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Ten lessons about infants' everyday experiences

Kaya de Barbaro¹, Caitlin M. Fausey²

¹Department of Psychology, The University of Texas at Austin, SEA 4.208, 108 E. Dean Keaton Stop A8000, Austin, TX 78712-1043

²Department of Psychology, University of Oregon, 1227 University of Oregon, Eugene, OR, 97403

Abstract

Audio recorders, accelerometers, and cameras that infants wear throughout their everyday lives capture the experiences that are available to shape development. Everyday sensing in infancy reveals patterns within the everyday hubbub that are unknowable using methods that capture shorter, more isolated, or more planned slices of behavior. Here, we review ten lessons learned from recent endeavors that removed researchers from designing or participating in infants' experiences and instead quantified patterns that arose within infants' own spontaneously arising everyday experiences. The striking heterogeneity of experiences – there is no meaningfully “representative” hour of a day, instance of a category, interaction context, or infant – inspires next steps in theory and practice that embrace the complex, dynamic, and multiple pathways of human development.

Keywords

infancy; wearable sensors; ecology; everyday activities; development

Imagine a day-in-the-life of an infant who stays in the same sparsely furnished room from morning to evening, playing with the same object while hearing the same words from their caregiver on loop, uniformly well-fed and alert. A striking contrast to this imagined monotony – the ups and downs of everyday interactions complete with diaper changes, dishwashing, sibling screaming, bath times, and bedtimes – emerges from records of infants' activities captured by wearable sensors that travel with infants across space and time. Here, we review ten lessons about infants' everyday experiences based on recent research that has quantified patterns of infants' sensory histories as they do, learn, and grow in their real lives.

Wearable sensors like audio recorders, accelerometers, and cameras that infants wear throughout their everyday lives capture the experiences that are available to shape their development. Importantly, these experiences are not scripted by developmental theorists nor perturbed by the presence of an outsider recording infants' behaviors. Wearable sensors thus offer the unique opportunity to capture the experiences on which a lot of learning

is hypothesized to depend. Insights about these experiences raise new hypotheses and sharpen our collective focus toward theories of developmental change that center everyday heterogeneity.

The following lessons are things we have learned about the distribution of infants' experiences across space, time, and the richness of everyday settings. We also review implications for learning and developmental change when supported by available evidence. We highlight connections to extant theories and point to new directions prompted by these lessons.

1. Infants don't repeat the same experience over and over.

Everyday infancy includes multiple activities (Roy et al., 2015; Soderstrom & Wittebolle, 2013), postures (Franchak, 2019), objects (Clerkin et al., 2017), speakers (Bergelson et al., 2019a) and musical tunes (Mendoza & Fausey, in press). The full diversity of experiences cannot simultaneously occur every second of every day. Instead, experiences vary over time. For example, infants encounter some hours and days that are verbally chattier than others (Casillas et al., 2020; d'Apice et al., 2019). Relatedly, extrapolating evidence from one timescale to another is not straightforward. For example, recent observations about the number of distinct nouns like *cup*, *bowl*, *spoon*, *cat*, *dog* and so on spoken near infants showed that infants heard roughly 75 different nouns during one continuous hour and roughly 200 different nouns across a full ten-hour recording (Bergelson et al., 2019a). That is, infants encountered neither the same 75 nouns within every hour of the day nor a linearly extrapolated rate of 75 new nouns each hour of the day. Sensors capturing these dynamics are reinvigorating research about how developmental change arises from multiple timescales of cumulating experience.

2. Infants encounter a lot of different things, but they pervasively encounter a small set of things.

When digging deeper into patterns of repetition and change during infants' experiences, a strikingly consistent pattern emerges: infants encounter some individual identities very much more often than others. For example, infants see many different people's faces but they see a small number of these individuals repeatedly (Jayaraman et al., 2015). Similarly, infants encounter a huge variety of objects during mealtime activities but a small set of them like cups and spoons are especially prevalent (Clerkin et al., 2017). Among the many distinct tunes that infants encounter, some tunes dominate a day's musical seconds while others are brief (Mendoza & Fausey, in press). The non-uniform nature of everyday distributions in which some items are prevalent while many others are less prevalent is inspiring new hypotheses about how people remember and generalize as they learn (Smith et al., 2018).

3. Inputs are nested within everyday activities.

The objects, words, and interactions from which infants learn arise within everyday activities. For example, an infant might see a cup and hear their father name it while sitting in a highchair during breakfast. Or, they could encounter a cup while playing with siblings

in their toy kitchen. Perhaps they notice a cup in their favorite picture book at bedtime. New insights about the organizing power of activities for learning has emerged from several recent investigations. For example, we now know that hearing words in a consistent location and time of day, over the days and weeks of early life, helps infants learn to say the word themselves (Roy et al., 2015). We have also discovered that activities like holding objects generate first-person views of these objects that are variable and linked in time, which strengthens skills like recognizing objects in new contexts (Bambach et al., 2018). Finally, caregivers' emotional availability during bedtime routines predicts infant sleep quality (Teti et al., 2010), suggesting the possibility of context-specific constraints on multiple kinds of early learning.

4. Experiences change over developmental time.

Just as infants' interests and abilities change over time, so too do their everyday experiences. For example, two-month-olds encounter many more minutes per day of faces than do 15-month-olds (Jayaraman et al., 2015). And the faces-in-view for younger infants are more likely to be close to the infant and persistent in time than the faces-in-view for older infants (Jayaraman et al., 2015; Jayaraman & Smith, 2019). In contrast, infant views increasingly include hands, and hands holding objects, over developmental time (Fausey et al., 2016). Postures and motor activities also change over developmental time, with increasing rates of sitting and decreasing rates of being held over the first year of infancy (Franchak, 2019). Limb dynamics like arm movements become increasingly dependent on recent prior motor behaviors over the course of the first year of life (Abney et al., 2014). The extent to which other sensory histories like everyday objects, language, and music change over developmental time are open questions worthy of future investigation.

5. Downtime is part of the everyday rhythm.

The reality that activities start and stop is readily observed in everyday life. Freeflowing behavioral streams consist of numerous activity durations and switches befitting the attentional and emotional needs of infants and caregivers alike. Sometimes, everyone is playing on the living room floor with objects and other times caregivers wash dishes while silently monitoring their infant. Any single activity, like speech, therefore rises and falls over time. In fact, recent reports have revealed that roughly 20 to 30 percent of everyday samples do not include any speech at all, in dramatic contrast to traditional laboratory samples during which caregivers talk constantly (Cristia et al., 2021; Tamis-LeMonda et al., 2017). The contrast between behaviors during a play session in a special-purpose room for a predetermined amount of time and behaviors in everyday life highlights an emerging priority to account for the prevalence and rhythm of everyday activities in accounts of experience-dependent learning.

6. Some everyday rhythms take hours – not minutes – to arise.

Some patterns of activity take hours to unfold. For example, some caregivers might talk a little bit throughout an entire day and this would never be knowable by sampling only five minutes. Similarly, an infant crying for five minutes might affect caregiver mental health

differently than an infant crying for eight *hours*. Wearable sensors have recently captured such extended behaviors and their effects. For example, the degree to which caregivers are consistently “chatty”, participating in at least one back-and-forth conversational turn with their infant every five minutes throughout the day, predicts lower symptoms of toddler psychopathology, with little evidence that one-hour volume measures of caregiver speech matter (King et al., 2021). Another study that quantified mothers’ mood using ecological momentary assessments along with infant crying detected in everyday audio discovered that both ten minutes and eight hours of above average crying predict worse mood. However, only when crying is above average for eight hours do mothers show subsequent feelings of depression and lower self-efficacy (de Barbaro, Micheletti et al., under review).

7. Everyday activities showcase an expansive construal of caregiving.

Expansive time, space, and caregiver responsibilities at home have implications for caregiving and its consequences. For example, individual differences in how caregivers structure physical space, and in how they encourage or restrain their infants’ movements, can affect infants’ opportunities to sample their environment (Rachwani et al., 2020). Other forms of everyday encouraging, like the extent to which caregivers praise their infants for helping, vary across families as well (Dahl, 2015). Further, in addition to well-established variation in the quality of caregiver-infant interactions, wearable sensors are also revealing that caregivers vary in the total amount of time they spend directly engaging with their infants. For example, in one study, roughly half of families read to their infants at least once in a day and about half did not (Clemens & Kegel, 2021). Caregivers also differ in many dimensions of their availability like physical presence, proximity, and physical contact with infants (Rachwani et al., 2020; Yao et al., 2019). For example, caregivers held their infants from 10 to 30 minutes within a 45-minute session (Yao et al., 2019), and everyday holding matters for infants’ distress, feeding, and sleep (Little et al., 2018; St James-Roberts et al., 2006).

8. Experiences are not interchangeable across infants.

There is tremendous diversity within and across the world’s communities in childrearing beliefs, caregiving configurations, access to material resources, and many other circumstances that structure everyday life. Individual infants’ experiences are therefore nested within many organizing levels of local context. Infant-to-infant variation in everyday experiences has been extensively documented in language, with individual infants of similar age encountering different daily rates of child-directed speech (Casillas et al., 2020; Weisleder & Fernald, 2013), conversational back-and-forth with caregivers (Romeo et al., 2018), and density of language over multiple timescales (d’Apice et al., 2019; King et al., 2021). Demographic realities like maternal education and socioeconomic status have been associated with some of these variations. For example, in North American families, mothers with higher education on average are especially talkative with their infants (Bergelson et al., 2019b). In the motor domain, some infants walk up their caregivers’ chests while others lay bound for hours in cradles (Rachwani et al., 2020). The causes and consequences of infant-to-infant variation in everyday experiences are complex, as we highlight in the final two lessons.

9. What you do is what you learn.

Experience-dependent learning pervades human development. Classically, infants learn to speak the language(s) and recognize the faces in their everyday milieu. Recent discoveries link detailed quantifications of everyday experiences to learning. One striking example is that infants who encounter more child-directed speech in their everyday lives process speech faster and have larger vocabularies (Weisleder & Fernald, 2013), with potential implications for school readiness. Connecting heard words to seen objects also matters, such that infants who more often see objects while they are being named are more likely to learn object names (Bergelson & Aslin, 2017). Infants' earliest learned object names also overlap with pervasively seen objects (Clerkin et al., 2017). We also know that everyday opportunities to move independently accelerate sitting and walking (Rachwani et al., 2020). Overall, seeing, hearing, and doing drive development.

10. There are multiple pathways to learning.

Importantly, links between quantified features of everyday experiences and learning do not always straightforwardly generalize across infants. For example, infants in Tzeltal Mayan communities encounter lower rates of child-directed speech than do infants in upper-class English-speaking USA communities yet show similar developmental timing of early language skills (Casillas et al., 2020). The experiences that give rise to learning are necessarily specific to individual learners; no single infant encounters an "average" history of everyday experiences. If the varied features of everyday life cohere in different ways for different infants, then the impact of any single feature for learning may also vary across infants. We have a lot yet to discover, thanks to the fact that developmental pathways arise from multiple causes and multiple interacting processes (Samuleson, 2021).

Building next-generation theories of developmental change.

Fully understanding experience-dependent developmental change is a work-in-progress. Moving forward, we envision research that centers everyday experiences as both the causes and consequences of developmental change over time, integrating lessons from multiple approaches to reveal mechanisms by which infants build skills over time.

Because infants' everyday skills may or may not overlap with the behavioral repertoires elicited in researcher-designed tasks or caregiver report, any account of developmental change will benefit from continued reports of the nature of everyday behaviors. For example, while stepping behavior as measured by walking on an elongated pressure mat provides an efficient and reliable assessment of motor development, it misses infants' omnidirectional steps observed when infants can roam around a room (Lee et al., 2018). Relatedly, distinguishing word referents in a two-alternative forced-choice task provides insight into early stages of word comprehension. However, it obscures potential challenges and scaffolds for learning and identifying referents in everyday language use (Gogate et al., 2000). As such, characterizing everyday experience showcases skills that become the to-be-explained developmental achievements in our theories. Additionally, reports of everyday behaviors can drive new hypotheses about relevant mechanisms for learning-in-context. Indeed, many of the operative mechanisms may be the everyday behaviors themselves as infants practice

over time (Lockman & Tamis-LeMonda, 2021). For example, infants' self-sitting experience shapes visual perception skills (Soska et al., 2010). While such everyday experiences are commonly presumed in theories of development, they are typically not directly assessed (Nastase et al., 2020). Thus, an important step en route to understanding how experiences matter for emerging skills is to characterize behaviors in context (Adolph, 2019).

Advancing our understanding of precisely how everyday behaviors arise and matter for developmental change can also benefit from iterative synergies with researcher-constrained studies. For example, now that we know that everyday distributions are highly non-uniform in many domains, next-step researcher-constrained studies can investigate the impact of these everyday parameters on learning in traditional lab paradigms. Other synergistic innovations could merge everyday complexity with researcher-designed control. For example, manipulating free-flowing parent-child interactions can test the importance of parents' real-time multi-modal feedback for language production (Goldstein & Schwade, 2008). Similarly, manipulating infants' grasping experiences over weeks can be used to assess the importance of extended timescales of everyday experiences for learning (Needham et al., 2002).

Throughout, our understanding about infants' everyday experiences will benefit from evidence across the world's diverse contexts. Much of our current understanding is drawn from white western educated populations and cannot be considered evidence for universal lessons about the nature of infants' everyday experiences.

Conclusion.

Everyday sensing in infancy has revealed the complex and dynamic nature of the experiences available to shape development. The striking heterogeneity of experiences across space, time, and context suggests three important priorities en route to creating a world that supports everyone's endeavors to learn and grow. First, the dynamic rising and falling of infants' opportunities to learn about the world should prompt researchers to sample ever more extended timescales in order to detect the frequency, variability, and organization of everyday experiences. Second, caregivers, clinicians, and policy makers may find inspiration and information in a base of evidence that increasingly approximates the realities of everyday life. Importantly, studies that compare behaviors from laboratory and everyday samples sometimes discover generalizable insights and other times highlight certain realities that arise only in everyday life and may prompt updated practices (Tamis-LeMonda et al., 2017). Third, variation in everyday experiences within and across communities is observed, with implications for children's skills and opportunities over time. This variation can sometimes serve as a barometer for potential structural inequities that may shape everyday interactions and more severely impact some communities than others. Everyone dedicated to supporting healthy development would be wise to attend to these findings, pursue understanding of their multiple causes and consequences, and integrate ideas across expertises in order to best serve all children.

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