Play fair: Humans prefer an equal division of labor in a joint multiple object tracking task

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Abstract

In daily life, humans perform tasks in teams, in which the labor division is decided by one individual in the team and not jointly by the team members (e.g., if an employer delegates a task to an employee). In the present study, we tested how the labor is divided if one team member decides the labor division in a joint multiple object tracking (MOT) task. We found that humans preferred to equally split the number of tracked targets in the joint MOT task. When comparing the data with our previous study, in which participants performed the same task with a computer partner, we found that this preference for an equal labor division is specific to interactions with a human but not with a computer partner. Moreover, participants also tended to take into account the tracking difficulty of the delegated targets more with a human compared to a computer partner.

Keywords: Labor division; Collaboration; Cognitive Offloading; Social Cognition; Human-AI collaboration; Human-Computer Interaction

Introduction

In daily life, humans often engage in collaborative tasks (for reviews, see Frith and Frith (2012); Vesper et al. (2017); Sebanz, Bekkering, and Knoblich (2006)). In such tasks, co-actors may divide the task demands to achieve higher performance than when working alone. For example, while searching for a friend in a crowd, one person might look at the left side while the other looks at the right side of the crowd, thereby speeding up the search (for a recent review on joint visual search tasks, see Wahn and Schmitz (2023)). In previous studies on this topic, researchers have investigated interpersonal coordination mechanisms related to how well and quickly dyad members tend to distribute task demands (i.e., form labor division strategies) depending on the received information (S. E. Brennan, Chen, Dickinson, Neider, & Zelinsky, 2008; A. A. Brennan & Enns, 2015; Malcolmson, Reynolds, & Smilek, 2007; Niehorster, Cornelissen, Holmqvist, & Hooge, 2019; Wahn, König, & Kingstone, 2021). Importantly, in these studies coordination strategies emerged from a bidirectional exchange of information between individuals (e.g., by verbally communicating) such that co-actors adapted to each others actions and thus jointly formed a division of labor strategy. In other words, in earlier studies both co-actors were part of the decision process when forming a division of labor strategy. However, other interactions in daily life can be unidirectional in a sense that task demands are delegated by one individual to another individual in order to decide for a labor division. For instance, an employer may assign a task to one of her/his employees while performing another task. In this case the decision solely lies with the employer and the employee simply follows the assignment. Despite the prevalence of these real-life situations, to date, researchers have not investigated how in such circumstances one person decides the labor division for a dyad. The goal of the present study is to address this gap in the literature.

When looking at studies in which labor divisions are jointly formed (i.e., decided by both members in a dyad), researchers thus far found that humans tend to divide the labor equally (Wahn, Czeszumski, Labusch, Kingstone, & König, 2020). That is, for instance, in a joint visual search task, we found that dyad members divide the search space equally such that each member approximately searches the same amount of search space. In line with this are findings in a joint perceptual decision-making task (Mahmoodi et al., 2015), in which researchers found that humans tend to assume an equal skill level in the other member of the dyad (i.e., a so-called "equality bias"), which would again speak in favor of splitting the labor equally in line with the assumed skill level. Collectively, based on these earlier findings on collaborative tasks, we would predict that in cases when a labor division is decided by one individual in the group that one would also decide for an equal division of labor.

However, a recent set of studies (Wahn, Schmitz, Gerster, & Weiss, 2023; Wahn & Schmitz, 2024) in a different research domain referred to as "cognitive offloading" (Risko & Gilbert, 2016; Hertz & Wiese, 2019; Wiese, Weis, Bigman, Kapsaskis, & Gray, 2022), in which participants could decide for a computer partner in a multiple object tracking task (MOT) how many targets participants track on their own and how much a computer program will track, participants did not favor an equal division. In fact, they gave more targets to the computer partner than they tracked on their own. In other words, humans preferred to do less work when they were in charge of deciding how the labor should be split. However, it is important to note that here the labor division was decided when interacting with a computer partner and it is an open question how humans would offload targets (i.e., split the labor) with a human partner. Thus, based on earlier findings on cognitive offloading, we would predict that in cases when a labor division is decided by one individual in the group that one would also decide for an unequal division of labor.

Taken together, our research question is how do humans

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decide for a labor division in a joint task (i.e., a MOT task) if the labor devision is decided by one individual in a dyad? Based on earlier findings on human-human collaborations (Wahn et al., 2020; Mahmoodi et al., 2015) and cognitive offloading (Wahn et al., 2023; Wahn & Schmitz, 2024), two opposing predictions can be formulated. On the one hand, if preferences from a jointly formed division of labor strategy translate to a context when only one person is in charge of deciding the labor division, then humans should also decide for an equal labor division when only one person is in charge of the decision process (Wahn et al., 2020; Mahmoodi et al., 2015). Conversely, if humans generally do prefer to do less work when they are in charge of deciding the labor division as in studies on cognitive offloading (Wahn et al., 2023; Wahn & Schmitz, 2024), then humans should decide to offload more targets to another human than they track on their own.

To resolve which of these two opposing predictions is true, we ran the same experiment as in our previous studies on cognitive offloading (Wahn et al., 2023; Wahn & Schmitz, 2024) but this time humans offloaded targets not to a computer but to a human partner in a MOT task. In addition, we compared the data in the present study with data from our previous study (Wahn et al., 2023), which had an identical experimental setup. With this analysis we aim to assess whether the tendency to divide the labor equally is specific to human partners or also extends to computer partners.

Materials and methods

Participants

26 participants took part in our study (*M* = 24.23 years, *SD* = 4.44 years, 20 female, 6 male). We matched our sample size our previous studies on cognitive offloading (Wahn et al., 2023; Wahn & Schmitz, 2024). Moreover, we ran a Power analysis using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) and found the chosen sample size to be sufficient to find medium-sized effects for within-subjects comparisons (Cohen's $d = 0.58$, Power = 0.80; alpha = 0.05, two-sided paired samples t-test) and large effects for between-subjects comparisons (Cohen's $d = 0.80$, Power = 0.80; alpha = 0.05, two-sided two-sample t-test). Participants provided their informed consent before the experiment and were paid 10 EUR as compensation. The study was approved by the ethics committee of the Institute of Philosophy and Educational Research at Ruhr University Bochum (EPE-2023–003).

Experimental setup and procedure

The experimental procedure was the same as in our earlier study on cognitive offloading (Wahn et al., 2023) with the only difference that participants were instructed that they were interacting with a human partner. The alleged human partner was a confederate, which participants briefly met before participating in the experiment. The participant was then made to believe that the confederate and she/he were seated in separate rooms. Once the participant was seated in her/his room, the confederate would actually leave the lab. In the following, for all conditions of the experiment, the experimenter would first instruct the participant about the experimental procedure and then would ask the participant to wait a few minutes as she would leave the room to instruct the alleged human partner in the other room. The experimenter would then wait several minutes outside of the room and return to the participant to inform that the alleged human partner is now instructed as well and that she/he can start the experiment. In the experiment room, participants sat in front of a 24" computer screen (refresh rate: 60 Hz, resolution: 1920 x 1080) at a distance of 90 cm and had a keyboard and mouse within easy reach. The experiment consisted of a Solo condition, in which the MOT task was performed alone and in a Joint condition, in which participants had the option to offload (part of) the MOT task to a human partner. The Solo condition was always performed first as we wanted that participants first learn about their own tracking capacity (i.e., how many targets they can track successfully) before making decisions about how many targets are offloaded to the human partner. Before starting the Solo condition, the task procedure was explained by the experimenter and participants were instructed to perform two training trials to become familiar with the procedure. Before starting the joint condition, another two trials were performed. The experiment encompassed 75 trials out of which 25 trials were Solo condition trials and 50 trials were Joint condition trials.

Solo condition A trial (for an exemplary trial sequence, see 1, top row) started with 19 stationary objects (circles) displayed on the screen. Six randomly selected objects were highlighted in white, which were the "targets" whereas the remaining 13 objects were the "distractors" and were colored in grey. Participants were instructed to select those targets (i.e., between 0-6) that they intended to track in a given trial by clicking on the targets via a mouse and confirming their choice by clicking on a dot in the center of the screen. Once the participant's selection was entered, the targets switched their color to grey such that all objects (targets and distractors) looked the same. Then, all objects moved across the screen in random directions and repelled each other as well as the screen border in a physically plausible manner (i.e., angle of incidence equaled angle of reflection). After 11 seconds, objects stopped moving and participants were required to select those objects with the computer mouse that they selected in the beginning of a trial. Participants confirmed their selection by clicking on the dot in the center of the screen, which ended a trial. Participants were instructed to identify as many targets as possible without making mistakes and that they earned one point for each correctly identified target and lost one point for each incorrectly identified target.

Joint condition The experimental procedure was the same as for the Solo condition with the only difference that participants were now instructed that targets that they did not select at the beginning of a trial would be offloaded to the alleged human partner sitting in the other room. Thus, partici-

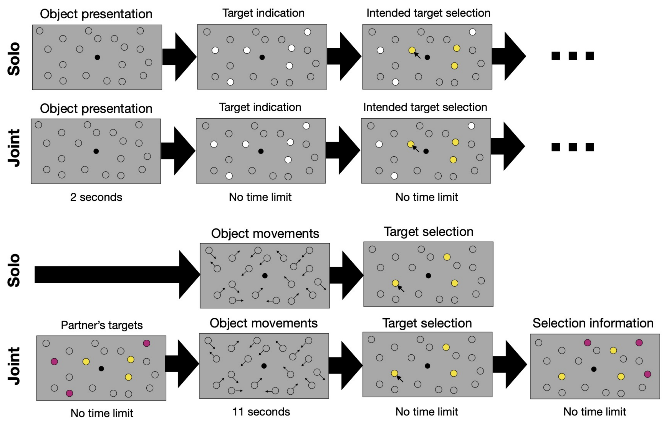

Figure 1: 1st and 3rd row: Example trial for the Solo condition. 2nd and 4fth row: Example trial for the Joint condition when participants chose to offload a subset of targets to the human partner.

pants had the option to offload as many targets as they wanted to their human partner. Moreover, prior to starting the joint condition, we showed to participants a fake message on the computer screen that a network connection between the participant's and the partner's computer is now established. The trial sequence started in the same way as the Solo condition: Participants first selected the targets they intended to track and confirmed their choice. Then, participants would see that the remaining targets were highlighted in violet, indicating that these targets had been offloaded to the human partner. For instance, if a participant chose three out of the six targets, the remaining three targets were automatically offloaded to the human partner. Then targets and distractors would revert to looking identical and start moving across the screen in randomly chosen directions. After 11 seconds, the objects came to a halt and participants were required to click on those targets, which they indicated at the beginning of the trial. After participants confirmed their choice, the selections of the alleged human partner were shown in violet. For the selections of the alleged human partner, we programmed a realistic delay (2.2 seconds per target selection) based on the averaged selection times our previous study (Wahn et al., 2023). For instance, if a participant selected two targets and would have taken about 5 seconds, the alleged human partner would take 8.8 seconds to select four targets. So the participant would need to wait 3.8 seconds for the alleged human partner to finish the selections. Participants would then confirm with the space bar that they have seen the selections by the alleged human partner, which ended a trial. For an exemplary trial sequence. please see Figure 1 (2nd row).

The alleged human partner was programmed to have an accuracy of 100% to ensure comparability to our previous study with a computer partner (Wahn et al., 2023), which had a 100% accuracy as well. This perfect accuracy may appear unrealistic at first but the accuracy data from our previous studies (Wahn et al., 2023; Wahn & Schmitz, 2024) indicate that participants almost obtained a perfect accuracy for their selections in the joint condition (97%).

Participants were instructed that the goal for the joint condition was to identify as many targets as possible without making errors. As for the Solo condition, participants would earn for each correctly identified target one point and lose one point for each incorrect selection. The same rule applied to the human partner's selections. The total score thus consisted of the participant's own and the human partner's points.

After participants completed both conditions, participants were asked in a questionnaire how they decided how many targets to track themselves and how many targets to "offload" to the human partner. Also, participants were asked to indicate how many targets they believed the human partner could track accurately (on a scale from "0 targets" to "more than 6 targets").

After participants completed all questions in the questionnaire, the experimenter debriefed the participants about the belief manipulation (i.e., that the human partner was a confederate) and asked them whether they believed the manipulation or not. The experimenter would then document their answers, which were classified in three categories (yes / doubts / no). Participants in the "doubts" category would express that they first believed that they interacted with a human partner but then had doubts whether this was a belief manipulation or not. Please note, if a participant expressed doubts and clearly stated she/he did not believe the manipulation, she/he was classified as a "no" response.

We programmed the experiments in Python 3.0 with the pygame library. Participants took about 60 minutes to complete the experiment and the questionnaires. We performed all analyses in R using customized R scripts.

Results

We first verified whether our belief manipulation worked. We found that 19 believed that they interacted with the alleged human partner, 5 had doubts, and 2 did not believe it. We excluded the latter 2 participants from our analysis. Importantly, note that the pattern of results for the following analyses would be the same if we would have also excluded the 5 participants who did not believe the manipulation fully. However, to have a comparable sample size for our analysis later on, in which we compare the present data with the data from our previous study with a computer partner (Wahn et al., 2023), we chose this inclusion criterion.

We first addressed the question whether humans are willing to offload part of their tracking load to another human by comparing the number of tracked targets between the Solo and Joint conditions (for a descriptive overview, see Figure 2, upper panel). We found this to be the case ($t(23) = 3.19$, $p = .004$, Cohen's $d = 0.65$). We next tested whether this decrease in tracking load would also improve the participants' tracking accuracy and found this to be the case as well ($t(23) = 2.99$, $p = .006$, Cohen's $d = 0.61$; see Figure 2 lower panel, for a descriptive overview).

To gain a better understanding of participants' motivations for offloading targets to their human partner, we looked at how participants would describe in the questionnaire how they decided how many targets to track themselves and how many targets to "offload" to the human partner. The majority of participants would describe that they intended to divide the labor equally out of a sense of fairness (75%, 18/24). In short, participants benefited from offloading targets in their tracking accuracy and preferred a fair split of the labor.

Next, we addressed how humans' offloading behavior for a human partner would compare to the offloading behavior for an artificial partner. For this purpose, we took data from an Experiment (N = 26) from our earlier study (Wahn et al., 2023), which was identical to our experiment but performed with a computer partner instead of a human partner (see Figure 3, for a descriptive overview). Also note, the experiment from our earlier study was ran by the same experimenter, with exactly the same experimental setup and equipment, and the demographics of participants are similar to the present study (M = 25.82 years, SD = 4.30 years, 11 female, 15 male).

We ran a 2x2 linear mixed model with the within-subjects factor Condition (Solo, Joint) and between-subjects factor Experiments (Human partner, Computer partner). Moreover, we added random intercepts and random slopes for the factor Condition to the model.

We found a significant main effect of Condition ($t = 4.71$, $p < .001$) and a trend towards a significant interaction effect (t = 1.83, p = .074). The latter trend towards an interaction effect suggests that the offloading extent is larger when interacting with a computer partner compared to with a human partner (see Figure 3, for a descriptive overview). However, given we only find a trend towards significance, we only interpret this effect with caution later on.

Next, we compared how participants rated the tracking capacity of the human compared to the computer partner (for a descriptive overview, see Figure 4). We found that the tracking abilities of human partners were rated lower compared to computer partners as indicated by a significant Chi-Square test ($\chi^2(5) = 22.39$, $p < .001$). That is, the majority of human partners were rated to have a tracking capacity of four targets where the majority of computer partners was rated to have a tracking capacity of more than 6. Importantly, in both Experiments the actual tracking capacity of the partner was a 100%. These findings suggest that participants offloaded targets to the human partner in line with their rated tracking capacity of that partner whereas this was not the case for the computer partner.

Finally, we tested whether the participants' disposition towards fairness when interacting with a human partner not only applies to an equal division of targets but also is reflected in which targets participants choose to offload to a human compared to a computer partner. That is, do humans take into account the tracking difficulty of offloaded targets when interacting with a human compared to a computer partner? In our

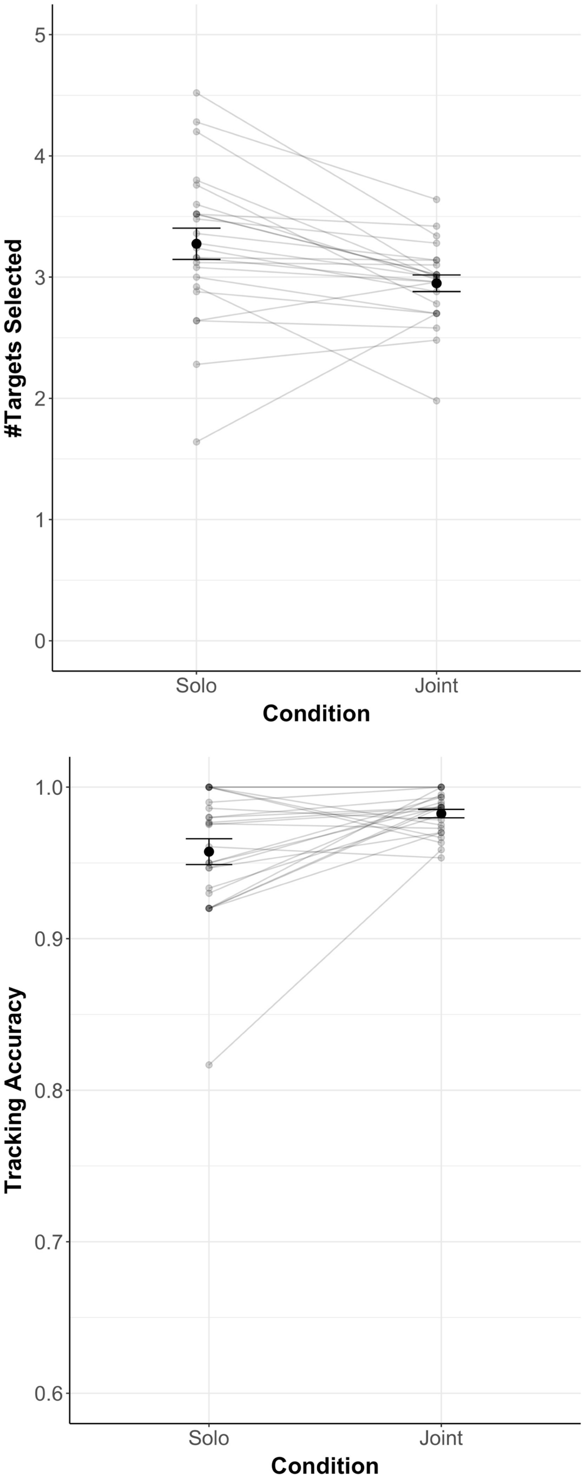

Figure 2: Upper panel: The average number of targets participants chose are displayed as a function of condition (Solo vs. Joint). Lower panel: The accuracy participants obtained with their target selections as a function of condition (Solo vs. Joint). Error bars show Standard Error of the Mean. Lighter gray dots and lines show individual participants.

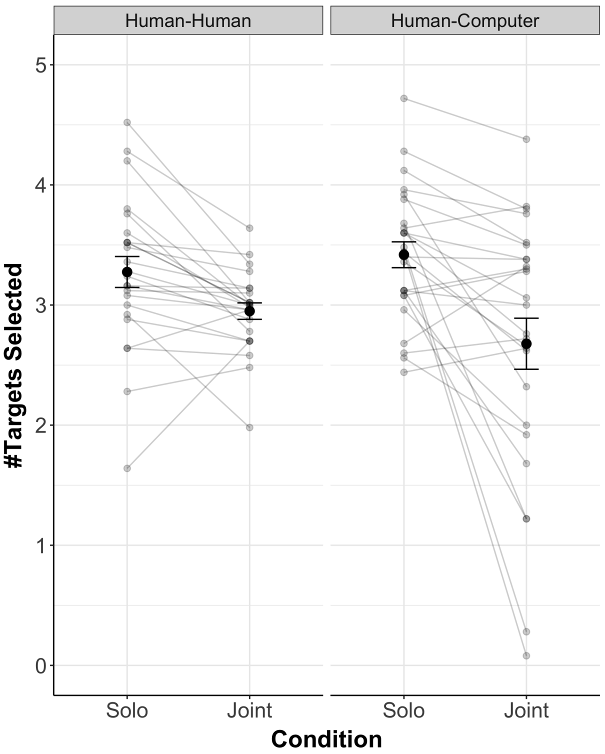

Figure 3: The average number of targets participants chose are displayed as a function of condition (Solo vs. Joint), separately the present study (human partner) and our previous study (Wahn et al. (2023); computer partner). Errors bars show Standard Error of the Mean. Lighter gray dots and lines show individual participants.

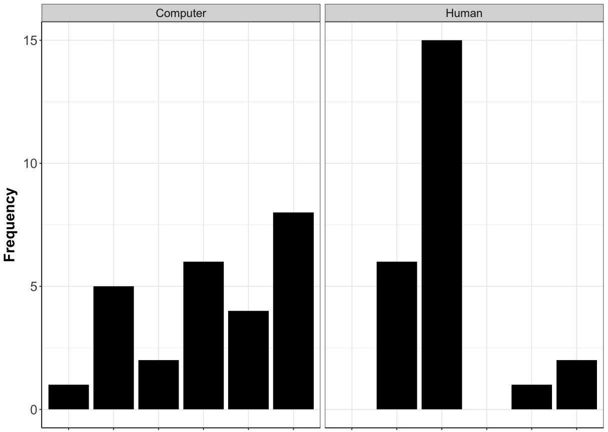

Figure 4: Frequency of rated capacity for a computer partner (left panel; from our earlier study (Wahn et al., 2023)) and a human partner (right panel, present study)

earlier study (Wahn et al., 2023), it was reported that humans tend to select targets, which are close together as they are considered easier to track. The question we want to address now is whether humans also offload targets which are easier to track (i.e., are close together) to their human partner compared to a computer partner? For this purpose, we calculated a measure that quantifies how close the set of targets for each co-actor are. In particular, we extracted the two sets of coordinates of the starting positions of the selected and offloaded targets for each trial. To quantify the closeness of each set of targets, we then calculated all pairwise euclidean distances separately for each set, averaged the euclidean distances for the trial, and then across all trials for each participant, separately for each condition (Solo vs. Joint; see Figure 5, for a descriptive overview).

With this dependent measure, we ran a linear mixed model with the between-subjects factor Partner (Human, Computer) and Targets (Participant, Partner). We included random intercepts and slopes for each participant. We found a significant main effect of Targets ($t = 8.27$, $p < .001$) and a significant interaction effect ($t = 2.57$, $p = .013$). The main effect of Partner was not significant ($t = 0.39$, $p = .701$). The significant interaction effect suggests that participants did offload targets to a human partner that are easier to track compared to offloading targets to a computer partner. That is, participants not only have a tendency for a fair/equal division but also take into account the difficulty of the offloaded targets when delegating them to the human partner.

Discussion

In the present study, we investigated how humans decide for a labor division in a joint task (i.e., a MOT task) if the labor devision is decided by one individual in a dyad. We had two opposing predictions. On the one hand, previous research on collaborative tasks would predict an equal labor division (Mahmoodi et al., 2015; Wahn et al., 2020). On the other hand, previous research on cognitive offloading (to a computer partner) would predict an unequal labor division (Wahn et al., 2023; Wahn & Schmitz, 2024). We found that humans decided for an equal labor division in line with earlier findings from collaborative tasks (Mahmoodi et al., 2015; Wahn et al., 2020). That is, they preferred to evenly split the tracked targets in a MOT task. In addition, when comparing the data from the present study with our previous study (Wahn et al., 2023), in which participants performed the MOT task with a computer partner, we found that this preference for an equal labor division is specific to interactions with a human but not with a computer partner. Also, we found that humans rated the tracking capacity (i.e., how many targets can be tracked in a MOT task) of a computer partner significantly higher than of a human partner. These findings suggest that participants offloaded targets to the human partner in line with their rated tracking capacity of that partner whereas this was not the case for the computer partner. Finally, participants also tended to take into account the tracking difficulty of tracking targets when offloading them to another human. That is, we know from our earlier study (Wahn et al., 2023) that humans perceive targets which are closer together as easier to track and

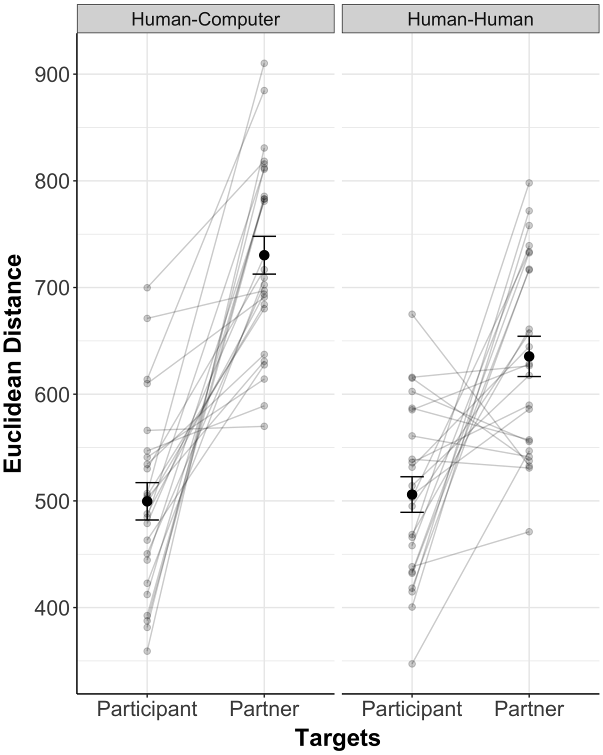

Figure 5: Euclidean distance (in pixel) between target selections of the participant and the offloaded targets to the partner, separately for a computer partner (left panel, experiment from our earlier study (Wahn et al., 2023) and a human partner (right panel; present study).

we found in the present study that participants chose to offload targets to a human partner that are closer together (and thus easier to track) than for a computer partner. Taken together, our research extends earlier findings both on collaboration (Mahmoodi et al., 2015; Wahn et al., 2020) as well as cognitive offloading (Wahn et al., 2023; Wahn & Schmitz, 2024) as we show that humans tend to prefer an equal fair labor division when delegating task demands to another human (but not for a computer partner) and also take into account the difficulty of the task demands when offloading them to a human.

Future studies could further investigate whether this tendency towards an equal division is modulated by the relationship between the members of the dyad. For instance, differences in the social status may lead to differences in allocated workload across co-actors. That is, for instance, members of a lower status may delegate less workload to members of a higher status than to themselves. Likewise, an employer-employee relationship could also modulate the allocated workload with employees delegating less workload to their employer. Moreover, if skill differences between co-actors are made more apparent (e.g., by showing an accuracy score), labor divisions may also be chosen more in line with the co-actors' skills rather than splitting the labor equally. The abovementioned asymmetries between co-actors may also lead to differences in allocated workload depending on who is charge of deciding the labor division. Taking a different tack, studies could also explore triadic scenarios where one person decides the labor division for members of a dyad. That is, a third person may either also adhere to splitting the labor fairly for the members of a dyad or alternatively may take into account other factors such as interindividual skill differences and decide for a skill-dependent labor division. In the long run, studies could map out the different factors that influence whether humans divide the labor fairly among co-actors in a dyad.

Considering human-computer interactions, future studies could further explore if making an artificial agent more human-like (Müller, Chen, Nijssen, & Kühn, 2018; Nijssen, Müller, Baaren, & Paulus, 2019; Stenzel et al., 2012) could lead to a more fair behavior towards that agent regarding splitting work load. On the one hand, treating an artificial agent more fairly could have the benefit of preventing overusing artificial agents such as robots, potentially preventing damage. On the other hand, humans may then not take advantage of the potentially higher processing capacities of an artificial agent and do more work than they actually need to do. Already in our results, we do find that humans do not take advantage of the higher processing capacities of the computer partner even though they rated it to have a high tracking capacity. These findings connect with the literature in human factors on disuse (i.e., the underutilization of automation Parasuraman and Riley (1997)). In our recent study, it was found that this disuse can be circumvented if participants are given the option to perform another task when they offload all targets to a computer partner (Wahn & Schmitz, 2024).

Considering shortcomings in our study, we want to point out that present conclusions are of course limited to the MOT task we tested. Future studies could thus investigate other tasks, potentially more closely related to real-life scenarios, to assess to what extent conclusions generalize across tasks and to real-life scenarios. In the present study, we chose the MOT task as it does allow for a careful control and straightforward division of the task demands and because it builds on our earlier research on cognitive offloading (Wahn et al., 2023; Wahn & Schmitz, 2024).

In conclusion, the present study extends earlier findings on collaboration and cognitive offloading by showing that humans split the labor equally when delegating task demands to another human. Moreover, compared to delegating task demands to a computer partner, we show that humans also take into account the difficulty of the task demands more if they are delegated to another human.

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