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**The Electronically Activated Recorder or EAR:
A Method for the Naturalistic Observation of Daily Social Behavior**

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Abstract

This article reviews the Electronically Activated Recorder or EAR as an ambulatory ecological momentary assessment tool for the real-world observation of daily behavior. Technically, the EAR is an audio recorder that intermittently records snippets of ambient sounds while participants go about their lives. Conceptually, it is a naturalistic observation method that yields an acoustic log of a person's day as it unfolds. The power of the EAR lies in unobtrusively collecting authentic real-life observational data. In preserving a high degree of naturalism at the level of the raw recordings, it resembles ethnographic methods; through its sampling and coding, it enables larger empirical studies. The article provides an overview of the EAR method, reviews its validity, utility, and limitations, and discusses it in the context of current developments in ambulatory assessment, specifically the emerging field of mobile sensing.

Keywords: Ambulatory Assessment; Ecological Momentary Assessment; Naturalistic Observation; Smartphone Sensing

Laypersons often think of psychologists as professional people watchers. It is ironic, then, that naturalistic observation, as a methodology, has a remarkably thin history in our field (Funder, 2009). In contrast to ethologists (and researchers working with infants), psychologists are in the privileged position to be able to obtain valuable data by simply asking their subjects (Rozin, 2001). At the same time, there are clear limitations to what self-reports can assess.

Experience sampling—also known as *ambulatory assessment* and *ecological momentary assessment* --was developed to address concerns around global and retrospective self-reports and constitutes the effective gold standard for measuring psychosocial factors in daily life (Bolger & Laurenceau, 2013; Smyth & Stone, 2003; Trull & Ebner-Priemer, 2014; Reis & Gosling, 2010). Yet, the psychological scientist's tool kit also needs a method to directly observe human behavior in daily life. Just as experience sampling brings self-report data collection to where moment-to-moment experiences naturally happen, naturalistic observation can bring behavioral data collection to where moment-to-moment behavior naturally happens.

What is the EAR Method?

As an ecological behavioral observation method, the Electronically Activated Recorder (EAR) seeks to accomplish that (Mehl et al., 2001; Mehl et al., 2012). Technically, it is a portable audio recorder that intermittently records ambient sound bites. Participants wear it while going about their days, unaware when exactly the device is recording. By tracking the ambient sounds of their lives, the EAR yields acoustic logs of their days. In preserving a high degree of naturalism at the level of the raw data, it resembles ethnographic methods. Through its sampling, it protects privacy and enables large(r) empirical studies. The sampled recordings are then transcribed and coded for aspects of participants' momentary location, activities, interactions,

and affect expressions. Since its initial development in 1999 (with James Pennebaker), the EAR has evolved from a chip-triggered microcassette recorder into a smartphone app (Figure 1).

Currently, we are using a fourth-generation “iEAR” system that runs on iOS; an Android version will be available in 2017.

Wearing the EAR is minimally bothersome (although it currently still requires carrying an extra mobile device) and it has been successfully used, with good acceptance and compliance, in age groups ranging from childhood to old age (3 years to 93 years; Alisic et al., 2015; Bollich et al., 2015) and with different healthy (Holleran et al., 2011; Slatcher & Rhobles, 2012) and clinical (Baddeley et al., 2013; Brown et al., 2014; Tobin et al., 2015) populations. Practical recommendations for how to use the EAR, including information about existing coding systems, are available at Megan Robbins’ OSF EAR Repository: <https://osf.io/n2ufd/>.

Figure 1. The evolution of the EAR method

What are Ethical Considerations around Sampling Ambient Sounds?

Recording ambient sounds raises ethical and legal concerns. EAR studies generally implement several safeguards to protect the privacy of participants and conversation partners. First, the audio sampling limits the net recording to a small fraction of the day (e.g., 5% when sampling 30 sec every 12 min). Second, the short recordings (e.g., 30 sec or 50 sec) ensure that minimal personal information is captured beyond what is necessary for reliable coding. Third, participants can review their recordings and censor any they wish to remain private. Fourth, a “warning triangle” is placed visibly on the EAR device to alert conversation partners of the possibility of being recorded. Finally, most EAR studies in the United States are covered by an NIH Certificate of Confidentiality to protect the data against forced third-party disclosure. The iEAR app further has an optional privacy button that can guarantee a pre-specified period of non-recording, and an optional pitch transformation that renders voices deidentifiable prior to storing the audio. With these safeguards, EAR studies have been approved by various ethics committees.

What Research Speaks to the EAR Method’s Validity and Utility for Studying Daily Life?

Because of the paucity of naturalistic observation research in psychology, our initial research focused on the psychometrics of EAR-assessed behavior. In a series of studies, we used the method to show (a) that a broad spectrum of daily behaviors can be assessed reliably and with low levels of reactivity from the sampled ambient sounds (Mehl & Holleran, 2007), (b) that these behaviors show large between-person variability and good temporal stability (Mehl & Pennebaker, 2003) and (c) that they have good convergent validity with theoretically-related measures such as the Big Five (Mehl et al., 2006) and narcissism (Holtzman et al., 2010).

The next studies, then, were aimed at clarifying the method’s utility and added value relative to existing methods. From this, three concrete ways have emerged in which naturalistic

observation with a method such the EAR can enrich psychological science.

It can provide ecological, behavioral criteria that are independent of self-report. In psychology, measuring behavioral “ground truth” is a vexing issue. Self-knowledge research struggles to measure self-insight without relying on self-reports of both self-perceptions and actual reality. Health research struggles to empirically tease apart the important conceptual distinction between loneliness and social isolation and perceived support and provided support. Morality research struggles to assess moral actions isolated from moral intentions. Where it is critical to assess behavior ecologically and free from self-report, the EAR can help achieve this.

For example, Vazire and Mehl (2008) tested the accuracy of self- and peer-reports by comparing the predictive validity of participants’ self-ratings of daily behaviors (e.g., talking on the phone, laughing, watching TV) to similar ratings obtained from friends. The frequency with which the EAR captured participants engaging in these behaviors served as accuracy criterion. Self- and peer-ratings showed comparable validity but also uniquely predicted certain behaviors. Importantly, to avoid giving one perspective an undue predictive advantage, shared method variance with both had to be minimized. The EAR-derived behavior counts sought to accomplish. Similarly, Ramirez-Esparza and colleagues (2009) studied Americans’ and Mexicans’ sociability and found that although American participants reported being *more* talkative than their Mexican counterparts, they talked significantly and substantially *less* –almost 20%-- in their daily conversations. Finally, Tobin and colleagues (2015) found that an EAR measure of family conflict predicted youth asthma symptoms over and above a diary measure of negative family interactions, suggesting that the method may capture unique variance particularly with evaluative behaviors (Bollich et al. 2016).

It can help study psychologically important subtle and habitual behaviors. In everyday

life, many subtle and habitual behaviors do not pass the threshold of conscious recognition. For example, sighs or laughs and automatic aspects of language use such as pronouns or prepositions are often not consciously noticed and therefore inaccessible to self-report. Therefore, the study of these more elusive—yet psychologically non-trivial—aspects of our social lives can be enriched through naturalistic observation approaches such as the EAR.

For example, in one study, arthritis patients wore the EAR and completed depression and physical symptom measures (Robbins et al., 2011a). Incidents of sighing were coded from the recorded sounds. Consistent with the idea that sighing can be more indicative of depression than of pain, sighing was more strongly related to patients' depressive symptoms than to their experienced pain and flare days. In another study, arthritis and breast cancer patients wore the EAR to track their natural language use (Robbins et al., 2011b). Information on how much participants were swearing was derived from automatic text analysis. Consistent with the idea that swearing can undermine support at the expense of psychological adjustment, swearing in the presence of others was related to decreases in emotional support and increases in depressive symptoms over time. Together, these findings suggest that naturalistic observation can help with studying subtle and automatic health behaviors that “fly below the radar” of self-report.

It can help calibrate psychological effects against act-frequencies of real-world behavior.

Most measures in psychology use arbitrary metrics which renders effect interpretations difficult. A better understanding of effect sizes can be obtained through the calibration of psychological effects against real-world behaviors (Sechrest et al., 1996). The EAR's binary coding (behavior present vs. absent) yields a non-arbitrary and intuitively meaningful metric, act-frequencies of daily behavior (e.g., a participant was talking in 40% of the recordings or an estimated 40% of her wake time) and can thereby help make abstract effect sizes “graspable”.

In one study, for example, we found that greater well-being was related to having less small talk and more substantive conversations (Mehl et al., 2010). The effect sizes, $r = -.33$ and $r = .31$, respectively, mean that the happiest participants in the sample (+2.0 SD) had roughly twice as many substantive conversations (45.9% vs. 21.8%) and one third of the small talk (10.2% vs. 28.3%) relative to the unhappiest ones (-2.0 SD). Whereas the happiest participants had about four substantive interactions for every small talk, the unhappiest ones sadly engaged in more small talk than substantive conversations. In another study, testing whether women are indeed much more verbose than men, we estimated that both men and women use about 16,000 words per day (Mehl et al., 2007). A gender difference of 546 words compared to a range of 46,000 words between the least and most talkative participant (695 vs. 47,016) illustrates the (trivial) effect size—and speaks powerfully to the magnitude of individual differences.

To summarize, naturalistic observation with a method such as the EAR occupies a methodological niche; it is not for everyone and everything. It is labor-intensive and thus requires careful consideration as to when it should be used instead of more economic methods. However, in providing ecological behavioral data that (a) are independent of self-report, (b) can capture subtle and automatic aspects of behavior, and (c) come in a non-arbitrary, highly intuitive, and real-world relevant metric, it can yield valuable findings that are difficult to obtain otherwise and it can that way contribute to psychology as a strong behavioral science.

How does the EAR Method Compare to Other Methods for Studying Daily Life?

As a method for studying daily life (Mehl & Connor, 2012), the EAR compares most directly to the highly established and widely used experience sampling method (ESM). On the other hand, it can also be compared to emergent mobile sensing methods (MSM) that use

ubiquitous mobile devices, smartphones and wearables, to collect real-world behavior data via embedded sensor and interaction logs (Harari et al., 2016). Table 1 identifies similarities and differences between these methods. A comprehensive discussion can be found in Alisic et al. (2015) and Wrzus and Mehl (2015).

All three methods pursue an ecological approach. The most important conceptual difference between them lies in the fact that ESM is based on momentary self-reports whereas EAR and MSM are based on momentary acoustic and sensor-based observations, respectively. They hence adopt different assessment perspectives: ESM adopts the first-person perspective of the self, the EAR the third-person perspective of an observing bystander, and MSM an objective observational account derived from event log histories.

Whereas ESM requires an active user response, assessment happens passively and, after a habituation period, usually with low awareness with EAR and MSM. This has implications for the temporal resolution that the methods can achieve. Whereas ESM is practically limited to around a dozen prompts per day, MSM allows (pseudo-)continuous tracking, with EAR falling in between with its sampling rate of 5-6 recordings per hour. Because data are collected digitally in (electronic) ESM and MSM, larger sample sizes can be achieved relative to the EAR, which requires manual coding. The psychometric properties of ESM are extensively studied and well-documented. Adequate psychometric information exists for the EAR for selected variables and populations but more evidence is needed, particularly with respect to the reliability of within-person variance. The psychometric properties of MSM are understudied but first evidence is emerging (Harari et al., 2016).

Table 1

A Comparison of the EAR as a Naturalistic Observation Method with Related Methods for Studying Daily Life

	Experience sampling method (ESM)	Electronically Activated Recorder (EAR)	Mobile sensing methods (MSM)
Approach	Ecological	Ecological	Ecological
Medium	Paper & pencil, electronic	Electronic	Electronic
Mode	Active (voluntary response)	Passive (unobtrusive recording)	Passive (embedded sensor logs)
Method	Self-report (survey responses)	Behavioral observation (raw audio data)	Behavioral observation (sensor metadata)
Perspective	First-person (the self)	Third-person (others)	Objective (event log)
Awareness of assessment	High	Low after habituation	Low after habituation
Burden for participant	Practical (temporary interruptions)	Psychological (privacy intrusion)	Psychological (privacy intrusion)
Burden for researcher	Participant training	Coding of audio recordings	Post-processing of sensor data
Data collection limited by	Response burden	Privacy considerations, lab capacity for data coding	Privacy considerations, technological constraints
Temporal resolution	Low (max. several times per day)	Moderate (max. several times per minute)	Continuous (determined by sensor resolution)
Achievable sample size	Large	Modest	Potentially very large, “at scale”
Psychometric properties	Extensively documented	Documented for selected variables and populations	First evidence accumulating
Measurement flexibility	High (theory-based item selection)	High (theory-based coding)	Currently low (limited to what sensors provide)
Optimized for assessment of	Subjective experiences and perceptions	Observable social interactions	Objective events and activities

Additionally, a critical difference emerges with respect to measurement flexibility. Both ESM and EAR can measure a range of constructs specifically and precisely through careful item selection or coding category definition. With MSM, researchers are limited to those (few) psychological variables that can currently be extracted from sensor streams (e.g., physical activity from accelerometer; geographic location from GPS). Therefore, ESM and EAR allow for the typical research approach where measurement follows from theory, whereas MSM presently requires an inverse approach where theory, or what can be studied, follows feasible measurement.

Taken together, the conceptual differences between the three methods suggest differential optimal domains of assessments. In capturing the agent's first-person or "insider" perspective, ESM is optimized for assessing subjective experiences and perceptions (e.g., thoughts, feelings). In contrast, in capturing the observer's third-person "outsider" perspective, the EAR is optimized for assessing audible aspects of social interactions (e.g., verbal and paraverbal communication behavior). MSM, finally, through its use of smartphone and wearable sensor logs, is optimized for the assessment of objective events and activities (e.g., space use, social media use).

The Future of the EAR as an Observational Ambulatory Assessment Method

Over the last 10 years, a mobile device revolution has unfolded. The diffusion of smartphones into all pores of our lives has opened up powerful ways to assess objective daily life information (Miller, 2012). As our social lives are increasingly digitally encoded in smartphones and wearables, mobile sensing methods are "graduating" from early feasibility studies in computer science and engineering and are getting ready for mature large-scale implementation in psychology (Harari et al., 2016; Sandstrom et al., 2016). The question at the EAR's

methodological coming of age then becomes what will happen to it in the future. Will it become obsolete as mobile sensing platforms become more robust, validated, and researcher-friendly? Will it “move in” with other ambulatory assessment methods, for example, in form of a multi-modal mobile research platform that merges experience, behavior, and location sampling? Or will it continue to exist and mature as a stand-alone naturalistic observation method?

My prediction is that it will likely live aspects of all three scenarios. Mobile sensing combined with the powers of behavioral signal processing will ultimately render the assessment of at least some behaviors automatic. Further, researchers have already begun incorporating elements of the EAR into their ambulatory assessment systems (e.g., a custom-made, battery-efficient wearable for the long-term tracking of ambient audio and GPS information and an experience sampling platform that allows for time- or event-contingent audio recordings). From a practical perspective, an integrated, open-source multi-modal ambulatory assessment system, akin to the legendary ESP program (Barrett & Barrett, 2001) would seem to be an asset for the field. Finally, for the foreseeable future, there will likely continue to be a need for a stand-alone measurement tool that, along with other naturalistic observation tools such as wearable cameras (Doherty et al., 2013; Wettstein & Scherzinger, 2015), enables psychologists to indeed be professional “people watchers” or observers of human behavior.

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