Ergodicity is sufficient but not necessary for group-to-individual generalizability

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Researchers commonly draw inferences from the group level to the individual and vice versa—that is, across levels. One of the empirical cornerstones of medicine is the clinical trial that tests the efficacy of a drug compared with placebo. If the intervention group outperforms the placebo group, the conclusion is that the drug should be prescribed for individuals with a given disorder. When are such inferences across levels defensible?

In their recent paper in PNAS, Fisher et al. (1) state that "statistical findings at the interindividual (group) level only generalize to the intraindividual (person) level if the processes in question are ergodic," meaning that the effects of interest are homogeneous across individuals and stable over time (for formal definitions see, e.g., refs. 2 and 3). Fisher et al. demonstrate that ergodicity does not hold in multiple datasets, concluding that nonergodicity is a "threat to human subjects research."

While we commend the authors for the insightful manuscript, we want to stress that ergodicity is sufficient, but not necessary, to draw inferences across levels (3, 4). Accordingly, recent work on ergodicity vs. nonergodicity has shifted away from a binary conceptualization to the idea of a continuum connecting the two (3–6). Fisher et al. (1) briefly acknowledge this perspective, and we want to highlight some important implications here.

First, we might encounter different degrees of partial equivalence between levels, depending on where processes are situated on the nonergodicity continuum. In all such cases, ergodicity holds conditional on (i.e., after controlling for) sources of heterogeneity between individuals and/or instability over time. Such "conditional equivalence" (3) allows for conditional inferences across levels. Which and how many sources of heterogeneity will have to be conditioned on, and whether the resulting conditional inferences remain meaningful, will depend on the phenomenon, population, and time span studied (3).

Second, statistical approaches such as structural equation or state-space modeling allow one to estimate conditional ergodicity by taking into account (un)observed sources of heterogeneity between individuals and/or instability over time. In addition, as our introductory example alluded to, conditional ergodicity can be accomplished by design; for example, randomization is a powerful way to condition on unobserved heterogeneity between individuals, allowing for treatment effects to be interpreted within (the average) person (conditional on assumptions of temporal stability).

Third, research on nonergodicity needs to be comprehensive. Heterogeneity between individuals, as highlighted by Fisher et al. (1), is one important complication for inferences across levels. But instability over time can also produce ambiguous effects and promote interpretational fallacies. For instance, psychological data may involve effects between and within days, and failure to distinguish them will mischaracterize both processes (7). Empirical quests into nonergodicity therefore need to incorporate variance sources at both levels.

Since (unconditional) ergodicity is the exception in psychological data (1), studying nonergodic processes promises important avenues for future research. Such endeavors can build on existing theoretical and methodological work and are greatly facilitated by recent advances in mobile and wearable technology that allow collecting data within individuals to systematically investigate questions of conditional ergodicity.

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