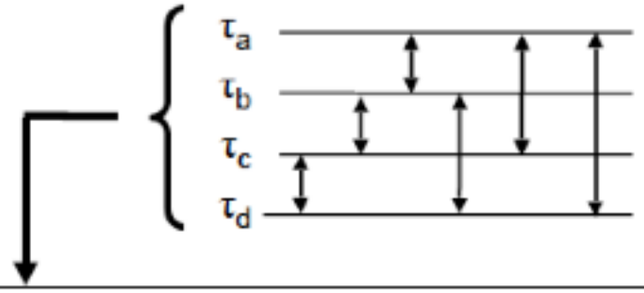
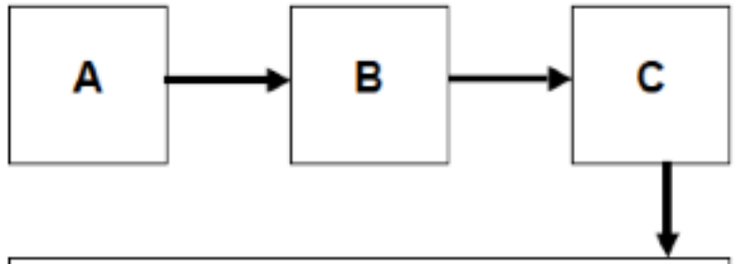
Interaction dominant dynamics



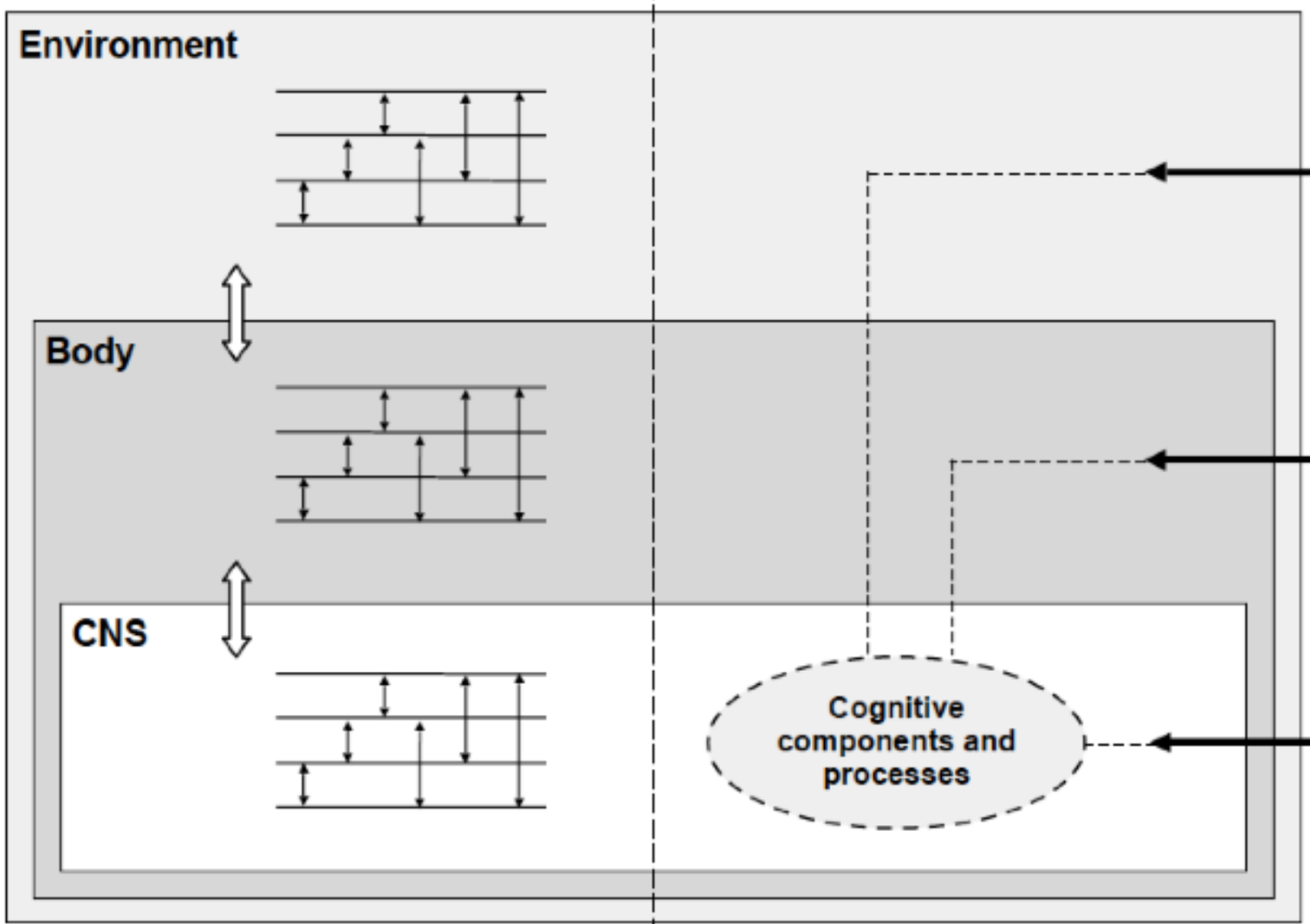
Behavior emerges from interaction between many processes on different timescales in body and environment

Component dominant dynamics



Behavior is the result of a linear arrangement of a virtual architecture of cognitive components and processes

Place of measurement of efficient causes

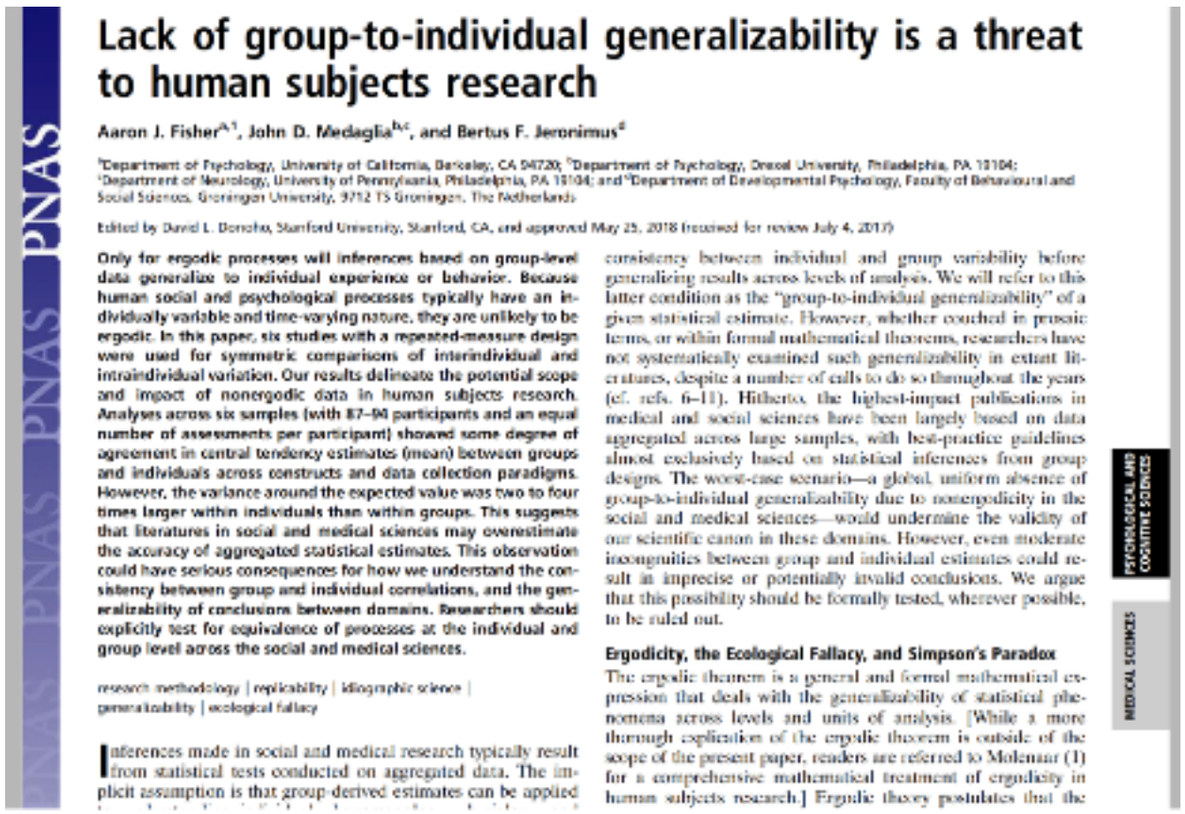


Environmental factors, Performance and perception measures, Social interactions, ...

Genetic, immunological, endocrine systems. Biophysical composition, physiology, Organic chemistry, ...

Structure and function of the cortex, cerebellum, brainstem, neural pathways. Neurochemistry, ...

“Lack of Group to Individual Generalizability”



PNAS PNAS

Lack of group-to-individual generalizability is a threat to human subjects research

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Only for ergodic processes will inferences based on group-level data generalize to individual experience or behavior. Because human social and psychological processes typically have an individually variable and time-varying nature, they are unlikely to be ergodic. In this paper, six studies with a repeated-measure design were used for symmetric comparisons of interindividual and intraindividual variation. Our results delineate the potential scope and impact of nonergodic data in human subjects research. Analyses across six samples (with 87–94 participants and an equal number of assessments per participant) showed some degree of agreement in central tendency estimates (mean) between groups and individuals across constructs and data collection paradigms. However, the variance around the expected value was two to four times larger within individuals than within groups. This suggests that literatures in social and medical sciences may overestimate the accuracy of aggregated statistical estimates. This observation could have serious consequences for how we understand the consistency between group and individual correlations, and the generalizability of conclusions between domains. Researchers should explicitly test for equivalence of processes at the individual and group level across the social and medical sciences.

research methodology | replicability | idiographic science | generalizability | ecological fallacy

Inferences made in social and medical research typically result from statistical tests conducted on aggregated data. The implicit assumption is that group-derived estimates can be applied

consistency between individual and group variability before generalizing results across levels of analysis. We will refer to this latter condition as the “group-to-individual generalizability” of a given statistical estimate. However, whether couched in prosaic terms, or within formal mathematical theorems, researchers have not systematically examined such generalizability in extant literatures, despite a number of calls to do so throughout the years (cf. refs. 6–11). Hitherto, the highest-impact publications in medical and social sciences have been largely based on data aggregated across large samples, with best-practice guidelines almost exclusively based on statistical inferences from group designs. The worst-case scenario—a global, uniform absence of group-to-individual generalizability due to nonergodicity in the social and medical sciences—would undermine the validity of our scientific canon in these domains. However, even moderate incongruities between group and individual estimates could result in imprecise or potentially invalid conclusions. We argue that this possibility should be formally tested, wherever possible, to be ruled out.

Ergodicity, the Ecological Fallacy, and Simpson’s Paradox

The ergodic theorem is a general and formal mathematical expression that deals with the generalizability of statistical phenomena across levels and units of analysis. [While a more thorough explication of the ergodic theorem is outside of the scope of the present paper, readers are referred to Molenaar (1) for a comprehensive mathematical treatment of ergodicity in human subjects research.] Ergodic theory postulates that the

PSYCHOLOGICAL AND COGNITIVE SCIENCES

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There are two important takeaways from these findings:

(i) **Aggregated estimates did not consistently agree with individual estimates [...]** the present study provides an empirical demonstration of [*the implausibility of ergodicity in human subjects research*] across multiple settings and constructs.

(ii) even in the best-case scenario, **we should not think of a correlation in group data as an estimate that generalizes to any given individual in the population**. Only 68% of all individual correlational values fall within a range that would be predicted by group data to cover 99.7% of all possible correlations—a discrepancy of nearly 32%.

The worst-case scenario is clearly dire: It is plausible that **inattention to nonergodicity and a lack of group-to-individual generalizability threaten the veracity of countless studies, conclusions, and best-practice recommendations.**

Fisher, A. J., Medaglia, J. D., and Jeronimus, B. F. (2018). Lack of group-to-individual generalizability is a threat to human subjects research. *Proceedings of the National Academy of Sciences.*