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STUDY PROTOCOL

What inclines us towards collective decisions

[version 1; peer review: 2 approved with reservations]

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Abstract

Collective decisions are ubiquitous, but so is the drive for autonomy. What makes people choose one over the other? Previous literature mainly contrasts how people take decisions when they are in groups or on their own, leaving it open when and why they would opt for either in the first place. To tackle this question, we will ask participants to make perceptual decisions and subsequently to choose whether they wanted their rewards or losses to depend only on their decision or to have their decision pooled with those of other participants. First, we will examine whether the preference for collective or individual decisions is a trait, and if so, on which individual characteristics it may depend. We will then consider whether being less certain about one's decision and risking a loss makes people more prone to join a group, and if this is reflected in feeling less responsible for the decision outcome.

Keywords

Collective decisions, individual differences, confidence, responsibility, perceptual decision

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Any reports and responses or comments on the article can be found at the end of the article.

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Introduction

Imagine you are faced with a difficult choice such as moving to a new place, quitting your current job, investing in a new hedge funds or getting a neck tattoo. What can make these decisions so difficult is not only the individual responsibility you will bear for the potential consequences, but also the desire to be in control of your choices. Many people would probably not want to flip a coin or let someone else choose for them. Previous studies have shown that people prefer to be autonomous and have control over their decisions and actions from a very early age (Leotti *et al.*, 2010; Murayama *et al.*, 2015; Murayama *et al.*, 2016), even when this autonomy comes with emotional costs (Botti & Lyengar, 2004; Botti & McGill, 2006). Autonomy may look more or less attractive across cultures (Nanakdewa *et al.*, 2021), but accepting to decide with a small group of friends or neighbors seems ubiquitous across times and cultures (Blunden, 2017). While previous studies have compared how people make collective or individual choices by putting them in either situation, we know less about why and when people prefer to join groups or decide alone, when they are given the choice (El Zein *et al.*, 2019a). Collective decisions may result in better decisions when the appropriate conditions are met (Bahrami, 2018). They may also reduce the stress and burden of individual responsibility, especially when faced with possible losses. Empirical evidence here confirmed that, during risky decisions, people's feelings of regret and responsibility encourage them to turn to collective decisions (El Zein & Bahrami, 2020). But what explains the variability in such choices?

A first explanation would be that humans have different stable inclinations towards collective or individual decisions depending on how much they value social bonding over their personal control. A second prudential explanation could, particularly for those with no or weak fixed preference towards collective or individual decisions, have to do with lack of confidence and prospects of facing losses. Here, we assess whether tendencies to decide alone or in groups are stable, and whether personality traits could explain these tendencies. We then examine the impact of two motives on people sometimes deciding alone, and sometimes joining a group: how sure they are that they got things right on their own, and whether they are faced with gains or losses.

To arbitrate between these explanations, we ask participants to first solve a perceptual problem, by telling whether a set of moving dots were moving left or right, knowing that their correct answer would either allow them to win money, or avoid losing money. After entering their response and level of confidence, they can choose either to face the consequences of their individual decisions, or pool their answer with four other people's answers, and let the collective decision determine the outcome. After this, they indicate how much responsibility they feel they add in the outcome. Even though non-interactive, pooled answers are considered as a form of collective decision, similar to voting and choice aggregations, as the final choice reflects the contribution of several individuals constituting a group.

The first aim of the study is to identify whether and which individual differences play a role in the tendency to make a decision alone or as a group. While there is literature on people's behaviour *once* placed in a social context (Bahrami *et al.*, 2010; Bahrami *et al.*, 2012; Koriat, 2012; Kurvers *et al.*, 2016; Mahmoodi *et al.*, 2015; Molleman *et al.*, 2019; Navajas *et al.*, 2018; Prelec *et al.*, 2017), participants are seldom asked whether they prefer to decide alone or as a group. As an exception, one study that did, revealed that humans differ in their preferences: approximately half of the participants prefer to choose either option (alone or group) more than 80% of the time, suggesting a fixed preference, while the other half showed a more flexible behavior (El Zein & Bahrami, 2020). To examine if these preferences are stable, and reflect a dispositional trait of the individual, we will conduct a test-retest study and collect relevant measures to see whether individual traits explain the tendency to be individualistic, collectivistic or flexible (see Figure 1 and Table 1, **Hypothesis 1a–e**). We selected individual measures related to self-assessment on one hand: self-efficacy (Schwarzer & Jerusalem, 1995) and self-esteem (Rosenberg, 1965); and measures related to social motives on the other hand: social conformity (Mehrabian & Stefl, 1995), closeness to others in the group (Aron *et al.*, 1992) and proneness to reduce responsibility in a group (measured as described in Methods).

Having established how much preferences for collective or individual decisions reflect a personal trait, we examine which contextual factors can make those with no or weak such preferences flexibly choose one or the other (see Figure 1). Here we propose to compare the motive of accuracy to that of sharing responsibility. If flexible individuals accept collective decisions because they can improve their accuracy, they should do so when they realize their own decision could be wrong. In the absence of immediate feedback—which is the case in many real-life decisions—how one assesses their own accuracy can be measured by trial-by-trial confidence ratings (Fleming *et al.*, 2012). Thus, we predict that in socially flexible individuals, low confidence should be associated with increased decisions to join a group (**Hypothesis 2**). Importantly, this strategy would highlight another "social" component of metacognition (Shea *et al.*, 2014), as people with better insight in the reliability of their own decisions could be more strategic in deciding when joining a group could improve their chances of being right. If individuals are also motivated to join a group to share responsibility when they anticipate a negative outcome (El Zein *et al.*, 2019a; El Zein *et al.*, 2019b; El Zein & Bahrami, 2020), they should do so more often when having to avoiding a loss rather than expect a gain (**Hypothesis 3**). This effect may occur through two possible mechanisms: expecting a loss or a gain could *directly* influence the decision to join a group (**Hypothesis 3a**). Yet, as expecting loss or gain changes confidence judgements in perceptual and learning tasks (Lebreton *et al.*, 2018; Lebreton *et al.*, 2019), expected outcomes may *indirectly* influence the decision to join the group, by changing confidence, which in turn will predict subjects' decision to join a group (**Hypothesis 3b**).

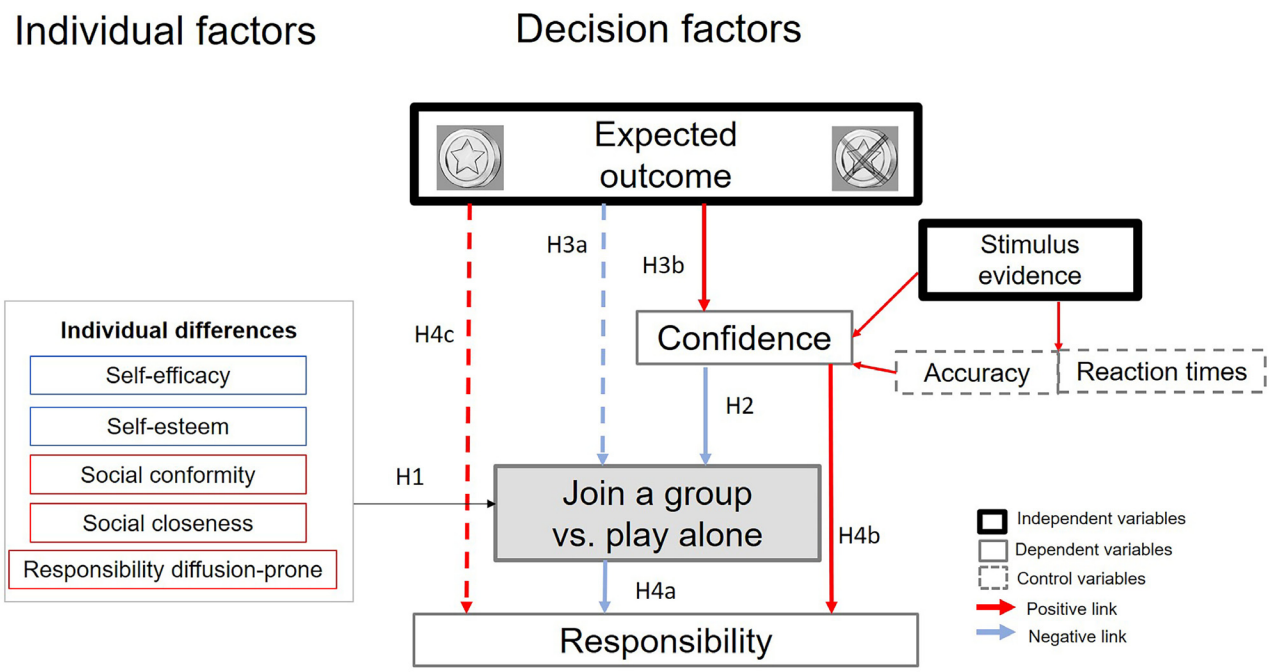


Figure 1. Summary figure of hypotheses showing the predicted influence of individual and decision factors on the choice to play alone or as a group. Arrows indicate the directions of relationships with the hypotheses that will be tested. Full arrows indicate hypotheses that were validated by the pilot study (H2, H3b, H4a-b) allowing us to calculate the required sample sizes while dotted arrows indicate the hypotheses that were not validated in the pilot study and therefore not used to calculate sample size. Rectangles around individual differences are coloured based on the predicted positive (red) or negative (blue) influence on joining groups. Individual factors refer to between-participant analyses (trait), whereas decision factors refer to contextual/state manipulations.

Finally, we investigate whether the decision to join a group is reflected in changes in responsibility for the decision outcome. We predict that individuals will feel less responsible for outcomes when they are part of a group (Forsyth *et al.*, 2002; Jaquiery & El Zein, 2021; Jaquiery & Zein, 2021), confirming that group decisions allow to reduce reported responsibility over outcomes (El Zein *et al.*, 2019a) (**Hypothesis 4**). Together, the findings of our study will give insight into both personal and contextual influences on the motivation to choose alone or with others.

Methods

Participants will be recruited on the online platform Prolific (www.prolific.co). They will provide informed online consent as described in the 'Ethics and consent' section below. Participants will do so by clicking on one of the two buttons 'Agree' or 'Disagree' after reading the consent form. Participants will be rewarded GBP 4 for their participation. They can earn up to GBP 2 as a bonus payment (see 'Incentive and structure bonus' below).

Design

Perceptual task. We will rely on perceptual decision-making as a model system, for which the decision formation process and confidence have been precisely characterized. Specifically, we will use a random dot kinematogram (RDK) task that has been adapted for online experiments (Rajananda *et al.*, 2018). The RDK will be presented for 700 milliseconds. Following this, participants will be asked to estimate the direction of the dots (left or right) and their confidence in their response, on a rating scale going from 100% sure left to 100% sure right. This scale allows to simultaneously record the perceptual decision and confidence. Participants will have to move the cursor away from the middle and therefore necessarily make a left/right choice in addition to their confidence. The choice is considered 'Left' if they move to any place on the scale on the left and considered 'Right' if they move to any place on the scale on the right. These choices (independently of confidence) are used to calculate the percentage of correct responses. A 1-up 2-down staircase procedure with equal step size will be used to adjust accuracy across participants (expected range of performance: around 70% correct) (García-Pérez, 1998). Participants will start with a training of 24 trials in which they will only perform the RDK judgements, for initializing the staircase procedure. Across these 24 trials, the steps of the staircase will decrease progressively. The step of the staircase will then be kept constant during the 64 trials of the experiment.

Trial and block structure. The experiment is a within-subject design. Data collection and analysis will not be performed blind to the conditions of the experiments. In a

Table 1. Design table.

Question	Hypothesis	Sampling plan (*e.g.* power analysis)	Analysis plan	Interpretation given to different outcomes
Which individual trait differences explain the tendency to decide alone or as a group?	H1a The higher reported self-efficacy, the less joining groups.	Between 525 and 640 participants included based on exclusion criteria	GLM with all individual measures as predictors of the proportion to join the group in each participant.	If significant negative parameter estimate, then high self-efficacy trait is associated with the tendency to decide alone and lower group joining.
	H1b The higher reported self-esteem, the less joining group.			If significant negative parameter estimate, then high self-esteem trait is associated with the tendency to decide alone and lower group joining.
	H1c The higher reported social conformity, the more joining groups.			If significant positive parameter estimate, then high social conformity trait is associated with the tendency to join a group.
	H1d The higher fusion with other participants, the more joining groups.			If significant positive parameter estimate, then fusion with group members is associated with the tendency to join a group.
	H1e The more responsibility dilution prone, the more joining groups.			If significant positive parameter estimate, then dilution proneness is associated with more group joining, showing that reducing responsibility may be an important motive to join the group.
What predicts deciding alone or joining the group on a trial by trial basis?	H2 The lower people's decision confidence in the perceptual task (dissociated from their accuracy, decision evidence and reaction times), the more often they will join a group.	Power analysis based on pilot: 72 participants required to achieve 99% power	1) Logistic regression within each participant: outcome=join a group, predictors= expected outcome and confidence rating, control predictors: Accuracy, dots coherence and reaction times. 2) For H3b, GLM within each participant: outcome=confidence, predictor=expected outcome, control predictors: Accuracy, dots coherence and reaction times.	Significant mean negative parameter estimates of confidence variable against zero would indicate that the higher confidence, the more deciding alone and the lower confidence the more joining groups.
	H3 A loss vs a win expected outcome will lead people to join groups more often: - H3a: Directly influencing the decision to join a group. - H3b: Indirectly: Negatively valenced context (avoiding a loss) will decrease confidence when compared to positively valenced contexts (Seeking a gain) Decreased confidence will then increase joining groups (H2).	H3a Not confirmed in the pilot study – no sample size calculated. H3b Power analysis based on pilot: 210 participants required to achieve 99% power		Significant mean negative parameter estimates of expected outcome in the first regression against zero would indicate that negative expected outcomes directly increase joining groups independently of confidence. Significant mean positive parameter estimates of expected outcome against zero in the second GLM would indicate that positive expected outcomes increase confidence and negative expected outcomes decrease confidence. Then, low confidence increases joining groups (if H2 validated).
What predicts responsibility ratings on a trial by trial basis?	H4a Joining a group will decrease feelings of responsibility over potential outcomes as compared to deciding alone.	Power analysis based on pilot: 32 participants required to achieve 99% power.	GLM with outcome= responsibility ratings, and predictors=join a group, expected outcome and confidence rating, control predictors= Accuracy, dots coherence and reaction times	Significant mean negative parameter estimates of join a group regressor against zero would indicate that joining a group decreases responsibility ratings.
	H4b The higher the confidence on a specific trial, the higher the responsibility ratings whether playing alone or in group.	Power analysis based on pilot: 31 participants required to achieve 99% power.		Significant mean positive parameter estimates of confidence regressor against zero would indicate that confidence increases responsibility ratings.
	H4c A loss vs a win expected outcome will decrease feelings of responsibility (change in responsibility for the *expectation* –rather than reception - of an outcome) whether playing alone or in group.	Not confirmed in the pilot study – no sample size calculated.		Significant mean positive parameter estimates of expected outcome regressor against zero would indicate that a positive vs negative expected outcome increases responsibility ratings.

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blocked design, participants will either be able to win GBP 1 if they are accurate (expected outcome win) or lose GBP 1 if they are inaccurate (expected outcome loss). There will be two blocks of 16 trials per participant with expectation of win, and 2 blocks of 16 trials with expectation of loss, presented in a random order.

At the beginning of each trial, participants will be shown whether the current trial is a 'win one pound' or 'lose one pound' trial (Figure 2). Participants will then be presented with the RDK and asked to give their left/right response and rate their confidence. Afterwards, participants will have to choose whether to play alone or join a group within five seconds. Finally, they rate how responsible they feel about the outcome of the trial. Participants do not see the outcome of the trial and receive no feedback on their or their group accuracy. The reason why outcomes are withheld is so as not to influence subsequent decisions and isolate an effect of expected outcomes only.

Decision between group and alone. Participants will be explained that if they choose to join the group their response and confidence rating will be pooled with four other previous participants' ratings. Below are the exact instructions that will be given:

'After your confidence estimate about the dots, you will have the choice to join a group.

- If you join the group, your estimate will be pooled with the other group members' estimates. The average of yours and others' responses on the scale will determine the win or loss you receive.

- If you decide to play alone, win or loss will depend on your choice only. It is up to you, whether you decide alone or join a group.

You have 5 seconds to decide if you join or not. If you don't answer in time, you get the most negative outcome (losing in a losing round, and no win in a winning round).'

As described to the participant, in the group conditions, the five individual ratings on the confidence scale will be averaged, and the resulting rating will determine the group response (Left if the average is on the left of the scale, Right if the average is on the right of the scale.)

Expected outcome structure and bonus. Participants will be rewarded GBP 4 for their participation (~25–30 minutes task, ~9.5 GBP/hour). At the beginning of the experiment, they will be told that an additional GBP 1 bonus is at stake. They can lose or double this pound based on their outcome in one randomly selected trial. Below are the instructions they will be shown:

'You will earn 4 pounds for participating in the study. In addition, you will be given a bonus of 1 pound. What happens with this bonus depends on your or your group's performance in the experiment.

In 2 blocks of the experiment, at each round, you can lose your 1 pound bonus and end up with no bonus. In 2 other blocks of the experiment, at each round, you can double that 1 pound bonus and therefore transform your bonus into 2 pounds.

At the end of the experiment, one random round will be picked and your bonus will depend on the accuracy of your or your group's decision. The table shows how it works for the randomly picked round.' (Table 2)

We will indeed reward participants as a function of whether they are correct or incorrect. If a group trial is picked, then we will use the participant's response and the responses

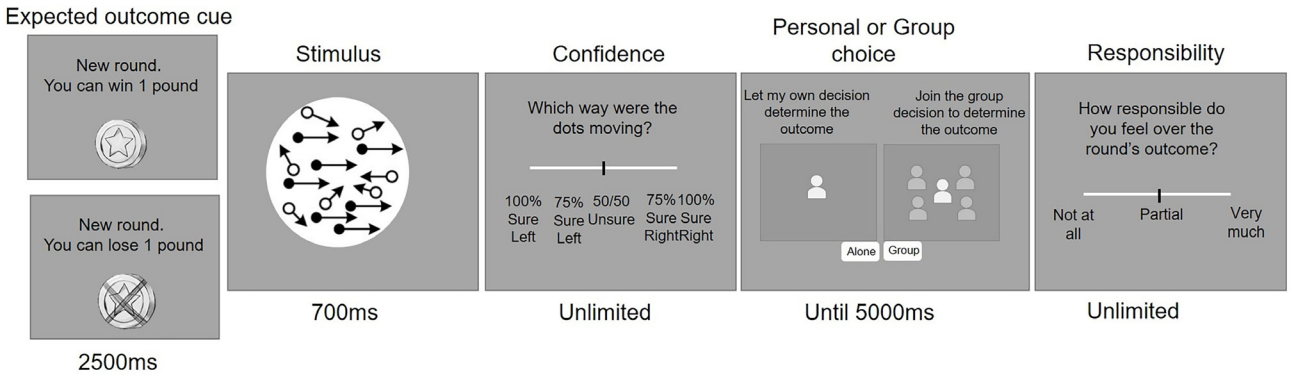


Figure 2. Trial structure. In each trial, participants first see whether they can 'win' or 'lose 1 pound' The expected outcome remains constant during a block. Then, they are shown a perceptual stimulus consisting of a cloud of moving dots among which a proportion of the dots are moving to the right or to the left, and the rest of the dots is moving randomly. Participants are asked to indicate which way they think the dots are moving while also providing their confidence in their response. Next, they choose whether they keep their decision individual or join a group decision for the outcome of the trial. Finally, they rate how responsible they feel for that outcome.

Table 2. Incentive structure table shown to the participants.

	CORRECT (you or your group)	INCORRECT (you or your group)
Win rounds	1 **+ 1** = £2 bonus Total earning = £6	1 **+ 0**= £1 bonus Total earning = £5
Lose rounds	1 **- 0** = £1 bonus Total earning = £5	1 **- 1** = £0 bonus Total earning = £4

of four other participants for the same stimulus (same direction and coherence). No deception is used here since the four other participants' responses will be based on actual collected data.

Self-reported measures for individual differences. At the end of the experiment, participants will have to complete four validated questionnaires.

To measure individual traits related to self-assessment and confidence:

-**Self-efficacy** (Schwarzer & Jerusalem, 1995): 10 items on a four point scale from 'Not at all true' to 'Exactly true' with items like : 'I can always manage to solve difficult problems if I try hard enough' and 'I am confident that I could deal efficiently with unexpected events'

-**Self-esteem** (Rosenberg, 1965): 10 items on a four point scale from 'Strongly Agree' to 'Strongly Disagree' with items like 'On the whole I am satisfied with myself' and 'I feel I have a good number of good qualities'

To measure traits related to social motives:

-**Social conformity** (Mehrabian & Stefl, 1995): 11 items on a nine point scale from 'very strong disagreement' to 'very strong agreement' with items like 'I often rely on, and act upon, the advice of others' and 'Basically, my friends are the ones who decide what we do together'.

-**Social closeness** (Aron *et al.*, 1992): the 'Inclusion of the Other in the Self' scale: participants are shown several pairs of circles, one circle representing them and the other circle representing 'Others' from no overlap to overlap increasing gradually to full overlap between the circles. They are asked to indicate which pair best describes their relationship with the others. The 'others' here will be the 'other prolific participants' with whom they can make the group decision.

We also introduce a new measure: the individual **proneness to dilute responsibility in a group** by asking participants to rate at the beginning of the experiment how responsible they would feel when they make decisions alone or as a part of a group. People more prone to dilute responsibility would indicate that they are more likely to feel reduced responsibility for decision outcomes when they are within a group *versus* on their own.

This is different from the reports of responsibility on a trial-by-trial basis that cannot give a trait-related measure as we predict they will depend on the different contextual factors throughout the task. Instead, we will ask participants how much they expect to feel responsible if deciding alone or deciding in a group in a future hypothetical scenario similar to the perceptual task they are currently doing, which allows us to have an individual measure as to how much they expect to reduce their responsibility as a group if indeed they were deciding in a group. Participants will provide ratings on the same scale as the one used in the experiment from 'not at all' to 'partially' to 'very much' to answer:

1) 'If you make the decision alone, how responsible would you feel for the outcome of that decision?'

2) 'If you make the decision as a part of a group of five with four other participants, how responsible would you feel for the outcome of that decision?'

Dilution proneness is computed by subtracting the rating of the second question to the rating of the first question.

Planned test-retest. In order to test our Hypotheses 1a–e linking specific personality traits with the propensity to decide alone or join groups in our perceptual task, we will aim to test (T1) and re-test (T2) the same participants two weeks following their first participation in our study. Self-efficacy, self-esteem, social conformity and social closeness that are already validated questionnaires will be filled only once at T1. The experimental task consisting of 64 trials will be repeated at T2.

As for the proneness to dilute responsibility trait measure, participants will complete it both at T1 and T2 to assess a test-retest reliability of this measure. At T2, participants will have more information about their performance at the perceptual task as they completed 64 trials of the task at T1, and this may influence their proneness to dilute responsibility at that task. To account for this, we will also take this measure at the end of the experiment at T1 (that will be comparable to the measure at the beginning of T2) and at the end of the experiment at T2 to assess the variability of this measure based on experience in the task.

We will also check whether the dilution-proneness trait measure correlates with participant's actual dilution proneness within the experiment at both T1 and T2. The experiment may thus validate our measure of dilution-proneness as a self-reported trait for future experiments, although testing its reliability across domains will only be possible in future studies using different non-perceptual tasks.

Quality checks

We will verify that participants indeed reach a reasonable level of perceptual performance (>60%), and that the staircase has converged to be able to interpret their data. We will verify that stimulus evidence, confidence, accuracy and reaction times are related to one another other such as the higher the

stimulus evidence, the higher confidence, the higher accuracy and the lower the reaction time (Kiani *et al.*, 2014) (please see Analysis plan for more details).

Pilot data

We have conducted a pilot study including 195 participants from the Prolific platform (El Zein *et al.*, 2023) to assess:

1. How subjects perform on the perceptual RDK in this context: what is the necessary exclusion rate based on low performance or the staircase not converging to the expected performance?

2. What is approximately the proportion of people that would mostly choose to decide alone or mostly join a group, thereby precluding us from analyzing the influence of trial-by-trial predictors such as confidence and the valence of expected outcomes on joining a group?

3. What is the sample size needed to test our hypotheses?

In this pilot, no gradual step for initializing the staircase was done, and the expected outcome (win/loss trials) was framed in terms of 'points' that would be converted into actual money.

The results of the pilot showed that about 18% of participants had an accuracy <60% or >85% correct (El Zein *et al.*, 2023). This consisted of 35/195 participants leaving 160/195 for analyses. In order to reduce this exclusion rate based on performance, we add a training phase of 24 trials for initializing the staircase procedure, where participants will only perform the RDK judgements. This should lead more participants to converge on the expected level of performance and thereby reduce exclusion rate. On the 160 included pilot participants, 56% (89/160) varied their response to play alone or in group less than 20% of the time, suggesting a basic preference in the choice to play alone or in a group that is not influenced by the factors of interest on a trial-by-trial basis such as confidence and expected outcome. These participants, thereafter, 'the socially fixed group' will be kept for testing the individual differences predictions (Hypothesis 1a–e) of these baseline preferences to play alone or in group, because this distribution of preferences replicates previous observations (El Zein & Bahrami, 2020) but not yet linked to self-reported questionnaires.

As for hypotheses 2–4, they will be examined on the 'Socially flexible group', *i.e.*, the remaining 44%. To test Hypotheses 2 and 3, we entered in a logistic regression for each participant expected outcome, confidence, accuracy, RDK coherence and RT as predictors of joining a group (65 instead of 71/160 participants were retained for these analyses as this trial-by-trial model to predict the choice to join a group did not converge for six participants). Then, we tested the individual betas of the predictors (regression coefficients) against zero. Hypothesis 2 was confirmed as confidence significantly negatively predicted joining a group over and above accuracy, reaction times and coherence (T_{64}=-4.15, p=0.0001, effect size d=0.51, mean ß=-1.51, 95%ci= [-2.24, -0.78]). The evidence for Hypothesis 3a predicting that expected outcome will directly influence joining a group was inconclusive (T_{64}=-0.24, p=0.80, effect size d=0.02, mean ß=-0.02, 95%ci= [-0.23, 0.18]). On the contrary, expected outcome had a positive effect on confidence (Hypothesis 3b), while including expected outcome, accuracy, coherence and RT as predictors of confidence (T_{64}=2.42, p=0.0184, effect size d=0.30, mean ß=0.69, 95%ci= [0.12,1.27]). For Hypothesis 4, expected outcome, confidence, accuracy, dot coherence and confidence RT and joining the group were entered as predictor of responsibility ratings. Hypothesis 4a was confirmed as joining the group negatively predicted responsibility, *i.e*, decreased responsibility in a group (T_{64}=-6.38, p=<0.0001, effect size d=0.79, mean ß=-8.54, 95%ci= [-11.21, -5.87]). Hypothesis 4b was confirmed as confidence had a positive influence on responsibility (T_{64}=6.41, p<0.0001, effect size d=0.79, mean ß=4.98, 95%ci= [3.43, 6.53]). Evidence for Hypothesis 4c was inconclusive as there was no effect of expected outcome on responsibility (T_{64}=-0.76, p=0.44, effect size d=0.093, mean ß=-0.36, 95%ci= [-1.31, 0.58).

Sampling plan

We will provide the samples needed for each of our confirmed hypotheses described above based on the pilot data to achieve 99% power (two tailed t-tests) and choose the highest required sample among all hypotheses. For Hypothesis 2, 72 participants are required. For Hypothesis 3b, 210 participants are required for the first path: expected outcome influence on confidence. For Hypothesis 4a, 32 participants and for Hypothesis 4b, 31 participants are required.

The largest sample size required is based on Hypothesis 3 (210 participants). However, this sample size concerns the Socially Flexible group which represented ~40% of the total sample in the pilot study. Therefore, we aim to include 525 participants to achieve a sample of 210 socially flexible participants (40% of 525 would reach the 210 participants in the socially flexible group). We will also take into account the 18% exclusion rate for accuracy, which indicates that we should collect a total of 640 participants. This exclusion rate based on accuracy should be reduced with our new staircase initialization, but we prefer to calculate our sample taking it into account. Moreover, such a large sample will be statistically powerful for investigating for the first time individual differences in the choice to join a group. We will thus aim to recruit 640 participants for the study.

We will use the following exclusion criteria:

-Participants who have an accuracy of <60% or >85% correct, based on previous exclusion criteria (Rouault *et al.*, 2018): since we use a staircase for perceptual performance, participants' performance should converge around 70% and remain about constant throughout the experiment. Therefore, performance in the task beyond the 60% or 85% bounds indicates that the staircase has not worked well (not enough trials to converge for instance).

-Participants who select more than 95% of the time the same confidence rating or the same responsibility rating.

For the re-test at T2, all participants who meet the inclusion criteria at T1 will be re-invited to participate.

For Hypothesis 1, all participants after exclusion are included in the analysis. For Hypotheses 2–4 that concern predicting people's flexible behaviour on a trial-by-trial basis, analyses will be conducted on the socially flexible participants who vary their response to play alone or in group at least 20% of the time.

Analysis plan

We will use Matlab R2020b (open-access alternative: RStudio 2023.03.1) and JASP 0.14.1 to carry out the analyses. We will verify as a positive control and data quality check that stimulus evidence, confidence, accuracy and reaction times are related to one another other such as the higher the stimulus evidence, the higher confidence, the higher accuracy and the lower reaction time, replicating previous perceptual task measuring confidence. A general linear model with confidence as output and stimulus evidence, accuracy and reaction times as regressors will allow us to test the expected directionality of these effects within each participant and at the group level by testing whether the average parameter estimates (regression coefficients) significantly differ from zero using one-sample t-tests.

All our hypotheses will be tested at both T1 and T2, which will allow to evaluate whether the results replicate at the group level.

For hypothesis 1, we will use a general linear model **at the group level** that includes **the proportion joining group of each participant** as an outcome and as regressors all the five measured individual differences variables**: self-efficacy, self-esteem, social conformity, closeness to others in the group and proneness to dilute responsibility in a group**. If the scores of these five measures happen to be too strongly correlated in our sample, we will run separate regressions. The regressors that significantly predict the proportion to join a group ($p<0.05$, negative parameter estimate expected for self-efficacy and self-esteem, positive parameter estimate expected for social conformity, social closeness and dilution proneness) will be considered as relevant individual characteristics explaining who prefers to decide alone or join a group.

For hypotheses 2–4, we will use General Linear Models to estimate **within each participant** how trial to trial contextual factors influence confidence, joining a group and responsibility ratings. **Accuracy, RDK coherence and reaction times** will be included in all the models as control variables to investigate the effects of the other predictors over and above these control variables (see Figure 1). All regressors will be z-scored to ensure comparability of regression coefficients.

We will test significance at the **group level** by testing whether the average parameter estimates (regression coefficients) significantly differ from zero using one-sample t-tests.

For hypothesis 2 and 3, for each participant, we will run a logistic regression with **the decision to decide alone or join the group** as an outcome and **expected outcome** and **confidence rating** (absolute value of confidence regardless of the left or right choice) as regressors.

For hypothesis 3b, we will run an additional general linear model to predict trial by trial **confidence rating** with **expected outcome** as a regressor.

For hypothesis 4, we will run a general linear model with **responsibility ratings** as the outcome and **expected outcome, confidence rating** and the **decision to join the group** as regressors (to capture the effect of the decision to join the group independently of these other task factors but see below our additional planned analyses).

If our hypotheses are inconclusive, we will conduct Bayesian statistics in order to test evidence in favor of the null hypothesis.

To compare the propensity to decide alone or as a group from T1 to T2 within-participants, we will compare this variable at the two timepoints using Pearson correlations. We will also compare the strength of the links between the questionnaires and this propensity from T1 to T2.

Additional planned analyses:

In addition to the influence of joining a group on responsibility, we investigate how trial-by-trial reported responsibility over outcomes is influenced by expected outcomes and confidence through the general linear model described above for Hypothesis 4. Individuals tend to credit themselves with more responsibility after a positive outcome, rather than a negative one, ('the self-serving bias' (Forsyth & Schlenker, 1977; Jaquiery & El Zein, 2021; Jaquiery & Zein, 2021; Leary & Forsyth, 1987; Yoshie & Haggard, 2013). Here, as each trial consists of a potential gain or loss but the actual outcomes are not shown at the end of the trial, we test whether this bias also applies when anticipating a positive *versus* negative outcome, both when deciding alone or as a group (**Hypothesis 4b**). As for the link between confidence and responsibility, we predict higher confidence to be associated with higher responsibility reports both when participants decide alone or as a group (**Hypothesis 4c**); importantly, we will check that this link is specifically with subjective decision confidence and not other task factors that contribute to it such as objective accuracy, response times or decision evidence (Rouault *et al.*, 2019; Sanders *et al.*, 2016).

All raw data and materials of the main experiment will be shared on the OSF repository in case of acceptance of the Stage 2 manuscript. All code used to analyze the main

experiment will be shared on the OSF repository in case of acceptance of the Stage 2 manuscript. The results of the study will be presented in internal lab meetings and international conferences.

Study status

The study has received ethics approval and will only be conducted online after peer-review and publication of the Stage 1 registered report.

Ethics and consent

The research complies with all relevant ethical regulation. The experiment will be conducted online on the Prolific platform (www.prolific.co). Participants will provide informed online consent according to regulations approved by the Max-Planck for Human Development Ethics Committee (project Group Choice A-2022-02). They will do so by clicking on one of the two buttons 'Agree' or 'Disagree' after reading the consent form and the following statements:

- I have read and understood the conditions outlined above, and had the opportunity to clarify open questions.

- I consent to participate in the study and agree to the collection, storage, and use of my data as described in the previous pages.

- I agree to be re-contacted in 2 weeks' time to participate to the second part of the study.

Please say whether you agree or disagree with the 3 above statements:

2 buttons: Agree/Disagree.

For the included pilot study results, participants provided informed online consent according to regulations approved by the UCL Research Ethics Committee (project ID number 5375/001) by checking fours boxes associated with the different consent statements and clicking on a button to proceed:

By checking the boxes below, I agree that:

1) I have carefully read the information page

2) I have been given contact details of the researcher to ask any question or discuss the study.

3) I understand that I am free to withdraw at any time, without giving a reason, and without incurring any penalty.

4) I am over 18 years of age)

1 button: Proceed to study instructions.

Data availability

Underlying data

No data are associated with this article.

Extended data

OSF: Opting for individual or collective choice. https://doi.org/10.17605/OSF.IO/C5BG2 (El Zein *et al.*, 2023).

The project contains the following extended data:

- ACCURESP_ANALYSIS_OSF.m (The code used to analyze the pilot data)
- SUB1156973_GRCHOICE_PROLEXPV3.mat–SUB9988716_GRCHOICE_PROLEXPV3.mat (The pilot data from 198 participants)
- Questionnaires to use.docx (the questionnaires items that will be used)

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

Acknowledgements

We would like to thank Ralf Kurvers for providing feedback on the manuscript.

References

Aron A, Aron EN, Smollan D: **Inclusion of Other in the Self Scale and the structure of interpersonal closeness.** *J Pers Soc Psychol.* 1992; **63**(4): 596–612.
Publisher Full Text

Bahrami B: **Making the most of individual differences in joint decisions.** In: *Metacognitive diversity: An interdisciplinary approach.* Oxford University Press, 2018; 68–79.
Publisher Full Text

Bahrami B, Olsen K, Bang D, *et al.*: **What failure in collective decision-making tells us about metacognition.** *Philos Trans R Soc Lond B Biol Sci.* 2012; **367**(1594): 1350–1365.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Bahrami B, Olsen K, Latham PE, *et al.*: **Optimally Interacting Minds.** *Science.* 2010; **329**(5995): 1081–1085.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Blunden A: **The Origins of Collective Decision Making (2016)**. 2017.
Reference Source

Botti S, Lyengar SS: **The psychological pleasure and pain of choosing: When people prefer choosing at the cost of subsequent outcome satisfaction.** *J Pers Soc Psychol.* 2004; **87**(3): 312–326.
PubMed Abstract | **Publisher Full Text**

Botti S, McGill AL: **When Choosing Is Not Deciding: The Effect of Perceived Responsibility on Satisfaction.** *J Consum Res.* 2006; **33**(2): 211–219.
Publisher Full Text

El Zein M, Bahrami B: **Joining a group diverts regret and responsibility away from the individual.** *Proc Biol Sci.* 2020; **287**(1922): 20192251.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

El Zein M, Bahrami B, Hertwig R: **Shared responsibility in collective decisions.** *Nat Hum Behav.* 2019a; **3**(6): 554–559.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

El Zein M, Rouault M, Deroy O, *et al.*: **Opting for individual or collective choice.** OSF. [Data], 2023.
http://www.doi.org/10.17605/OSF.IO/C5BG2

El Zein M, Seikus C, De-Wit L, *et al.*: **Punishing the individual or the group for norm violation [version 2; peer review: 2 approved].** *Wellcome Open Res.* 2019b; **4**: 139.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Fleming SM, Dolan RJ, Frith CD: **Metacognition: Computation, biology and function.** *Philos Trans R Soc Lond B Biol Sci.* 2012; **367**(1594): 1280–1286.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Forsyth DR, Schlenker BR: **Attributing the causes of group performance: Effects of performance quality, task importance, and future testing.** *J Pers.* 1977; **45**(2): 220–236.
PubMed Abstract | **Publisher Full Text**

Forsyth DR, Zyzniewski LE, Giammanco CA: **Responsibility Diffusion in Cooperative Collectives.** *Pers Soc Psychol Bull.* 2002; **28**(1): 54–65.
Publisher Full Text

García-Pérez MA: **Forced-choice staircases with fixed step sizes: Asymptotic and small-sample properties.** *Vision Res.* 1998; **38**(12): 1861–1881.
PubMed Abstract | **Publisher Full Text**

Jaquiery M, El Zein M: **Stage 1 Registered Report: How responsibility attributions to self and others relate to outcome ownership in group decisions [version 2; peer review: 2 approved].** *Wellcome Open Res.* 2021; **6**: 24.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Jaquiery M, Zein ME: **Stage 2 Registered Report: How responsibility attributions to self and others relate to outcome ownership in group decisions [version 2; peer review: 2 approved].** *Wellcome Open Res.* 2021; **6**: 362.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Kiani R, Corthell L, Shadlen MN: **Choice certainty is informed by both evidence and decision time.** *Neuron.* 2014; **84**(6): 1329–1342.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Koriat A: **When Are Two Heads Better than One and Why?** *Science.* 2012; **336**(6079): 360–362.
PubMed Abstract | **Publisher Full Text**

Kurvers RHJM, Herzog SM, Hertwig R, *et al.*: **Boosting medical diagnostics by pooling independent judgments.** *Proc Natl Acad Sci U S A.* 2016; **113**(31): 8777–8782.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Leary MR, Forsyth DR: **Attributions of responsibility for collective endeavors.** In: *Group processes.* Sage Publications, Inc, 1987; 167–188.
Reference Source

Lebreton M, Bacily K, Palminteri S, *et al.*: **Contextual influence on confidence judgments in human reinforcement learning.** *PLoS Comput Biol.* 2019; **15**(4): e1006973.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Lebreton M, Langdon S, Slieker MJ, *et al.*: **Two sides of the same coin: Monetary incentives concurrently improve and bias confidence judgments.** *Sci Adv.* 2018; **4**(5): eaaq0668.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Leotti LA, Iyengar SS, Ochsner KN: **Born to choose: The origins and value of the need for control.** *Trends Cogn Sci.* 2010; **14**(10): 457–463.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Mahmoodi A, Bang D, Olsen K, *et al.*: **Equality bias impairs collective decision-making across cultures.** *Proc Natl Acad Sci U S A.* 2015; **112**(12): 3835–3840.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Mehrabian A, Stefl CA: **Basic temperament components of loneliness, shyness, and conformity.** *Social Behavior and Personality: An International Journal.* 1995; **23**(3): 253–263.
Publisher Full Text

Molleman L, Kurvers RHJM, van den Bos W: **Unleashing the BEAST: A brief measure of human social information use.** *Evol Hum Behav.* 2019; **40**(5): 492–499.
Publisher Full Text

Murayama K, Izuma K, Aoki R, *et al.*: **"Your Choice" Motivates You in the Brain: The Emergence of Autonomy Neuroscience.** In: *Recent Developments in Neuroscience Research on Human Motivation.* Emerald Group Publishing Limited. 2016; **19**: 95–125.
Publisher Full Text

Murayama K, Matsumoto M, Izuma K, *et al.*: **How Self-Determined Choice Facilitates Performance: A Key Role of the Ventromedial Prefrontal Cortex.** *Cereb Cortex.* 2015; **25**(5): 1241–1251.
PubMed Abstract | **Publisher Full Text**

Nanakdewa K, Madan S, Savani K, *et al.*: **The salience of choice fuels independence: Implications for self-perception, cognition, and behavior.** *Proc Natl Acad Sci U S A.* 2021; **118**(30): e2021727118.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Navajas J, Niella T, Garbulsky G, *et al.*: **Aggregated knowledge from a small number of debates outperforms the wisdom of large crowds.** *Nat Hum Behav.* 2018; **2**: 126–132.
Publisher Full Text

Prelec D, Seung HS, McCoy J: **A solution to the single-question crowd wisdom problem.** *Nature.* 2017; **541**(7638): 532–535.
PubMed Abstract | **Publisher Full Text**

Rajananda S, Lau H, Odegaard B: **A Random-Dot Kinematogram for Web-Based Vision Research.** *J Open Res Softw.* 2018; **6**(1): 6.
Publisher Full Text

Rosenberg M: **Society and the Adolescent Self-Image.** Princeton University Press, 1965.
Reference Source

Rouault M, Dayan P, Fleming SM: **Forming global estimates of self-performance from local confidence.** *Nat Commun.* 2019; **10**(1): 1141.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Rouault M, Seow T, Gillan CM, *et al.*: **Psychiatric Symptom Dimensions Are Associated With Dissociable Shifts in Metacognition but Not Task Performance.** *Biol Psychiatry.* 2018; **84**(6): 443–451.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Sanders JI, Hangya B, Kepecs A: **Signatures of a Statistical Computation in the Human Sense of Confidence.** *Neuron.* 2016; **90**(3): 499–506.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Schwarzer R, Jerusalem M: **Generalized Self-Efficacy scale.** In: *Measures in health psychology: A user's portfolio. Causal and control beliefs.* Windsor, UK: NFER-NELSON. 1995; 35–37.
Reference Source

Shea N, Boldt A, Bang D, *et al.*: **Supra-personal cognitive control and metacognition.** *Trends Cogn Sci.* 2014; **18**(4): 186–193.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Yoshie M, Haggard P: **Negative emotional outcomes attenuate sense of agency over voluntary actions.** *Curr Biol.* 2013; **23**(20): 2028–2032.
PubMed Abstract | **Publisher Full Text**

Open Peer Review

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?

Uri Hertz
University of Haifa, Haifa, Haifa District, Israel

In their study protocol, El-Zein et al. suggest examining how people arbitrate between using wisdom of crowd and relying solely on their own knowledge. They designed an experiment in which participants are required to make perceptual judgements regarding the movement direction of noisy dots configurations and report their confidence level regarding their decisions. They are then asked whether they want the outcome of the trial to be dependent only on their own decision, or on the aggregated confidence reports of their own and four other participants. The authors suggest examining this decision in loss and gain conditions, and to examine how this decision is related to individual traits regarding self-efficacy and responsibility perception, and to responsibility judgments.
The main question is important and interesting, and the experimental design seems appropriate, and the general analysis plan and sample size considerations.
I have a number of technical comments and questions.

1. I do not understand the process of group decisions. Are participants interacting with four other participants all playing together? Are the group opinions generated by some algorithm? Sampled from previous participants responses?
2. How do you account for learning effect during the experiment – people become better at the task over time, and as noise is kept constant it may be that accuracy on later blocks will be higher than in the first trials.
3. You may want to consider other options for manipulations – you currently have loss/gain conditions, but hard/easy conditions seem more natural and in-line with the crowd consulting effect – whether people tend to consult crowds more when the task is difficult. While you include RT and confidence as a measure of uncertainty in the response, making some trials easier or harder than others may lead to stronger effects.
4. Test-retest is a great idea, however it may be that some effects will not reproduce. This can be due to the experience from previous experiment where decisions effect on bonus was limited, fatigue or boredom, and learning effects (are you running the staircase again? Will you account for changes in expertise/RT?). Maybe confound some of the hypotheses for T1 and test some others in both T1 and T2?
5. Individual and group level analyses – I suggest using a hierarchical regression instead of

running second level analysis on individual fit in the second part of the experiment. These analyses tend to be more robust at identifying group-level effects while accounting for individual differences.
6. Some hypotheses seem to indicate a mediation effect (the effect of framing on decision to join a group may be mediated by confidence, for example). Maybe worthwhile considering such analyses to account for dependencies between variables.
7. You may want to consider findings [1] in your introduction.

References

1. Yonah M, Kessler YJ *Cogn*. 2021; **4** (1): 30 PubMed Abstract | Publisher Full Text

Is the rationale for, and objectives of, the study clearly described?

Yes

Is the study design appropriate for the research question?

Yes

Are sufficient details of the methods provided to allow replication by others?

Partly

Are the datasets clearly presented in a useable and accessible format?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Social Decision Making

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 19 September 2023

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?

Niccolo Pescetelli

New Jersey Institute of Technology, Newark, New Jersey, USA

I read with a lot of interest the study protocol “What inclines us towards collective decisions” by El Zein, Rouault, Wurzer, Haggard, and Deroy. The protocol starts from the observation that people value making autonomous decisions but also sharing a decision’s responsibility with a group of

peers. The authors set out a very detailed plan to uncover the effect of personal traits and trial-level variables on people's choices to make decisions alone or as part of a group.

I think the experimental question is an important one. Past research has shed light on the mechanisms behind social learning, advice-taking, and collective decisions, but we still do not understand how people decide when they want to make decisions autonomously or as part of a group. The question is thus novel and worth pursuing.

I have, however, several suggestions that might help the authors refine their approach.

Analysis plan
I am not entirely convinced about the analysis plan. I have listed below some of my concerns and suggestions.

From Table 1:
First regression
1) Logistic regression within each participant: outcome=join a group, predictors= expected outcome and confidence rating, control predictors: Accuracy, dots coherence and reaction times.

Significant mean negative parameter estimates of confidence variable against zero would indicate that the higher confidence, the more deciding alone and the lower confidence the more joining groups.

Significant mean negative parameter estimates of expected outcome in the first regression against zero would indicate that negative expected outcomes directly
increase joining groups independently of confidence.

The authors should explain why they did not include an interaction term between confidence and expected outcome. I suspect that the expected outcome will interact with confidence, given the non-linear relationship between wins/losses' objective value and subjective value. Larger potential losses will induce greater risk aversion and potentially a more conservative decision criterion and lower confidence. Including an interaction term should remove the need to run two separate models as the direct and indirect effect of expected outcome on Joining a group will be now modulated by confidence. Perhaps the authors have a different opinion, but I'd like to see it spelled out more clearly.

In the description of the GLMs (Table 1), I suggest including the baselines (reference level) for all binary variables like Expected outcome and Joining a group. This will add a lot of clarity for the reader.

The authors should better motivate their choice of running separate GLMs for each participant and then run t-tests on the coefficient estimates. In my opinion, a more appropriate approach is to run mixed effect regressions modelling different sources of correlations in the data structure, such as:

(a) individuals are expected to show baseline differences in their propensity to join a group
(b) individual answers are sometimes grouped together.

Instead of running a different GLM for each participant, the authors should consider running a

mixed-effect regression and model:

1. Random effects (e.g. intercepts) for each participant

2. The nested hierarchical structure of the data (with individuals being part of groups)

The second point might be irrelevant here (although it is a better representation of the data) as the group aggregation method is non-interactive, and so one would expect individual responses in a group to be independent. However, introducing the first term (random effects for individuals) is appropriate. Indeed, one would expect trial-level data to be more correlated within an individual than across individuals. Introducing the random effect should help better estimate the coefficients for hypotheses H2+, while taking into account differences in individual baselines. If model complexity is an issue, random effects should at least be used to model trait variability (e.g., a random effect for High self-efficacy vs. Low self-efficacy).

Modeling random effects will also avoid misinterpreting the coefficients for hypotheses H2+. For instance, while self-esteem is predicted by the authors to directly influence Joining a group, it might well be that self-esteem has an indirect effect on joining a group by increasing average confidence. These indirect effects are currently not accounted for in the GLMs described in the proposal. Including random baselines for each subject will account for variability due to trait differences and thus make the trial-level coefficients (H2-4) more accurate.

The authors suggest z-scoring predictors so that coefficients are comparable. Z-scoring should not be applied to binary variables such as Expected outcome, Joining a group or Accuracy. However, there is a case to be made for z-scoring not being applied to continuous variables such as confidence and responsibility ratings either. The reason is that, while the coefficients will be comparable amongst each other, their baselines (intercepts) will be more difficult to interpret. For instance, the baseline in a non-standardised confidence distribution is easily interpreted as the effect observed when the subject is maximally uncertain. The baseline in a standardised confidence distribution corresponds to the effect observed when the subject shows their average confidence. A better approach would be to transform all distributions to the same positive range (e.g. [0,1] or [0:100]). This approach will make coefficients comparable while keeping an interpretable baseline (e.g. zeros corresponding to “no confidence”, and “no responsibility” etc.).

Other considerations

The authors contrast decisions to decide alone vs. as part of a group. When deciding as a group, they particularly stress the importance of “social bonding” and “diffusion of responsibility.” The focus seems to be on social and emotive mechanisms. This is perfectly fine, given the authors’ interest and past work. However, it is worth mentioning (perhaps in the introduction) also cognitive and informational mechanisms that might lead someone to opt for a collective decision. Receiving collective rewards can help the group reach greater collective accuracy when sources of information are correlated across judges (e.g., https://doi.org/10.1073/pnas.1618722114; https://doi.org/10.1371/journal.pcbi.1003762 and https://psyarxiv.com/w6nc5/).

The authors say, “*If individuals are also motivated to join a group to share responsibility when they anticipate a negative outcome (El Zein et al., 2019a; El Zein et al., 2019b; El Zein & Bahrami, 2020), they should do so more often when having to avoiding a loss rather than expect a gain (Hypothesis 3).*” However, they do not explain why participants should do so more often when having to avoid a loss rather than expect a gain. What mechanism or literature do they cite to make this statement?

The authors say the participants will go through 64 trials in 30 minutes and receive 4 GBP (+1 GBP bonus). The stakes are not high enough. The participants' base pay and bonus seem very small, which might attenuate the effects of the Expected outcome and so the chance to detect these effects. Also, the fact that only one round is picked at random (instead of averaging, say five trials) can be perceived by the participants as "just luck" and further reduce people's perceived agency.

The authors suggest keeping the stimulus intensity constant after the first 24 trials. Given that dot coherence is modeled as a control predictor at the trial level, why not continue titrating the perceptual evidence/accuracy throughout the experiment?

Since no feedback is given on a trial level, participants cannot determine the usefulness of joining a group. I strongly believe most people do not possess statistical notions of the wisdom of crowds and other benefits of pooling independent information together. In the absence of trial-level feedback or theoretical understanding, people's choices will reflect their prior beliefs about groups' effectiveness. Although I'd like to think that the traits highlighted by the authors are theoretically important, I am afraid that most people in reality will choose based on their preconceived heuristics about group performance. I advise the authors to measure participants' prior beliefs as part of the individual trait assessment. A simple question about expected group accuracy might suffice to distinguish people who believe in the wisdom of crowds from those who believe in collective stupidity.

A different approach could be used to solve the same issue, namely giving participants aggregate feedback at the end of the block (or every eight trials). This will align all participants on the objective usefulness of joining a group while reducing the trial-level effects of feedback.

Regarding the new measure of dilution of responsibility prone, the authors choose a prospective measure (what would you do in a future hypothetical situation?). These measures can sometimes be less accurate than retrospective measures (what did you do in the past?). For instance, it is common practice in hiring panels to ask "behavioural questions" like "Tell me of a time when you showed leadership" rather than hypothetical questions like "How would you show leadership in situation X?". Similar practices are used in customer interviews when assessing the value of a product or service. Unless the authors have reasons to do otherwise, I suggest rephrasing the question and asking participants to think about the responsibility they felt in the past in a specific or average situation when choosing alone vs. as part of a group.

The Authors say, "*To account for this, we will also take this measure at the end of the experiment at T1 (that will be comparable to the measure at the beginning of T2) and at the end of the experiment at T2 to assess the variability of this measure based on experience in the task*".
I am very confused about the timing of the test-retest schedule. The authors seem to suggest that they will test the Responsibility diffusion-prone measure at the end of the first experiment (T1), at the beginning of the next experiment (T2), and at the end of the second experiment (T3?). I suggest including a figure with the said schedule to avoid confusion.

The authors suggest that H1 will be tested only on Socially fixed participants and H2+ will be tested only on Socially flexible participants. If so, what is the classification criterion for including a participant in a group vs. the other? Isn't it more appropriate to model Socially fixed vs. Socially flexible as a continuum?

In the sentence "*For Hypothesis 4, expected outcome, confidence, accuracy, dot coherence and confidence RT and joining the group were entered as predictor of responsibility ratings.*" what do the authors mean by "confidence RT"? Is this a typo, or do they actually mean the reaction times associated with the confidence judgment? I suspect it is a typo, as the Method section clearly explains that binary judgment and confidence judgment are measured simultaneously on the same scale.

References

1. Mann RP, Helbing D: Optimal incentives for collective intelligence.*Proc Natl Acad Sci U S A*. 2017; **114** (20): 5077-5082 PubMed Abstract | Publisher Full Text
2. Kao AB, Miller N, Torney C, Hartnett A, et al.: Collective learning and optimal consensus decisions in social animal groups.*PLoS Comput Biol*. 2014; **10** (8): e1003762 PubMed Abstract | Publisher Full Text
3. Pescetelli N, Rutherford A, Kao A, Rahwan I: Collective learning in news consumption. 2020. Publisher Full Text

Is the rationale for, and objectives of, the study clearly described?

Yes

Is the study design appropriate for the research question?

Partly

Are sufficient details of the methods provided to allow replication by others?

Yes

Are the datasets clearly presented in a useable and accessible format?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Metacognition, decision-making, collective decisions, psychophysics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.