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A Normative Account of Specialization: How Task and Environment Shape Role Differentiation in Collaboration

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Abstract

In collaborative groups, both humans and artificial intelligence (AI) agents frequently adopt specialized roles, yet the conditions that govern the optimal degree of specialization remain poorly understood. In this work, we propose that specialist teams outperform generalist ones when environmental constraints limit task parallelizability—the potential to execute task components concurrently. Drawing inspiration from distributed systems, we introduce a heuristic to predict the relative efficiency of generalist versus specialist teams and validate it through three multi-agent reinforcement learning (MARL) experiments in Overcooked-AI, demonstrating that key factors limiting task parallelizability influence specialization. Notably, as the task space expands, agents reliably converge on specialist strategies, even when generalist ones are theoretically more efficient, suggesting that specialization may help mitigate costly learning demands. Our findings provide a normative framework for understanding when and why specialization emerges as the optimal strategy in collaborative settings.