jewitt &Leder Mackley, 2019), to explore both the social semiotic and experiential dimensions of touch practices, and the Owlet device. We use a 'focused' ethnographic approach (Knoblauch, 2005). While some have critiqued this approach for being short-term and therefore superficial, others have argued that shortness is compensated for by the intensity of the data (ibid): an intensity created through detailed video observations of activity, and a depth and immersion generated through close analysis (Pink & Morgan, 2013). While this interventional approach has limitations (e.g., in relation to longitudinal questions), we argue, it is particularly suited to our focus on the unspoken, sensory, multimodality of the everyday and the contemporary context of the study. An ethnographic sensitivity enabled us to get close to people's everyday ways of sensing, doing, knowing, imagining, and meaning-making and to engage with participants in collaborative and partly speculative ways. We used video re-enactments (Pink & Leder Mackley, 2014) to bring the whole body to the fore. Since mundane, intimate moments in participants' lives can be difficult to recall and describe, asking participants to walk and talk us through a relevant everyday routine – putting the baby to bed – aimed to elicit unreflected/-ive moments of touching, and to create an empathetic route into participants' practices and giving parents agency in co-constructing research-encounters. These collaborations with participants underpin the intensity of the research encounter (Pink & Morgan, 2013).

Recruitment and participants

The study was conducted in the South-East of England in a commuter town half-an-hour from London by train, whose population reflects England's demographic profile, suggesting that there are no specific cultural contours of parenting that may have impacted on the study. Parents were self-selecting volunteers, recruited via online adverts, parenting

networks, posters at surgeries, nurseries, in toy/book shops, and personal contacts. Their motivations for participating included the opportunity to meet other local parents, to share experiences, curiosity about parenting technology, particularly Owlet (unavailable in the UK). Participants were aged between 28 and 40 years, with babies' age ranging from 14 to 54 weeks. Following a brief scoping questionnaire, key research stages included (1) four 'parent and baby' style focus group discussions with a total of 13 adult participants (including one couple) and 12 babies; (2) home visits with four of these families, involving semi-structured interviews and bedtime video re-enactments; (3) a trial period of OSS use of up to three weeks, accompanied by participant-led WhatsApp updates and a reflective interview that explored the Owlet experience post-use. Focus group participants, with the exception of one father were mothers. Fathers participated in 3 of the 4 families in the home study, however, with the exception of one household, the mothers were more actively involved. This was, we suggest, related to the socio-economic arrangements of work in the households. The parents who participated in the home study (stages 2 and 3) were self-selecting volunteers, and did not differ from other participants in terms of the data we collected through the scoping questionnaire: participants' and babies' ages, siblings, parents' profession, and any previous experience with baby monitors and self-tracking devices.

The three research stages are outlined below. Each stage built on the insights provided by the previous one, honing in on touch practices and building in intensity of closeness.

Focus groups: involved four group interviews, with 2–4 participants per group, plus babies (*n* = 13, Table 1). Sessions were video recorded and lasted 1½-2 hours. With one exception, the focus groups were attended by individual mothers. Focus groups took place at a local community centre and provided a sense of parent and baby coffee mornings, with toys, play mats, refreshments and baby changing facilities. An ice-breaker activity had participants engage with 'tactile props', personally meaningful objects that parents and babies might routinely 'touch' (Figure 1). We used visual aids to discuss the nature and personal significance of different kinds of touch, as well as any skills involved. A semi-structured topic guide covered parents' first and subsequent baby handling memories, details of bedtime routines and discussion of baby monitors and self-tracking experiences. Each session concluded with the introduction of the OSS, including participants' interaction with the OSS, and a discussion of

Table 1. Participant details per focus group, names changed for confidentiality, except where parents were happy to use first names.

FG	Parent (age)	Profession	Child (age)	Sibling ages
1	**Susan (40)**	Full-time mother	Harrison (26 weeks)	7, 11, 14
	Becky (40) (+Adam)	Carer	Neil (40 weeks)	7, 17
2	Rhian (38)	Planning/Insight Director, digital agency	Edward (54 weeks)	4
	Sarah (35)	Brokerage, adult social care	Erin (28 weeks)	4
	Phoebe (37)	Accountant	Darren (38 weeks)	4
3	Alice (32)	Civil Servant, policy	Kit (14 weeks)	2
	Kate	Advertising operations	Charlie (18 weeks)	3
	Naomi (36)	Marketing	Aelfred (24 weeks)	–
	Garrath (36)	Lecturer in Design		
4	Laura (32)	Manager in housing	Bette (38 weeks)	6
	Gill (33) (+Jon 33)	Police Officer	Wynne (14 weeks)	5
	Sally (28)	Receptionist	Alex (19 weeks)	6
	Deb (35)	Legal	Josh (30 weeks)	2

Note: Participants in **bold** took part in home studies; participants in *italics* were involved during home studies but not focus groups.

Figure 1. Focus group props and participants interacting with the OSS (© [project]).

perceived opportunities or concerns, and provided a context in which to introduce and recruit participants to the next stage of the study – the home study.

Home visits: Four families chose to use the OSS for three weeks, with one couple, Naomi and Garrath, discontinuing use after one week (due to their experience of the device as disruptive). Home visits involved an audio-recorded semi-structured interview, which built on ideas generated through focus group discussions, elaborating the ways in which parents use touch and existing technologies to check on, soothe or bond with their babies, or when touch was initiated/resisted by infants. Participants were then video recorded while talking and walking through the sequence of activities that commonly formed part of their baby's bedtime routine. This involved the participant guiding the researcher through different parts of the home, showing what makes bedtime, from changing nappies and sleepsuits to adjusting the sensory environment of the bedroom. This situated encounter encouraged participants to demonstrate and share touch practices and felt experiences with the researcher and provided us with an empathetic sense of the tactile sensory environment of their parent-baby communication – the context into which the Owlet would be placed.

Owlet intervention: The families were each lent an Owlet unit and they were filmed and interviewed as they set up the device. Providing personal information about oneself or one's baby during set-up was optional. Participants were guided through the safety information and reminded that the OSS is not a medical or diagnostic device, and was not to be relied on to ensure their baby's wellbeing. Participants were invited to send *in-situ* updates to the research team via WhatsApp (or email), including photos and videos. This intervention phase concluded with a semi-structured interview at participants' homes, probing about participants' experience with the Owlet and what any changes in touch interaction (e.g., stopping to touch) meant for them.

Analytical process

Analysis was ongoing; we made sense of and responded to our research encounters, during and immediately afterwards, through field notes, team reflections, and engagement with the literature. More structured approaches to data analysis included revisiting audio and video recordings to identify overarching themes and follow through participants' individual stories and experiences as they shared insights across focus groups, home visits, and WhatsApp messages. Whilst touch is complex, analytical strategies and categories always risk simplification, finding different entry points and ways of (re)presenting materials throughout our analysis – for instance, by transcribing stretches of conversation verbatim or taking note of the detail of bodily movement on video – allowed us to attend to the ways in which touch was done, felt, talked about, and digitally mediated. Rather than counting or categorising instances of touch practices before and after the introduction of the Owlet, we sought to draw out their meanings and significance in relation to the biosensing technology.

'Talking' touch

Key focus group insights attending to how touch featured in everyday experiences revealed the dynamic nature of touch interactions, how touch related to wider notions of good or bad parenting, parents use touch to attend to their babies, and how their own bodies are bound up in these processes.

Parents spoke of developing new embodied skills that allowed them to hold babies in the right way: to support, soothe, protect, or handle. At times, these were learned from family members or medical professionals (cf. O'Brien & Lynch, 2011). Parents actively managed and attended to their children in response to or anticipation of infants' sounds, body movements and tactile interaction during the focus groups, for instance through repositioning, playing, feeding, rocking (Figure 2). Parents' talk indicated overall trends in touch interactions, such as a move from being supportive to constraining, as babies developed both the muscle and will to move and touch independently. While participants reported touch as an important part of their bonding experience and feelings of closeness, negative touch experiences were also made relevant, for instance when the right kind of latch could not be established during breastfeeding (cf. Lupton, 2013).

A key dilemma for participants were the contesting ideologies about the appropriate amount, nature and contexts of touch (cf. O'Malley Halley, 2009). As Becky (FG1) told

Figure 2. Talking and demonstrating touch during focus groups (© [project]).

us, with her third child, she was able to trust her own instinct, rather than be influenced by other people's perceptions:

> [with] the middle one, it'd be like, I wanted to hold her but I was told that I shouldn't be holding her and I'd spoil her. And it just didn't feel right […]. But with him, I just like ignored. […] He literally lived on me for, I don't know, four or five months. He's quite happy to be put down [now].

There was nevertheless a sense that touch was something parents had to actively manage and reflect upon, especially when it came to bedtime. Participants differed in their co-sleeping preferences and practices, highlighting the inconsistencies and historical trajectories of safe sleeping advice, and largely going with what worked best for them and their families.

Mothers commented on the special bond between themselves and child, and how comforting their babies also felt comforting to themselves. Rhian (FG2) described how 'when he gets kind of drowsy and comfortable, and you know he's kind of clinging onto you [holds onto top of her chest] and then finding you comforting, it's just a lovely, really lovely experience. […] You get the sense that he's seeking comfort and finding it.' Touch closeness was achieved through play, as well as 'skin-to-skin' and baby-carrying (using a baby sling or carrier).

Across the focus groups, parents reported medical circumstances that meant direct touch was not possible immediately, or sometime, after their children's birth. Some babies had been born prematurely or spent time in neonatal units. There was a sense of missing out on and feeling deprived of touch at important stages of their children's lives and development.

Existing baby monitors and Owlet

Participants' and babies' medical histories sometimes impacted on the kind of baby monitors already used in the home. Deb (FG4) continued a sense of close monitoring with both her firstborn and Josh via an AngelCare movement sensor mat. Her use of the device adapted, however, mostly relying on it as a temperature gauge, with the parent unit's sound turned down. Others reported having to be 'weaned off' hospital monitors or actively avoiding monitors that would provide too much information and increase parental stress.

While monitors were largely used to hear babies when awake, four participants used video monitors to view their children, including older siblings with medical conditions. These monitors did not fully replace touch, with parents reporting to still lay their hands on their children's chest before going to bed or, in Becky's, case throughout much of the night: 'I'm sort of connected with him, and I can feel that he's breathing, and that he's safe'. This routine touch was reported across the focus groups as managing one's own anxious bodies, as reassuring check, but also as a way to communicate presence to the sleeping child.

The ways in which participants approached the OSS varied. Some participants voiced cynicism, wondering whether the device was designed to 'prey' on the anxieties of parents. All participants saw its possible virtues as a medical device for the monitoring of babies with known conditions. For example, Susan referred to her older children's medical history of severe epilepsy and saw in the Owlet a possibility to check Harrison's wellbeing,

with the touch of the sensor detecting any unusual heart rate patterns: 'we don't yet know whether he's gonna end up with epilepsy, so to know that everything was steady and stable would be … , would put my anxiety at ease'.

In terms of its impact on touch interaction between parent and child, participants found it difficult to anticipate how they would behave personally. As such, participants situated technologies as agentive, and themselves as somewhat reactive to technologies' roles in their lives.

Situating touch through home visits

In this section, we situate touch in the context of existing parenting practices in the home, to paint a detailed picture of the kinds of contexts the Owlet entered during our study. While touch was not restricted to bedtime activities, we focus on interaction during bedtime because this is a moment at which Owlet is designed to integrate and impact.

> Every other evening, Aelfred's bedtime routine starts with a bath in the upstairs bathroom. The parents described how they bath and dry him. They massage his feet, hands, arms and shoulders with baby oil, before getting him dressed and take him into his nursery, they sit in an armchair to either bottle-feed or nurse him to sleep. Once asleep, Aelfred is transferred to his cot which sits alongside the bed. The parents prop two rolled up blankets against each side of Aelfred to maintain his feeling of being held. They might turn on the musical night light which turns itself on at a baby's cry. On evenings when he takes time to settle or wakes regularly, Naomi takes him downstairs for feeds – the noises of the TV and their voices usually send him back to sleep. During the night Aelfred will wake, feed and end up in Naomi and Garrath's bed, seeking Naomi out for feeds during the night. Co-sleeping is meant to be a temporary solution.

The above descriptive account of Aelfred's bedtime routine (Figure 3), whilst in many ways idiosyncratic, is also emblematic of the ways in which bedtime and night times played out across other participating households. Specifically, there were similarities in

Figure 3. Screenshots from Aelfred's bedtime routine, toy penguin used as prop in his place (© [project]).

the ways in which touch was embedded in wider parental routines, material and techno-logical contexts, and the sensory environment of the night time home. Locating touch as part of participants' narratives has revealed how touch is at once fleeting-incidental and actively employed and negotiated throughout the night, as part of a wider placing and managing of bodies and boundaries.

For Naomi and Garrath, the communicative aspects of touch were ones of reassuring Aelfred and signalling their presence, managing him during fractious moments and finding ways of calming and settling him to sleep. They took cues from Aelfred as to how relaxed his body was in any given place or position, and they sought to maintain this relaxedness through body contact, or blankets in place of bodies, and through familiarity of sounds and spaces. Similarly, Susan described how she swaddles her baby and rocks him to sleep when it comes to bedtime, first placing him in a moses basket in the living room, and then later in the night in a sleeping bag and side sleeper in the master bedroom: 'As soon as I swaddle him, and I just hold him in my arms, his eyes just close, and I just rock him gently, and he goes to sleep.'

During the night, Susan will feed him in bed where he might stay, curled into her arms, or she might place her hand on his tummy as he lays in the side-sleeper to settle him (Figure 4). For both families, the proximity and touching of bodies is important to their ability to respond to their child, and take cues from their own touch needs. In a third household, by contrast, Gill actively avoids co-sleeping, and either holds Wynne to rock her back to sleep, standing up by her moses basket, or takes her through to the nursery to feed her sitting up in an arm chair.

Signalling bedtime through touch, fabrics (e.g., muslin, sleeping bags), sounds, lighting and location was common across the four households, and there was a sense that babies (and parents) found solace in familiarity. Garrath and Naomi were not alone in creating a certain sensory environment for their baby's sleep time. For some, this involved existing technology. For example, Becky tends to check the room temperature on 'Ollie, the Owl' before deciding on layers and thickness of Neil's night time clothing, as guided by a Gro-bag chart. Once she has fed and rocked Neil to sleep, she transfers him to his cot and activates the sounding heartbeat of the 'myHummy' before turning on the sleep-optimised lighting of her Lumie lamp. Susan's sensory environment in the bedroom involves the rhythmic sound of a rain machine and the flow of air from a fan, both as much for her own comfort (and that of her co-sleeping older son) as for Harrison's. While these only loosely relate to touch, and touch is not one between bodies here, the rhythm of sound and touch as afforded by some of these sleep technologies were akin to those participants made relevant in describing the closeness between bodies. Especially the heartbeat was
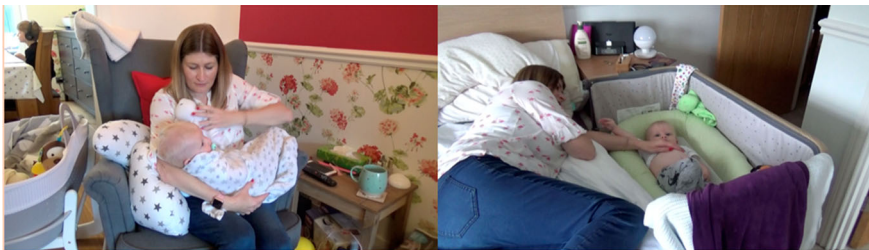

Figure 4. Susan demonstrating swaddling and side-sleeper touch (© [project]).

Figure 5. Sensory technologies in participant homes (© [project]).

seen to soothe and reassure in place of the mother's heartbeat and the wider multisensory environment of the mother's womb. These practices, then, seemed ones of extending the comfort of the maternal body and overcoming distance. (Figure 5).

The home visits gave deeper insights into the use of baby monitors across participant households, and how these were used to manage proximity and distance.

Becky demonstrated how she would sit on the sofa and mainly watch Neil asleep but also switch between cameras to see his sister. She had mentioned during the focus groups that she had experienced postnatal anxiety since Neil's birth, and the monitor was part of dealing with what she described as a regularly occurring 'knot of anxiety' in her chest. As Neil hardly moves when asleep, she still feels the need to go upstairs on a regular basis to touch his chest and check his breathing. She also wakes regularly during the night to touch-check him, which was easier when he was beside her bed, rather than in his cot:

> I wish they did like a fake hand because for a while he kind of, he kind of liked sleeping with like my hand on his tummy. [laughs] I could do with, like, one of those rubber joke hands or something […] so he feels […] the weight there.

Touch, here, is again one of sensing life as well as sending reassurance.

The Owlet experience

Here we reflect on the striking differences between the four families' experiences with the Owlet smart sock (OSS), and what they meant to how bodies related, touched and sensed. We classify them as experience types of which touch is a key element: diagnostic, transformative, disruptive, and inconsequential. As our findings demonstrate, the introduction of a technological probe like the Owlet needs to be understood in relation to existing routines, sensory-technological environments, and participants' understandings of their (own and) babies' bodies, rather than merely raising questions over the digital 'replacement' or

removal of parental touch. For instance, experiences seemed dependent on the kinds of touch OSS did or did not provoke or prompt, as well as the extent to which the OSS could be slotted into existing bedtime routines, the baby's age and size, and the meanings participants attached to the device.

Inconsequential: Gill and her husband's interest in OSS was largely informed by Wynne's readmission to hospital, in the early postnatal days, due to feeding problems. The readmission and the baby's low oxygen readings had come as a shock as Gill had felt things were starting to improve. If they had had something like the Owlet in those days, she felt, she would have been able to detect something was wrong. With Wynne older and healthier now, the Owlet did not make much difference to their routines, their touch interactions, or their understanding of Wynne's body and activities. Gill reported two yellow alarms, one at night when the sock had lost connection, and one when they forgot to switch off the Owlet base station. In fact, Gill only checked vitals in the first few days, then largely forgot about them, noticing one morning that she had left the base station off and Wynne unmonitored. 'I thought I might keep checking it all the time, but I didn't.' Gill put this down to a sense of security gained from her and her husband's close proximity to Wynne, being nearby and using their wider sensorium – hearing, seeing, sensing, touching – to make sure she was alright. Gill reflected that her mobile phone was more likely to impact on parent–child interaction, in that she might be holding her daughter and be distracted by everything she can access on her phone. Implied was the notion that touch in itself was not meaningful or a sign of 'good', attentive parenting.

Diagnostic: For Susan, the Owlet experience was more involved, demanding, and shaped by wider challenges around Harrison's older brother's epilepsy. It so happened that they acquired a heart rate monitor for Harrison's brother at the same time as trialling the Owlet. Susan regularly cross-checked Harrison's heart readings with the more fluctuating and, at times, worryingly high figures of this older brother. Despite manufacturer warnings, her sense was that the OSS would allow her to detect any signs of Harrison developing epilepsy. This led to some almost obsessive, time-consuming checking of numbers, even when sitting right next to Harrison. It was a relief to Susan to conclude the trial period because 'it'd be easy just to worry all the time'. In some sense, the Owlet use formed part of a process of (self-)discovery, that encouraged Susan to reflect on herself as a 'worrier' and on Harrison as a healthy baby: his heart beating at a 'normal' rate. In terms of touch interaction, Susan felt nothing had changed. The smart sock was easy to fit, set up and remove, and she continued to touch and be touched by Harrison in the same way as before, during day and night: 'he's a baby that needs a lot of hands-on attention … He still spent a lot of time in my arms, even with it on.' Touch is important because 'he likes to know you're there'.

Disruptive: In Garrath and Naomi's case, the Owlet experience was disruptive and led to them to stop after the initial seven nights, three of which (nights 1–3) Aelfred was not wearing it. An initial obstacle was finding the right moment to fit the smart sock as Aelfred seemed bothered by it and 'just kept trying to kick if off' (as evidenced by a video sent via WhatsApp). They 'removed it to calm him [,] otherwise he won't sleep'. The parents' attempts to get him used to the sock during the day were only partially successful; readings were tricky as Aelfred was wiggling when awake, and the sock needed charging at bedtime, once going flat and waking the family in the middle of the

night. The parents' trial and error continued until night 7 when Aelfred managed to kick off the sock at night, again sounding the alarm. In the end, Garrath and Naomi mainly associated 'stressful' touch and interrupted sleep with their use of the Owlet. As Garrath put it, 'everybody likes the idea of that extra bit of security', but 'you spend all your time trying to settle him and calm him [...], and then the second something makes a noise you're like "I hate you so much"'. And 'it's the constant having to engage with it and having to sort it out. [...] I don't need another baby, I've already got one!' Garrath and Naomi's experience highlighted how the Owlet's technological 'touch points', interfered with the tactility, calming and bonding activities that were part of the family's bedtime routine.

Transformative: By contrast, Becky's experience of the Owlet was especially positive and life-changing. During her use of the device, she sent us two video updates on WhatsApp. The first related to what seemed to be an accurate red alarm, which led her to find Neil nuzzled into his muslin and mattress in the corner of his cot. His oxygen levels had dropped to below 80% and, although she figured that he would have eventually freed himself, the event validated the device for her. The second update was her realisation, one morning, that she had woken up as usual to check on Neil but then refrained from getting up, as she was trusting the Owlet to notify her of anything untoward. This was not, in fact, a straightforwardly positive experience, it was tinted with sadness: 'That was my job to get up and check on him, and now the "Owl" was kind of doing the job.' At the same time, she reported that both her and Neil had slept better, and that she was happier as a result. She reflected at length about the difference the Owlet had made to her own behaviour. Although she had continued to check on Neil during the times when he was asleep on his own upstairs – viewed via video monitor and sensed by the Owlet – she would check her app first and *then* go upstairs, in the knowledge that he was probably alright; this took away some of her anxiety. She consciously did not touch him as much in the middle of the night, which 'feels okay' because 'it was like an extra thing that I didn't need to do'. Beyond this, Becky found additional significance in the Owlet data. Specifically, she became conscious of Neil's ability to fall asleep at his own accord, which she could see unfold on screen 'in his little heartbeat dropping'. It demonstrated to her how 'awesome' he was, how he was doing what 'good' babies do, and that she had succeeded as a parent in enabling him to drift away in this way. This was important in light of others labelling Neil as a 'bad' baby for not sleeping through the night and still waking for feeds. And she a 'bad' mother for constant anxious touching. Just like Susan found in Owlet a route to assessing her baby as 'healthy', it also enabled Becky to relate to Neil differently, with his bodily workings offering new insights into his nature and agency. Although outside the scope of the study, this family expressed interest in continuing to use the device, due to the benefits they felt they had experienced.

Discussion

Family home contexts, relations, routines and discourses were all in play in parent and baby touch communication. These shaped and were shaped by the introduction of the biosensing monitor Owlet. Across the four home contexts, parents actively negotiated this new technology near the baby's body in relation to their own roles as caregivers. While our research encounters fostered increased reflection on the Owlet use, these active and

dynamic negotiations of parental roles and their relations to touch interactions were part of a wider pattern of using the Owlet as a tool for (self-)discovery; discovery in relation to the baby's well-being and bodily agency, and self-discovery in the management of touch practices, parental emotions and the interrelations between parents and babies' bodies. The latter was for instance evident in Becky's interest in accessing historical (or trend) data about Neil's night time readings, in order to cross-check it with her Fitbit and find out if her and Neil's sleep cycles and rhythms were in-synch. Bio-sensing, here, meant finding new touchy connections between parent-infant bodies, including through a sense of remote contact as touch.

As illustrated by the short vignettes in the previous section, the technology effected, albeit in different ways, how babies and parents' bodies were positioned and (re)imagined, assessed, controlled, interrelated, experienced, and cared for. For some of the families the kinds of direct unmediated touch changed in frequency and character, and for some remote digitally mediated touch, a sense of being connected, were afforded through the Owlet app. The OSS intersected with parents' tactile understandings and experiences of bodies, both their babies' and their own towards reshaping the possibilities of touch between parent and child' in three significant ways.

First, the parents *measured* or *sensed* their babies' bodies using the device, which had implications for how they perceived their behaviour or physiology as more or less 'normal' (Lupton & Williamson, 2017), or in terms of being 'good' or 'bad' babies. This fits with the notion that bio-sensing technologies are a part of a contemporary data-culture that reproduces ideologies of the self (Day & Lury, 2016), in which Owlet was used as a form of private 'self-tracking' linked to notions of self-audit (Lupton, 2016). For some parents their use impacted on the kinds of touch that are deemed 'right', healthy or necessary, with attention to the removal of anxious touch, and the temporality of touch, with day-time touch being positive.

Second, we explored how the use of Owlet as a digital object within the tactile landscape of the home, changed touch practices, such as checking their baby: the hand on the chest to sense breathing, or moving it across the baby's body to assess their temperature (Kai, 1996), feeling the baby's muscle tone through holding, and manipulating limbs to test the baby's movements and sense of sensation. Several parents commented on the potential of the sensor technology of Owlet to shape the ways that they drew on their own tactile sensorium to monitor their baby: touching babies' skin to assess their relative body temperature, listening for breathing and movement, or physically and visually checking the position of the infant during sleep.

In Gill's case, the app could not replace her own multisensorial sensing of Wynne's wellbeing, and the figures on screen were only of marginal initial interest, although she noted their potential to have done so in the past.

The numbers on screen took on a very specific and different meaning for Susan who, against manufacturer recommendations, adapted the OSS as a diagnostic device. Here, the technology became demanding and provided a complex mix of anxiety and reassurance, ultimately to be abandoned for Susan's own sense of sanity. This resonates the argument that the context and histories of individual users of biosensing technologies provides with a variety of 'data' which they use to infer and interpret (often in alternative ways) their own recordings (Nafus, 2016b).

For Becky, the readings took on a role beyond questions of her baby's wellbeing to provide a sense of Neil's general activities, which were interpreted to demonstrate his bodily agency. Her giving meaning to the now visualised inner workings of his body, which began with a consideration of digital data and then extended to a more all-encompassing understanding of his being. This is reminiscent of Lupton and Maslen's concept of the 'more-than-human sensorium' (Lupton & Maslen, 2018). In the context of self-tracking apps, they note that

> regular use of a digitized self-monitoring device had begun with relying on the device's formulations of body metrics but gradually transformed into a routinized sensory engagement that no longer required the app to operate. Human and device worked together to configure a new sensory capacity. (2018,, p. 197)

Meanwhile, for Garrath and Naomi, the readings became irrelevant as touch interaction with the OSS itself got in the way of providing the calm, settled sensory and tactile interaction they sought as part of Aelfred's bedtime routine.

This shift echoes historical and contemporary fears of technology-induced touch deprivation, and give rise to the notion of sensory deskilling as regards parents' embodied ways of knowing. That is, where the wellbeing of the baby is measured by technology rather than drawing from the parent's sensorium, raising concern that this digital remediation of touch might supersede not only human touch, but also the parent's visual sense, and their sense of proprioception, time, and distance.

Third, the ways in which the socio-technical practices supported by the monitor extend what is understood as a touch practice or experience. While there is merit in questioning an 'ever-intensifying network of visibility, surveillance and normalization' (Lupton & Williamson, 2017, p. 786f) in which children become 'configured as algorithmic assemblages' (ibid: 787), we have found this assessment of children's 'objectification' at odds with the ways in which parents related digital information to their own babies. Those who attached meaning to the Owlet and used readings to compare their babies with other (healthy or good) children, tended to do so in ways that underlined babies' individuality as best known and understood by their parents. Within this frame, for some parents the app provided a sense of remote 'being there', a presence and knowing that they equated to a remote form of digital touch.

With regard to the general assertions that the Owlet might generate undue anxiety, our study suggests that parents negotiated and monitored their own emotions and touch interactions through the Owlet. In this sense monitoring their babies was also linked to parental 'self-tracking' and a belief that the self-knowledge that flowed from it might allow them to exert greater control over their and their baby's future.

Conclusion

In this article, we have explored the re-mediating affects of bio-sensing in the context of parental touch practices through the example of the Owlet Smart Sock (OSS). We explored how the OSS as a technological probe entered discourses and everyday domestics routines of parent-infant touch interaction. While there was a sense that participants anticipated the OSS to impact on their own behaviour in perhaps unexpected ways, we found that the device was bound up in the setting and redrawing of separations, boundaries and

connections between parental and infant bodies in ways that were actively managed and negotiated.

Participants' video re-enactments gave us insights into how touch is dispersed across, situated and made meaningful in family bed-time routines, in relation to how babies and parents' bodies were assessed, controlled, interrelated, experienced, and cared. This highlights the methodological challenges of extracting instances of touch from the ongoingness of parent-infant interaction. It also problematises the notion of the OSS and related technologies as simply 'replacing' parental touch. Instead, our work notes the ways in which parents adopted, adapted or rejected the device as part of their wider roles and responsibilities as caregivers, and how they experienced and made sense of their and their babies' bodies through the device. Along with the focus group discussions, the re-enactments highlighted how a technology like the OSS enters an already existing ecology of home that contains other technologies, bodies, material contexts, and wider sensory environments (cf. Pink et al., 2017). This helped us to explore the differences and nuances of what happens to touch practices and parent-infant touch communication when people take up a new technology within the social-material context of the home.

We have shown that touch was not replaced in a straightforward way but was experienced differently through newly interpreted and interpretable digital connections. More longitudinal research is needed, however, to document and assess the changing ways in which the Owlet might integrate with parents' practices of sensing, touching and caring for their babies.

Disclosure statement

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