Explaining intuitive difficulty judgments by modeling physical effort and risk

Ilker Yildirim
Massachusetts Institute of Technology, Cambridge, Massachusetts, United States

Basil Saeed
Massachusetts Institute of Technology, Cambridge, Massachusetts, United States

Grace Bennett-Pierre
Stanford University, Stanford, California, United States

Tobias Gerstenberg
Stanford University, Stanford, California, United States

Josh Tenenbaum
MIT, Cambridge, Massachusetts, United States

Hyowon Gweon
Stanford University, Stanford, California, United States

Abstract

The ability to estimate task difficulty is critical for many real-world decisions such as setting appropriate goals for ourselves or appreciating others' accomplishments. Here we give a computational account of how humans judge the difficulty of a range of physical construction tasks (e.g., moving 10 loose blocks from their initial configuration to their target configuration, such as a vertical tower) by quantifying two key factors that influence construction difficulty: physical effort and physical risk. Physical effort captures the minimal work needed to transport all objects to their final positions, and is computed using a hybrid task-and-motion planner. Physical risk corresponds to stability of the structure, and is computed using noisy physics simulations to capture the costs for precision (e.g., attention, coordination, fine motor movements) required for success. We show that the full effort-risk model captures human estimates of difficulty and construction time better than either component alone. Preprint link https://arxiv.org/abs/1905.04445.