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Permalink
https://escholarship.org/uc/item/8zp8f362

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 46(0)

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Publication Date
2024

Peer reviewed
Many Hands Don’t Always Make Light Work: 
Explaining Social Loafing via Multiprocessing Efficiency

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Abstract

Humans collaborate to improve productivity and collective outcomes, but people do not always exert maximal effort towards accomplishing collaborative goals. Instead, individuals often expend less effort in groups, a phenomenon known as social loafing that is traditionally viewed as detrimental to productivity. However, theories from distributed computer systems suggest that social loafing might be a rational response to the diminishing returns expected from division of labor when group size increases. Here, we examine how considerations of task efficiency affect the perceived acceptability of withholding effort during a collaborative task. We conducted experiments varying workload and group size across scenarios in which all group members except for one are actively contributing to a common goal. We then compare participant judgments to a model inspired by latency speed-up in distributed systems. We find that people are systematically influenced by task efficiency, in addition to social norms, when judging social loafing.

Keywords: collaboration; social loafing; distributed computation; multiprocessing; collective intelligence

Introduction

Humans frequently work together to tackle challenges and accomplish goals beyond the capabilities of a single individual. In an effort to enhance productivity, we coordinate our actions with others in a way that allows us to leverage collective effort and overcome individual constraints on time and resources (Griffiths, 2020; Vélez et al., 2023). Collaboration is thus motivated by the underlying belief that “many hands make light work”; as we pool shared resources, skills, and effort, we should benefit from an increase in our collective output. However, figuring out how to combine effort effectively across group members is not a trivial endeavor. Decades of psychological research reveal a tendency for individuals to expend less effort when working as a group (Ringelmann, 1913; Steiner, 1972; Ingham et al., 1974; Petty et al., 1977). This withholding of labor, also known as social loafing, enables group members to reap the benefits of a collaborative task without contributing their fair share of effort, and is often considered to result in a loss of group-level productivity (Latané et al., 1979).

Numerous theories have aimed to address the causes of social loafing, mainly focusing on social and psychological phenomena such as arousal reduction, evaluation potential, visibility, and dispensability and matching of effort (Karau & Williams, 1993). However, these explanations often overlook a crucial point: tasks vary in the degree to which they should theoretically benefit from collaboration. One factor that can impact collaborative efficiency is workload: the amount of work to be completed in a given time span. Adding group members may not improve performance in situations where the workload is too small. Secondly, tasks may contain serial dependencies that prevent effective division of labor. These bottlenecks, whether due to spatial constraints, limited physical resources like tools and workstations, or cognitive barriers hindering communication and information flow, can restrict the contributions of additional group members, even when there is more work to be done.

In order to properly evaluate the complexities that emerge when relating individual effort to group productivity, we need a normative theory that formalizes how people should distribute resources and labor during collaborative tasks. There are parallels between these challenges and ones that have already been solved in the field of distributed computer systems. Classic findings in distributed systems provide a formal way of analyzing system-level efficiency in terms of the number of machines that can be added to a task before expected speed-up improvements plateau (Amdahl, 1967; Gustafson, 1988; Hill & Marty, 2008; Cassidy & Andreou, 2011). We propose that this branch of computer science can provide a theoretical framework for analyzing analogous problems faced by groups of people as they transition from working individually to collaborating (Vélez et al., 2023). In particular, these theories suggest that what might seem like a lapse in human group dynamics could, in fact, be a rational collaborative strategy. Individuals might refrain from exerting effort when they perceive that their involvement will not significantly enhance overall task efficiency. While the idea that individuals consider effort when deciding to contribute to a task is intuitive, a formal model can provide a principled way of identifying optimal labor allocations and whether people are sensitive to varying levels of efficiency.

Principles from computer systems motivate the prediction that considerations of group-level efficiency may contribute to expectations about social loafing in addition to social norms. For example, suppose all of the guests at a dinner party have just finished eating, and it is now time to clean the dishes. If there is only one sink, and several other guests have already crowded around it, should an additional person try to contribute, or is it better that they remain seated at the table? Previous work on social norms suggests that the guest at the table may stand up and help with the dishes once they see other guests doing so (Hackman & Morris, 1975; Schmidt & Tomasello, 2012; Turner et al., 2014; Roberts et al., 2017). As the number of people contributing to the clean-up increases,
there will be heightened normative pressure on those remaining seated to participate in order to avoid resentment and being perceived as uncooperative in the eyes of the productive group members (Mas & Moretti, 2009). However, what is presently unclear is how normative pressure interacts with group members’ assessments of efficiency. The guest at the table may choose to remain seated, even though other guests are working, due to an implicit awareness of environmental constraints that hinder their ability to improve task performance. For example, if there are a limited number of plates to be cleaned, only so many guests can contribute to the task before there is nothing left to do. Similarly, if there are many dirty plates but only one sink, adding another helper will not reduce overall washing time due to a physical resource bottleneck.

Here, we assess whether people consider efficiency when deciding if an additional group member should contribute to a collaborative task, and we apply a novel modeling framework inspired by distributed computer systems to the study of human collaboration. We examine how assessments of task efficiency influence social loafing judgments in an experimental paradigm in which all group members except for one are actively engaged in completing a task. We find that both workload and group size significantly affect people’s judgments of the acceptability of social loafing. People consider social loafing to be less acceptable for high workloads and small groups, and more acceptable for low workloads and larger groups. In addition, using a model inspired by Amdahl’s Law in distributed systems, we find qualitative similarities between participants’ judgments and the predicted speed-up that would have been gained if the social loafing agent contributed to the task. Broadly, these results demonstrate that people take into account distributed task efficiency when judging the efficacy and scope of collaboration.

**Background**

**Collaboration and Group Performance**

Humans are motivated to work with one another as a way to leverage collective resources, yet collaboration itself poses problems such as how to divide labor, coordinate actions, and share collective output amongst group members (Vélez et al., 2023). Previous work shows that individuals tend to collaborate more with one another in larger groups, and as group size grows, the benefits of coordination outweigh productivity losses due to team members reducing their individual effort levels (Mao et al., 2016). Another factor that may impact group performance is task complexity. Previous work has shown that the number of components and inter-dependencies in a task moderate the benefits of collaboration. In particular, collaboration improves the efficiency and quality of solutions for complex tasks, but not simpler ones (Almaatouq et al., 2021). Related work from cognitive psychology examines how people may hold social loafers responsible for the consequences of their actions. These responsibility judgments are influenced by factors such as the causal impact of the target’s actions, how easily their contribution could have been replaced, and whether the outcome would have changed if the target had acted differently (Gerstenberg et al., 2018; Xiang et al., 2023; Wu & Gerstenberg, 2024).

**Social Loafing and Norms**

Previous work on social loafing and norms motivate the prediction that group size impacts collaborative effort. Research in social psychology indicates that individuals frequently exert less effort when working together. This phenomenon was first demonstrated by Ringelmann (1913), who found that when a group of people collectively pulled on a rope, the result was lower than each individual group member’s output (Kravitz & Martin, 1986). This finding has been replicated across a wide range of populations in both physical and cognitive tasks (Ingham et al., 1974; Petty et al., 1977). Many theoretical accounts aim to explain these productivity losses in terms of social mechanisms such as social impact, contribution visibility, and dispensability of effort (Karau & Williams, 1993; Simms & Nichols, 2014). Latané (1981) theorized that when an experimenter makes a suggestion to a group, the request will be divided amongst each member, resulting in a reduction of individual effort. Kerr and Bruun (1983) found that group members exert less effort because they perceive their contribution to be more dispensable to the overall outcome. Jackson and Harkins (1985) proposed that individuals diminish their contributions to avoid an unequal division of labor when they expect social loafing from the other group members. Williams (1981) found that reduced identifiability in group settings led individuals to feel less motivated to contribute to a common goal. Group size additionally impacts collaborative behavior by placing greater normative pressure on each individual to behave similarly to the collective. When judging whether or not certain behavior is acceptable, people tend to take into account both descriptive norms (e.g., the average, or what everyone else is doing), as well as prescriptive norms (e.g., the ideal, or what everyone should be doing) (Bear & Knobe, 2017).

**Distributed Systems**

Parallelism enables complex computations to be carried out simultaneously, leading to immense improvements in computational efficiency. However, coordinating multiple processors to tackle the same computations in parallel faces tremendous challenges (Baer, 1973; Almasi & Gottlieb, 1994; Kshemkalyani & Singhal, 2011). This literature focuses on the potential disadvantages that systems face when transitioning from one machine to distributed processing, as well as the best strategies for improving efficiency as tasks are allocated across processors. Amdahl’s Law is a formula that predicts the theoretical speed-up expected when a computation is executed across multiple processors in terms of the proportion of the process that can be parallelized (Amdahl, 1967; Hill & Marty, 2008; Cassidy & Andreou, 2011; Hennessy & Patterson, 2011). In the simplest case, there are only two levels of parallelism – a completely parallelizable proportion of the...
task \((f)\) that can be divided between all processors to achieve a speedup of \(s\), versus a completely serial proportion that must be performed by one processor \((1 - f)\). We will consider a subtask to correspond to a specific proportion of an overall task. Amdahl’s Law computes the predicted temporal speed-up for a fixed workload via

\[
S_{\text{time}}(s) = \frac{1}{(1 - f) + \frac{f}{s}}
\]  

(1)

As the number of processors increases, improvements in efficiency are limited by the proportion of the task that must be performed serially by a single processor due to time, resource, or memory dependencies. Amdahl’s Law points to an inherent limit to which parallelism can enhance task efficiency; it is only beneficial to allocate available processors to a computation when there is unfinished work and additional processor involvement will reduce the time to completion.

**Methods**

**Evaluating the Impact of Task Efficiency**

We develop a paradigm for evaluating how people take into account efficiency when deciding if an additional group member should contribute to a collaborative task. In particular, we predict that if the decision to contribute to a collaborative task is influenced by task efficiency, then participants should consider both workload and group size when evaluating the acceptability of social loafing. Alternatively, if the decision to contribute to a collaborative task depends solely on social norms, then participants should only take group size into account when evaluating social loafing, regardless of the potential marginal impact of their contribution.

Participants were presented with a series of dinner party scenarios. In each scene, all agents except for one ‘loafer’ were actively engaged in a task. Participants were asked to evaluate the acceptability of this agent’s social loafing behavior. All of these methods were preregistered prior to data collection at [https://aspredicted.org/8bj9q.pdf](https://aspredicted.org/8bj9q.pdf).

**Participants**

We recruited 300 English-speaking adults from the Prolific platform in exchange for compensation ($2.40 for a 10-12 minute experiment). Fourteen participants who failed an attention check were excluded from subsequent analysis, resulting in a total of 286 participants (87 male, 196 female; mean age = 38.8, SD = 13.1). The experiment was performed with IRB approval (IRB #15959); all participants provided informed consent prior to the experiment.

**Design and Stimuli**

We designed stimuli that varied across two independent dimensions: (1) workload, or the amount of work to be completed, and (2) group size, or the number of agents present in the scene. To ensure robustness, each condition was presented in two distinct kitchen scenarios. In Dish Clean-Up, agents were seated at the table with a number of plates in front of them. Participants were told that the agents needed to carry the plates to the sink, then wash and dry them. In Dish Clean-Up, workload was defined as the number of plates that need to be cleaned. In Salad Preparation, agents were also seated at the table with a number of carrots next to the sink. Participants were told that the agents needed to clean and chop the carrots to add them to the salad bowl. In Salad Preparation, workload was defined as the number of carrots that need to be prepared.

In each stimulus, every agent was depicted with a unique color. The red-colored agent was present in every scene in a fixed position, and this agent was always the loafer, or the guest that remained seated at the table without contributing to the task. Stimuli for this study were generated using Python and the Matplotlib library. We represented a kitchen using a 7×7 grid, and programmatically populated all of the various layouts, objects, and agents in the scene. This approach allowed for a high degree of consistency across scenes.

We manipulated each scenario to reflect low (1 plate/carrot), medium (4 plates/carrots), or high (8 plates/carrots) workload, as well as small (2 agents), medium (4 agents), or large (6 agents) group size. This approach resulted in a total of 18 unique stimuli, or 3 workload levels \(\times\) 3 group sizes \(\times\) 2 kitchen scenarios, in a fully within-participants design. Participants were presented the 18 stimuli in random order. Representative examples of our stimuli are shown in Figure 1.
subtasks due to different bottlenecks. The predicted speed-up that could be achieved if one more agent contributed to the task is given by

\[ S_{time}(p, b) = \frac{1}{(1 - \sum_{i=1}^{n} f(i)) + \sum_{i=1}^{n} \frac{f(i)}{S[p, b_i]}} \]  

(2)

Here, \( n \) is the number of parallelizable subtasks that can be divided amongst agents in each scene. We informed participants that the overall scenarios were composed of different subtasks. We assume that each subtask contributes equally to the overall task, i.e. that the proportion \( f(i) \) is a uniform function of the number of subtasks. For every scene, \( 0 \leq \sum_{i=1}^{n} f(i) \leq 1 \). \( \sum_{i=1}^{n} f(i) = 1 \) if every subtask is parallelizable to some extent. Therefore, \( 1 - \sum_{i=1}^{n} f(i) \) gives us the fraction of the task that cannot be parallelized, or split amongst group members. We assume that Dish Clean-Up and Salad Preparation are composed of two distinct subtasks: Dish Clean-Up involves bringing the plates to the sink and washing them, and Salad Preparation involves washing the carrots and chopping them on a cutting board. These assumptions are considered further in the Discussion section.

For each of the parallelizable subtasks \( i \), \( s(p, b_i) \) estimates the proportional increase in speed that can be achieved by adding the \( p \)th agent given the current number of agents \( p - 1 \) and serial bottlenecks \( b_i \), i.e.

\[ s(p, b_i) = \frac{\min(p, b_i)}{\min(p - 1, b_i)} \]  

(3)

To unpack this function, consider a scenario in which there are five agents but only two sinks, thereby \( p = 5 \) and \( b_i = 2 \). In this case, adding an additional agent to the task will have no impact on task efficiency due to the limited number of workstations that can be used to wash the dishes. Alternatively, if there are five agents and six sinks, i.e. \( p = 5 \) and \( b_i = 6 \), then as long as there is enough work to be done, recruiting another agent to wash the dishes will improve task completion time due to the availability of workstations. In this experiment, \( b_i \) was fixed across the different conditions for each scenario. Since \( s(p, b_i) = 1 \) when adding the \( p \)th agent will lead to no speed-up for a given subtask \( i \), we can equivalently re-write our model in terms of the number of total (parallelizable and serial) subtasks \( m \), or

\[ S_{time}(p, b) = \frac{1}{\sum_{i=1}^{m} \frac{f(i)}{S[p, b_i]}} \]  

(4)

Amdahl’s Law is calculated given a fixed workload \( w \). To compute the impact of a given speed-up on overall task efficiency given different workload levels, we scale speedup \( S_{time}(p, b) \) by \( w \). We consider social loafing acceptability to be inversely proportional to speed-up, or the “slow-down” that occurs when the social loafing agent does not contribute. Therefore, we predict loafing acceptability given speed-up efficiency, or \( y_{speedup}(p, w, b) \) (depicted in Figure 2), to be

\[ y_{speedup}(p, w, b) \propto \frac{1}{w \cdot S_{time}(p, b)} \]  

(5)
Small Group Size, and Low Workload, size levels, a fixed intercept term also included all interactions between workload and group size against the baseline middle level. In particular, interactions between factor levels, workload and group size were predicted continuous judgments of social loafing acceptability. We analyzed our data using a linear mixed-effects model that \( \beta \) load produced a significant decrease in acceptability judgments compared to the baseline of medium workload (\( \beta = -1.01, SE = 0.11, 95\% CI = [-1.22, -0.80], z = -9.41, p = 0.004 \)). Large group size led to a significant increase in social loafing acceptability, compared to the medium group size (\( \beta_{2.1} = 0.57, SE = 0.11, 95\% CI = [0.36, 0.78], z = 5.32, p < 0.001 \)). These results suggest that as group size increases, social loafing is also considered to be more acceptable. None of the estimates for the fixed effects of the interactions between workload and group size levels were significant: (1) low workload and small group (\( \beta = -1.2, SE = 0.15, 95\% CI = [-0.18, 0.42], z = 0.78, p = 0.439 \)), (2) low workload and large group (\( \beta, SE = 0.15, 95\% CI = [0.11, -0.54], z = -1.61, p = 0.106 \)), high workload and small group (\( \beta, SE = 0.15, 95\% CI = [-0.42, 0.18], z = 0.43, p = 0.649 \)), (4) high workload and large group (\( \beta, SE = 0.15, 95\% CI = [-0.18, 0.41], z = 0.76, p = 0.446 \)).

**Discussion**

Social loafing is typically considered to result from group members selfishly withholding effort during collaborations, thereby reducing group productivity. However, division of labor is not guaranteed to improve task completion. Research in distributed computing suggests that scaling the size of a system cannot always enhance performance in cases of insufficient workload and serial dependencies that prevent multiple processors from working on a computation simultaneously. Here, we assess whether people analogously take into account system-level efficiency when evaluating individual agents’ contributions to a group task, and we present a modeling framework inspired by distributed systems to formalize factors that may influence collaborative performance.

**Influence of Task Efficiency on Collaborative Effort**

In order to test whether people are aware of the inherent limitations that a group member’s contribution will have on a collaborative task, we measured the extent to which participants found a loafer’s behavior acceptable across a highly controlled set of stimuli. We found that both workload and group size, but not their interaction, were significant predictors of social loafing acceptability. In particular, participants judged social loafing to be less acceptable for high workloads compared to lower workloads, and for small groups compared to larger groups. It is less acceptable to loaf when there is more work to be completed, and when there are fewer agents to do it. Put together, our results suggest that social loafing may not always be sub-optimal – instead, people consider an individual’s impact on task efficiency when judging whether it is acceptable to withhold effort during collaboration.

**Distributed Systems Model Evaluation**

We also characterize a precise normative framework inspired by expected speed-up in Amdahl’s Law to model how people should withhold effort from a task depending on workload, group size, and environmental constraints. Our findings reveal a correspondence between model predictions and
observed behavior across different conditions. Particularly
notable is the model’s capacity to differentiate between low,
medium, and high workloads, as well as predict the same
general increase in social loafing acceptability as group size
increases. Interestingly, our model also begins to capture the
plateau that occurs with a medium sized group. This plateau
emerges due to the limited number of cutting boards in the
salad preparation scenario, as well as there only being one
sink and one towel in the dish-washing scenario. As group
size exceeds the number of bottlenecks that prevent parallel-
ization in each scene, efficiency improvements reach a sat-
uration point. That is, when there are more group members
than workstations, adding an additional agent will have a di-
minishing impact on the time required to complete the task.
This finding indicates that people are aware of the theoretical
limit to collaborative gains that may exist when environmen-
tal bottlenecks prevent subtask parallelization.

Alternatively, we considered several baseline models that
take into account the amount of work to be completed or nor-
mative social pressures as group size increases. None of these
models qualitatively compare to the trends found in human re-
sponses, suggesting that people base judgments about collabor-
ative contributions on a more complex model of how much
the task could be sped-up if another agent participated.

However, there are several limitations that arise from ap-
plying a distributed systems model to human collaboration.
Basic multiprocessing models lack key aspects of human
group dynamics, such as task allocation ambiguity, commu-
nication overhead, fairness, and social norms. For example,
standard distributed systems are typically not evaluated when
there is only one unit of workload, because it is illogical to
parallelize a single computation across processors. Alterna-
tively, in human responses, there appear to be differences in
perceived acceptability of social loafing even at the smallest
workload level across group sizes. This difference may oc-
cur due to factors like uncertain task allocation. In distributed
systems, there is no ambiguity about which processor will be
assigned to subtasks due to scheduling algorithms (Davis &
Burns, 2011). However, in human groups it is often unclear
who will work on each subtask unless communicated other-
wise. In our data, people may be simulating what will happen
if none of the guests stand up to complete the task, which be-
comes more probable when there are only two agents present
(Kwon et al., 2023). Unlike distributed systems, participants’
judgments may also be influenced by social concerns. It may
be counter-normative to make no attempt to wash the dishes,
even when doing so would have no impact on task efficiency.
This explanation poses a potential challenge in comparing
multiprocessing systems to human behavior. It is important
to consider the influence of social norms, such as whether or
not an invited guest should contribute to a task, as well as the
differences that arise cross-culturally in social loafing accept-
ability (Earley, 1989).

Our model also makes assumptions about the given tasks
and environments that impose limitations to its ecological va-
ligidity. Because we designed stimuli that are static screen-
shots of time-dependent tasks, the model must explicitly as-
sume the relative proportions of overall task time required
to complete each subtask. Our stimuli are highly controlled
“toy” examples of real-world tasks. In order to confirm the
model’s validity, it will be crucial to replicate these findings
using multi-player paradigms in which participants are able
to allocate roles, resources, and subtasks in real time (Shrout
& Rodgers, 2018; Yarkoni, 2022).

Future Directions
Our work provides a starting point for examining collabora-
tive behavior from a multiprocessing perspective. Moving
forward, this work can be extended in at least three ways.
First, distributed systems motivate several new predictions
about how individual contributions affect team performance.
These theories predict that the enhancements achieved via
parallelization are limited by not only workload, but also
serial dependencies in time, memory, or resources that pre-
vent computations from being distributed between proces-
sors. More concretely, changing the number of bottlenecks in
each scene – such as the number of sinks or cutting boards –
should shift the saturation point at which adding more agents
will no longer improve task completion. Future work should
assess how the presence of physical and cognitive bottlenecks
impact the efficiency of collaborative groups and judgments
of social loafing behavior. Second, our framework can be ap-
plied not just to predict third-party judgments, but also to test
how considerations of task efficiency affect participants’ first-
hand effort allocation in real-time collaborations. Third, our
framework can also be extended to capture properties that are
unique to human collaborations as compared to distributed
systems, such as how considerations of task efficiency may
interact with culturally-specific norms about whether a guest
is expected to contribute to household tasks.

Conclusion
Collaboration enables humans to achieve goals that no one
individual could do on their own – however, finding ways to
efficiently combine our efforts is itself a challenge. Here, we
propose that distributed systems provide a rich source of hy-
opotheses about how the structure of collaborative groups im-
pacts performance, and we find that theories inspired by these
systems capture human judgments about when it is accept-
able not to contribute to a collaborative task. Put together,
our work provides the first steps towards understanding hu-
man collaborations as a natural distributed system.

Resources for Reproducibility
The full stimulus set, behavioral dataset, and codebase
can be found at https://github.com/emieczkowski/
SocialLoafingEfficiency.

Acknowledgments
This work was supported by a grant from the Templeton
World Charity Foundation.
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