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Confidence Snowballing and Relative Performance Feedback

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CONFIDENCE SNOWBALLING AND RELATIVE PERFORMANCE FEEDBACK

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Abstract

We investigate whether relative performance feedback can create biases in confidence leading it to 'snowball'. We study elicited confidence about own performance, relative to other group members, in three stages. As subjects move across stages, we change group composition so that new groups contain either only top performers or only bottom performers, from the previous stage. Between treatments, we manipulate whether subjects know about their own past relative performance or that of currently matched group members. In the NoFeedback treatment, they know neither of these things and confidence remains calibrated and stable across the stages. In both of the other two treatments, we provide feedback on own performance and, in both of these treatments, confidence snowballs significantly in the direction of the feedback: confidence consistently rises among top performers and falls among bottom performers. In one of these treatments - the OwnFeedback treatment, which we interpret as inducing full reference group neglect – subjects are not told about how their reference group is changing. In the FullFeedback treatment, however, subjects do have a basis for judging that their own performance feedback is essentially uninformative, yet we still find strong evidence that confidence snowballs and only limited evidence that they are weaker than those arising from full reference group neglect. Hence, the results are broadly consistent with the reference group neglect hypothesis. The results suggest the possibility of confidence biases emerging and snowballing in a potentially wide range of field settings.

Keywords: overconfidence, relative performance feedback, confidence updating

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1 Introduction

An increasing number of studies investigate whether confidence biases can be eliminated with feedback and experience (Ertac, 2011; Grossman & Owens, 2012; Möbius, Niederle, Niehaus, & Rosenblat, 2014; Moore & Cain, 2007; Murad, 2016; Wozniak, Harbaugh, & Mayr, 2014). At the same time, several empirical and theoretical studies have speculated that overconfidence may *originate* from feedback and experience (Billett & Qian, 2008; Daniel, Hirshleifer, & Subrahmanyam, 1997; Daniel & Hirshleifer, 2016; Gervais & Odean, 2001; Hilary & Menzly, 2006). As far as we know, there has been no direct test of whether feedback can generate confidence biases. In this paper, we provide such a test and show that relative performance feedback can lead to the emergence and 'snowballing' of confidence biases in a dynamic setup, where biases are absent to start with.[1]

Our main motivation for studying confidence biases in a dynamic (i.e. multi-stage) setup derives from the existence of a variety of interesting naturalistic contexts, also having a dynamic structure, where confidence formation can play an important role in decisions. The confidence of employees can affect how much effort they exert (Barron & Gravert, 2018; Chen & Schildberg-Hörisch, 2019) and what kind of careers they pursue (Buser, Niederle, & Oosterbeek, 2014; Reuben, Wiswall, & Zafar, 2017). The relative confidence of students can affect their decisions about investment to study at different stages of the academic ladder (Fischer & Sliwka, 2018; Murphy & Weinhardt, 2018). The confidence of athletes progressing through a tournament, or entering consolation tournaments may affect their motivation for and decisions about subsequent training regimes (Rosenqvist & Skans, 2015). In corporate settings, the confidence of CEOs and investors can affect trading, merger and acquisition decisions (Billett & Qian, 2008; Daniel & Hirshleifer, 2016; Hilary & Menzly, 2006).

Studying confidence as a response to performance feedback can be difficult with naturally occurring field data. Confidence beliefs usually cannot be directly observed and may be confounded by factors such as self-selection; the interaction of confidence with effort and risk attitudes; and the effects of previous unobserved experiences. We thus use a controlled lab experiment to study the effects of feedback on confidence. We create an environment where we hypothesize that positive feedback "snowballs" confidence towards overconfidence while negative feedback "snowballs" confidence towards underconfidence. Our environment involves subjects completing a competitive task and reporting their confidence about their

[1] We use the label *snowballing* as a convenient metaphor to capture the idea of something becoming bigger (in absolute terms) as a consequence of some process evolving through time.

success, relative to a reference group of participants, at each of the three stages. Between stages, we manipulate the reference group; whether feedback on relative performance in the previous round is provided; and whether the feedback is only about one's *own* relative performance or also about that of the reference group. Our primary interest is in examining how confidence responds to feedback from one stage to the next. As far as we know, we are the first to test for reference group neglect in a dynamic setup.[2]

The focus of our paper is also novel in testing whether feedback can *cause* confidence biases. To this end, we wished to create an environment with a task where subjects' initial confidence assessments of their own relative performance would be unbiased. For this purpose, we choose the 'Circle task' introduced by Hollard, Massoni, & Vergnaud (2016). In this task, subjects see two black circles, briefly, on a computer screen with a varying number of white dots inside them. When the circles disappear from screens (after just one second of viewing time), subjects are asked to report their judgement of which circle contained more dots. We discuss the task and its properties in more detail later (see Section 2 and Appendix A1). For now, the crucial thing to note is that, as we conjectured and as evidenced by the data we report below, individuals' initial relative confidence assessments (prior to any performance feedback) were, on average, well-calibrated.

In each of the three stages of our experiment, subjects were allocated to groups of four, but these groupings changed at every stage of the experiment, with subjects achieving similar scores at stages one or two being grouped together at the subsequent stages. What subjects knew about this grouping structure varied between treatments. In every stage, subjects were required to complete a set of 20 circle tasks, but before doing the tasks, we elicited - using an incentive compatible tool - each subjects' confidence that their own score would be one of the top two in their group. Across three between-subject treatments, we manipulate the feedback subjects receive between stages. In the *NoFeedback* condition, subjects receive no feedback. In the OwnFeedback condition, we provide subjects with feedback about their own relative performance (whether they were in the top or bottom half of their groups) only. In the FullFeedback condition, we provide feedback both about subjects' own relative performance and about the relative performance of the rest of their new group (i.e. whether new members of their group this round were top half or bottom half performers last round). Given this structure, there is a basis for expecting subjects in the OwnFeedback treatment to update their

[2] The only other paper who changes reference groups subjects compare themselves against is by Berlin & Dargnies, (2016) who mainly focus on gender differences in willingness to complete as a reaction to changing reference groups.

confidence in the direction of the feedback received (upwards after positive feedback, and downwards after negative feedback). In the NoFeedback or FullFeedback treatments, subjects should not update their confidence as either there is no feedback to affect confidence or the feedback is uninformative (since subjects receive symmetric information about their own and their reference group's abilities in the task). In contrast, subjects prone to reference group neglect would update their confidence in the direction of the feedback received on their own performance in the FullFeedback treatment. In the case of full reference group neglect, we would expect behaviour in the OwnFeedback and FullFeedback treatments to coincide.

We find that, in the first stage, subjects are well-calibrated; that is overall we cannot reject the hypotheses that the median subject is 50% confident of scoring in the top half of their group. As subjects receive feedback, both in the FullFeedback and OwnFeedback treatments, confidence moves in the direction of own relative performance feedback. By stage three, this results in significant overconfidence among those who received two consecutive positive feedbacks and in significant underconfidence among those who received two consecutive negative feedbacks. We test whether the observed confidence snowballing after positive and negative feedback is different between OwnFeedback and FullFeedback treatments, i.e. whether subjects account for changing reference groups when updating confidence beliefs. We find little evidence of differences in snowballing tendency between the FullFeedback and OwnFeedback treatments. While we test a range of potential explanations for our results (see Section 3), the main patterns in our data are consistent with some degree of reference group neglect (Camerer & Lovallo, 1999): Subjects react to feedback about their own performance and only partially account for the changes in the reference group they are competing with when they are provided with that information.

2 Experimental Setup

Our experiment features three main treatments designed to test whether we can generate confidence snowballing and if we can, we wish to assess how far any snowballing observed is attributable to reference group neglect. In our environment, individuals complete a task in each of three stages and, in some treatments, we introduce feedback on subjects' own behaviour in the expectation that this may stimulate snowballing. As a benchmark, we include a treatment in which subjects receive no feedback on behaviour at all: in this case, we expect no snowballing. We include two variants of feedback treatments. In both of these treatments, we provide subjects with feedback on their own performance by telling them (truthfully) that their own performance placed them, respectively, in either the top or the bottom half of their group in the previous stage. Between stages, however, we manipulate group composition such that if subjects knew this and fully took account of it, they would realise that the feedback on their own performance should not affect their own confidence. In one of the feedback treatments the subjects are fully informed about the changing group composition; hence, observing snowballing in this treatment is evidence of some degree of reference group neglect. To allow us to assess the extent of reference group neglect, we include a second feedback treatment designed to *induce* full reference group neglect – we do this by not providing information to subjects about the previous stage performance of their new group members. Conditional on finding snowballing, we can test the extent of reference group neglect by comparing the degree of snowballing across the two feedback conditions. Full reference group neglect implies the same degree of snowballing in both treatments.

2.1 The Task

The experimental design consisted of three stages. At each stage, subjects were matched into groups of four and had to complete a set of 20 "Circle tasks". In a single task, an individual subject saw a pair of black circles, on a computer screen, for 1 second. Each circle contained a number of white dots and the subject's task was to judge which of the two circles had the most dots (Hollard et al., 2016). For our purposes, the Circle task has several attractive features. One is that it would not have been familiar to our subjects and, through pre-testing (See Appendix A1 for details), we established that subjects did not accurately predict their performance; importantly for our research objectives, there were no systematic biases in initial confidence beliefs. The pre-test data also showed no evidence of learning across stages, limiting concerns that performance differences between stages might interact with confidence levels. By testing the impact of large variations in piece-rate payments for success in the task, we also established that performance is highly insensitive to incentives. This is important for our purposes in reducing the likelihood that snowballs in confidence could be attributed to perceived changes in incentives, arising across rounds, from variation in own performance feedback across individuals. Finally, performance and confidence in relation to the task were unrelated to gender, risk attitudes and competitive attitudes.

Some previous studies have found the prevalence of overconfidence in easy and underconfidence in difficult tasks and varying reactions to feedback both in static and dynamic contexts (Hoelzl & Rustichini, 2005; Moore & Cain, 2007; Murad, 2016). With this in mind, in the main experiment, we manipulated task difficulty between-subjects: a Difficult treatment had circles with 50&51 dots and an Easy treatment had circles with 50&70 dots (see Fig 1).

At the start of the experiment, subjects read instructions then practised one set of 20 Circle tasks (with the same difficulty level as their incentivised tasks). The purpose of the practice set was to familiarise subjects with the task before eliciting Stage 1 confidence. No performance feedback was given to subjects for the practice set to avoid influencing confidence levels in Stage 1. After the practice set, subjects were informed about the matching structure of groups that would apply to them; this varied by treatment, as explained below.

2.2 Confidence Elicitation

Each experimental session involved 16 subjects. In Stage 1, the 16 subjects were randomly matched into four groups of four people. Each group was given an identifier (Group A, B, C or D) and subjects were told which group they were in and that they all would be completing a set of Circle tasks similar to the practice set. Before starting Stage 1, they were asked to complete a table as in Figure 2. This is a tool designed to infer confidence from a set of choices.[3] For every row of the table, subjects had to make a choice between two options, Option A and Option B. Subjects knew that any choice from any table could be paid for real at the end of the experiment. As such, the interpretation of options is that Option A (if for real) would pay £10 if a subject was one of the top two of her group, according to her performance in the set of Circle tasks of that stage and £3 otherwise. Option B was a lottery which paid either £10 or £3 with the chance of £10 progressively decreasing down the rows. Given the construction of the table, subjects were expected to choose Option B in the first row and Option A in the last row. At some point, they were likely to switch from option B to A, and this switch point was used to measure each individual's confidence of being in the top half of their group

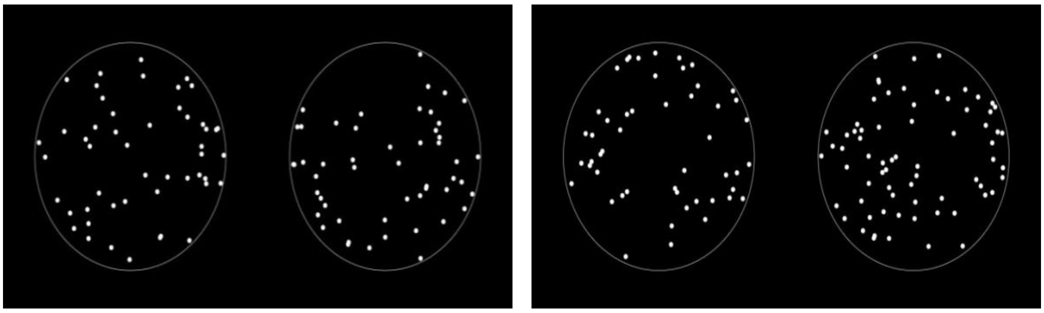
The elicited confidence in our design is interpreted as a subjective probability that a subject assigns to being in the top half of their group for a given stage. For example, subjects who assigned an equal probability to being in the top or bottom half of their group would switch in the 11th row the table and would be imputed a 50% confidence (± 2.5%).[4] If we assume additive subjective probability distributions, then this task elicits the whole belief distribution

[3] Relative confidence is usually elicited via self-reports of relative percentile rankings (Larrick, Burson & Soll 2007; Moore & Cain 2007; Brookins, Lucas & Ryvkin 2014), from estimates of absolute performance for self and others (Kamas & Preston 2012, Neyse, Bosworth, Ring & Schmidt 2015) or inferred from observed competitive payment schemes (Hoelzl & Rustichini 2005; Niederle & Vesterlund 2007).

[4] We eliminated the possibility of double switching by presenting subjects who attempted to double switch with an error message that asked them to think more carefully about their choices and decide on their switching point.

of any subject. The tool also has the attraction of being incentive-compatible for confidence revelation under both expected utility theory and prospect theoretic models which allow non-linear probability distortion (see Urbig, Stauf, & Weitzel, 2009). The tool is robust to the Benoît & Dubra, (2011) critique of “apparent overconfidence” and meets the requirements for incentivising confidence elicitation proposed by Benoit, Dubra & Moore (2015) (see Appendix A2 for further details).

After completing the confidence elicitation table at the beginning of a stage, subjects then undertook a set 20 Circle tasks that determined their performance for the stage. Each correct answer was worth £0.50 hence subjects could earn up to £10 for the set.



50&51 dots: Difficult

50&70 dots: Easy

[*After 1 second, the circles disappear from the screens*]

Which circle had more dots?
Left Right

Figure 1: The Circle Task

2.3 Feedback Manipulation

In all treatments, whether subjects were told this or not, the group matchings were always adjusted between each stage such that any pair of subjects who had performed in the top (respectively bottom) half of their group went on to be grouped with another pair of subjects in the next stage who had also been the top (respectively bottom) performers from another group. Between-treatments we manipulated whether subjects received feedback about their own relative performance feedback and whether they knew about how the composition of their group membership was adjusted, based on performance.

In the NoFeedback treatment, subjects did not receive any feedback (about their own performance or the changing group composition): after they completed a stage, they were just told that, in the next stage, two members (including them) from their old group would be matched with two members from another group. In the OwnFeedback treatment, after completing a stage they received either positive or negative feedback about their own relative performance: the feedback, which was true, simply read as “You were in the TOP two of your group” or “You were in the BOTTOM two of your group”. They were then told that in the next stage, two members (including them) of their old group would be matched with two members from another group (without specifying the abilities of their new group members). In the FullFeedback treatment, after completing a stage, subjects received either positive or negative feedback of whether they were in the Top/Bottom two of their groups in the stage (similar to the OwnFeedback treatment). They were then told that the two Top/Bottom half scorers of their group (including them depending on their ranking) would be matched with the two Top/Bottom half scorers of another group in the next stage. Thus in the FullFeedback treatment, subjects knew whether their last round’s performance placed them in the top or bottom half of the group and that they would be matched to similarly ranked subjects in the next stage.

Row	**Option A: Bet**	**Your Choice**	**Option B: Lottery**
1	You get £10 if you are one of the top two scorers of your group and £3 if you are one of the bottom two scorers of your group	A ○ ○ B	£10 with 100% chance
2		A ○ ○ B	£10 with 95% chance and £3 with 5% chance
3		A ○ ○ B	£10 with 90% chance and £3 with 10% chance
4		A ○ ○ B	£10 with 85% chance and £3 with 15% chance
5		A ○ ○ B	£10 with 80% chance and £3 with 20% chance
6		A ○ ○ B	£10 with 75% chance and £3 with 25% chance
7		A ○ ○ B	£10 with 70% chance and £3 with 30% chance
8		A ○ ○ B	£10 with 65% chance and £3 with 35% chance
9		A ○ ○ B	£10 with 60% chance and £3 with 40% chance
10		A ○ ○ B	£10 with 55% chance and £3 with 45% chance
11		A ○ ○ B	£10 with 50% chance and £3 with 50% chance
12		A ○ ○ B	£10 with 45% chance and £3 with 55% chance
13		A ○ ○ B	£10 with 40% chance and £3 with 60% chance
14		A ○ ○ B	£10 with 35% chance and £3 with 65% chance
15		A ○ ○ B	£10 with 30% chance and £3 with 70% chance
16		A ○ ○ B	£10 with 25% chance and £3 with 75% chance
17		A ○ ○ B	£10 with 20% chance and £3 with 80% chance
18		A ○ ○ B	£10 with 15% chance and £3 with 85% chance
19		A ○ ○ B	£10 with 10% chance and £3 with 90% chance
20		A ○ ○ B	£10 with 5% chance and £3 with 95% chance

Figure 2: Confidence Elicitation Table

The group matchings were explained to subjects in the instructions with the aid of diagrams to make the matching procedure as obvious as possible. Subjects’ understanding of the matching structure at each stage of the experiment was a crucial element of our design. Hence, we reminded them both verbally and graphically about how the grouping was formed and what group they were in at the beginning of each stage to make the changing reference groups a salient feature of the experiment. In the FullFeedback treatment, we included the words “Top” or “Bottom” in the group names to enhance salience. In the NoFeedback and OwnFeedback treatments, the Top/Bottom labels in the group names were simply replaced with numbers (“1” or “2”). For example, Top two scorers of group A would be matched with Top two scorers of group B, and the new group would be called group AB_Top in the FullFeedback treatment and group AB_1 in the NoFeedback and OwnFeedback treatments. After the second stage, Top two scorers of group AB_Top (AB_1) would be matched with the top two scorers of Group CD_Top (CD_1) to form the group ABCD_TopTop (ABCD_11). Similar matching was done for the bottom two scorers. Please refer to Appendix B Figure B1 for the summary of the matching structure.

2.4 Procedures

After Stage 3, subjects completed a questionnaire self-reporting socio-demographic information, risk attitudes, competitive attitudes and general level of confidence (Dohmen, Falk, Huffman, & Sunde, 2010). In the questionnaire, we also asked subjects whether their eyesight was impaired. Once all subjects had completed the questionnaire, the experimenter approached each subject with randomization devices to, privately, determine their payment. For each subject, one of the stages was randomly selected and within the chosen stage either one of the rows of the confidence elicitation table or the piece rate performance in a set of Circle tasks was selected. We explained the randomization procedure to the subjects using physical randomization devices such as a 6-sided, a 20-sided dice and a bag of numbered balls in the instructions of the experiment to make the independence of the randomization to subjects as clear as possible. For the full instructions of the experiment please see Appendix B, and for the summary of the experimental flow please see Appendix C Table C1.

Subjects were 384 undergraduate and postgraduate students recruited via Orsee (Greiner, 2015) from an online database of CeDEx laboratory at the University of Nottingham. Subjects, 54% female with 18% from Economics and Business majors, were divided into three treatments with 12 sessions for the FullFeedback treatment and 6 sessions each for the OwnFeedback and NoFeedback treatments. The experiment was programmed using Ztree (Fischbacher, 2007) and lasted around 30 minutes. Subjects were seated in private cubicles and were given paper instructions. The instructions were read by the same experimenter at the beginning of the experiment. The average subject payment was £7.60 (min. £3; Max £10).

3 Results

We first present descriptive results on the distribution of prior confidence levels. We then present evidence of confidence snowballing and the emergence of confidence biases from one stage to the next for the subjects that received relative performance feedback. We check the robustness of confidence snowballing and test for reference group neglect by comparing the FullFeedback and OwnFeedback treatments. Finally, we test for the existence of other confidence updating biases in our data such as fundamental misattribution bias, good-news-bad-news effects and motivational feedback effects.

3.1. Stage 1 Confidence: is confidence well-calibrated prior to performance feedback?

We first investigate whether initial beliefs about task performance are well-calibrated, prior to any feedback on task performance. Regarding the rational benchmark for belief formation, it is perfectly admissible for individuals to estimate their ability with error (e.g. overconfidence or underconfidence), but the distribution of these errors should have a mean of zero. Following Benoît & Dubra, (2011), in this benchmark case we require that beliefs of scoring in the top two of a group of four (i.e. being in the top 50%) are on average equal to 50% (± 2.5%). As Benoît & Dubra, (2011) show in their Theorem 3, if this does not hold in the population, then such beliefs cannot be rationalized.

Over all treatments, the median and modal first stage confidence in our data is 50%, and the mean is 52.29% (*st dev = 17.02, n=384)* suggestive of initially well-calibrated beliefs. This impression is confirmed by the Wilcoxon sign-rank test, which fails to reject the null hypothesis that the median confidence is not statistically different from 50% in the NoFeedback and the FullFeedback treatments (median = 52.5% and 50.0% respectively, p-value>0.10). While there is some evidence of overconfidence in the OwnFedback treatment (mean = 55%, p-value=0.096) it is relatively weak compared to previously cited studies (e.g. 63% and 56% in Hoelzl & Rustichini, (2005) and 67% in Benoît, Dubra, & Moore, (2015). The kernel density of the elicited confidence in Stage 1 is presented in Figure C2 of Appendix C.

Table 1 provides further tests for cross-treatment differences in first-stage confidence via regression analysis that allows us to exploit additional controls including task difficulty and individual-level characteristics elicited from the survey measures. As expected, task difficulty reduces confidence, but none of the individual-level characteristics, including gender, are significant.[5] In terms of treatment differences, we find no evidence that first stage confidence in the NoFeedback treatment is different from confidence in either of the feedback (Full or Own) treatments. We do, however, find marginally significant difference between the OwnFeedback and FullFeedback treatments; post estimation effect size is equal to -3.65 (p-value = 0.060) without controls and -3.39 (p-value = 0.089) with controls. Given these results, in the parametric analysis of feedback effects that follows, we always control for Stage 1 confidence levels and the difficulty level of the task.

Table 1: Predicting First Stage Confidence Levels

DV: Stage 1 Confidence	**Model 1**	**Model 2**
OwnFeedback	2.34 (2.33)	2.57 (2.36)
FullFeedback	-1.30 (2.24)	-0.82 (2.27)
Difficulty		-3.74 (1.72)**
Female		0.18 (1.78)
Age		0.49 (0.57)
Confidence_general		0.31 (0.64)
Competitive_general		0.03 (0.63)
Risk_general		-0.44 (0.72)
Eyesight		0.03 (1.76)
Constant	52.34 (1.83)	44.08***
N	384	384
R-Sq	0.003	0.001
Wald Coef. Own vs Full feedback	-3.65*	-3.39*

*Risk, Confidence and Competitive are self-reported measures of willingness to take risks, how confident and how competitive a person is in general. * p < 0.10, *** p < 0.01 of the underlying coefficient Standard deviations are clustered in session level. The outlier in Easy treatment is removed.*

3.2. Confidence Snowballing and the role of reference group neglect

Our main research question is how confidence changes from one stage to the next in response to the relative performance feedback (and changing reference groups). The main results are summarised in Figure 4. The figure presents the mean confidence of subjects at each stage with four separate panels for different pairings across rounds (TopTop, BottomBottom, etc). Since we find no significant differences in snowballing behaviour across difficulty levels (see Appendix C: Table C1), in this analysis we pool data across the two difficulty levels.

[5] The absence of gender differences in confidence is consistent with previous literature that has shown that the perceptions about the task being male or female can affect confidence levels and competitive preferences (Cárdenas, Dreber, von Essen, & Ranehill, 2012; Große & Riener, 2010; Günther, Ekinci, Schwieren, & Strobel, 2010).

Within each panel, we report pairwise tests for equality of confidence across stages (Wilcoxon matched-pairs signed rank tests), organized by treatment. We highlight several patterns evident in this figure. First, looking across the four panels for the NoFeedback condition, it is apparent that there are no significant changes in confidence levels across stages. Hence, in the absence of feedback, confidence levels are essentially stable.

We next consider whether there is evidence of snowballing: The top two panels are those where we can test for snowballing effects of feedback because these are the cases where the feedback had a consistent direction across stages: feedback on own relative performance was either indicative of consistently top performance (TopTop) or bottom performance (BottomBottom); likewise, in the full feedback condition, the feedback on the reference group either indicated that the reference group was consistently populated with last rounds better performers (TopTop) or consistently with the lower performers (BottomBottom). Looking at these top two panels, first, consider the OwnFeedback condition – and recall that these data are the cases where we have induced full reference group neglect (by not telling subjects how their reference group was changing). For these two cases, *we see clear and highly significant evidence of snowballing*: when feedback on own performance is consistently positive, average confidence consistently increases; but when feedback on own performance is consistently negative; confidence consistently falls.

Similar trends are apparent in the FullFeedback treatment, where subjects know that their reference group is changing, with systematic increases in confidence for TopTop and reductions in confidence for BottomBottom. This is evidence that subjects are prone to *some degree* of reference group neglect. Although highly significant, at the eyeball level, the snowballs effects in FullFeedback appear smaller in magnitude than those in OwnFeedback, consistent with partial rather than full reference group neglect.

The data reported in the lower two panels of Fig 4. – i.e. for BottomTop and TopBottom and relating to subjects who received two different signals between the two stages - tell a similar story: when subjects receive feedback on their own performance, confidence moves in the direction of their feedback, though because of the mixed nature of the feedback, we do not observe a snowball across the three rounds.

To test whether reference group neglect is full or partial, we use linear regression to test for a difference in snowball effects across the OwnFeedback and FullFeedback treatments. The results are presented in Table 2 where we report separate regressions for TopTop and BottomBottom. We test for the equality of confidence snowballing from Stage 1 to Stage 3 between FullFeedback and OwnFeedback treatments using two model specifications (Model 2 adds controls: individual characteristics; performance score; and task difficulty). For all four models we find that, as expected, confidence snowballs from Stage 1 to Stage 3 in the direction of the feedback received: it increases after receiving two consecutive positive feedbacks (statistically significant positive coefficient of Stage 3 in TopTop) and decreases after receiving two consecutive negative feedbacks (statistically significant negative coefficient of Stage 3 in BottomBottom). Testing for difference-in-difference in confidence snowballing using an interaction term, we find that the degree of snowballing is lower in the FullFeedback compared to the OwnFeedback treatment: the coefficient of Stage3×FullFeedback interaction term is negative in the TopTop and positive in BottomBottom conditions and shows around ~ 6.5% points difference in confidence. However, the coefficient is not significant.

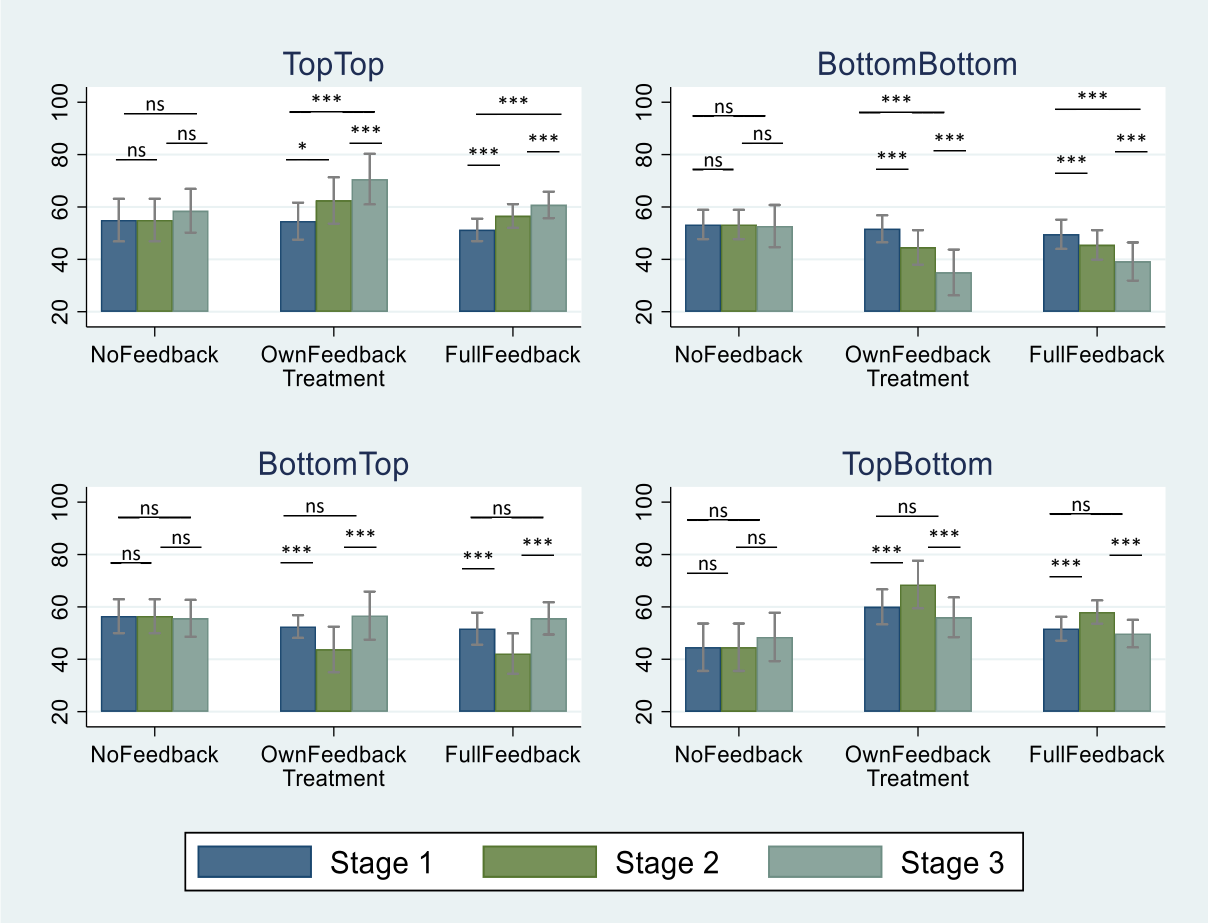


Fig 4. Mean confidence across stages and treatments. Wilcoxon matched pair signed rank test. *ns p>0.10, * p < 0.10, *** p < 0.01. Error bars are 95% confidence intervals.*

To complement this analysis, we also pairwise test whether the absolute level of confidence is significantly different between the OwnFeedback and FullFeedback treatments, in each stage, using the Wilcoxon ranksum test. For TopTop: Stage 1 p-value = 0.114; Stage 2 p-value = 0.073, Stage 3 p-value = 0.001. For BottomBottom: Stage 1 p-value = 0.880, Stage 2 p-value = 0.674, Stage 3 p-value = 0.345. Hence, in line with eyeball impressions from Fig. 4, this provides some statistically significant evidence that reference group neglect is partial in some cases (i.e. the TopTop condition).

Table 2: Testing for complete versus partial reference group neglect

	TopTop		**BottomBottom**	
	Model 1	Model 2	Model 1	Model 2
Stage 3	16.04***	15.97***	-16.66***	-18.50***
	(4.45)	(4.64)	(4.26)	(4.88)
FullFeedback	-3.33	-3.28	-2.08	-3.74
	(4.02)	(3.97)	(3.75)	(3.66)
Stage3×FullFeedback	-6.45	-6.33	6.25	7.05
	(4.75)	(4.91)	(5.91)	(6.31)
Constant	54.58***	36.96	51.66***	39.90
	(3.40)	(25.87)	(2.48)	(34.48)
Adj R^2	0.116	0.152	0.071	0.119
N	144	144	144	144
Controls	No	Yes	No	Yes

** 10%, *** 1% significance level, controls include actual performance score, task difficulty, gender and nationality dummies, age, general willingness to take risk, general level of confidence and competitiveness and whether any issues with eyesight was reported. Standard errors clustered at subject level.*

3.3 Is there evidence of alternative confidence updating hypotheses?

In this section, we test for alternative confidence updating hypotheses that have been previously studied in the literature. Firstly, feedback effects on confidence snowballing could be motivational (changing effort and thus performance) rather than simply cognitive (changing beliefs).[6] Feedback could affect subjects' subsequent motivations to exert effort and hence their confidence could follow this shift in their efforts/performance. We rule out this explanation for confidence snowballing. Firstly, our task was pre-tested so that incremental effort level exerted on the task did not improve/diminish performance (as long as the minimal effort was exerted; see Appendix A1). Secondly, in our analysis in Table 2, we explicitly control for the

[6] Ederer, (2010) and Fishbach, Eyal, & Finkelstein, (2010) argue for the motivating effects of positive feedback on performance and effort levels. Berger & Pope, (2011); Eriksson, Poulsen, & Villeval, (2009); Kuhnen & Tymula, (2012) show motivating effects of negative performance feedback on the subsequent effort levels in tournaments. Gill & Prowse, (2012); Malueg & Yates, (2010), argue for discouraging effects of negative performance feedback on the subsequent performance.

performance variable (the score in the set of Circle tasks in each stage). Hence any change observed in confidence from Stage 1 to Stage 3 is conditional on any change in performance. And thirdly, to test for other unobserved motivational effects of feedback on exerted effort levels, we asked subjects in the post-study questionnaire “Did you try harder in some stages of the Circle task than in others?”. Subjects could choose "I tried equally hard throughout"; "I tried harder in Stage 1"; “I tried harder in Stage 2"; "I tried harder in Stage 3”. 87%, 65% and 66% of our subjects in NoFeedback, OwnFeedback and FullFeedback treatments, respectively, reported that they tried equally hard throughout (Table 3). The responses of the remaining subjects were equally distributed across the stages. Moreover, no systematic relationship was detected across the feedback conditions (TopTop, TopBottom, BottomTop or BottomBottom) and subjects’ answer to this question (χ^2 p-value > 0.650). We thus consider it unlikely that the motivational effects of feedback may have contributed to confidence snowballing.

Table 3: Did you try in one stage harder than in the other? (frequencies of choosing an option)

FullFeedback	TopTop	TopBottom	BottomBottom	BottomTop	Total
I tried hard throughout	38	34	28	27	127
Stage 1	3	5	9	3	20
Stage 2	0	3	1	12	16
Stage 3	7	6	10	6	29
OwnFeedback					
I tried hard throughout	14	11	12	17	54
Stage 1	4	4	2	4	14
Stage 2	1	3	3	3	10
Stage 3	5	6	7	0	18
NoFeedback					
I tried hard throughout	-	-	-	-	83
Stage 1	-	-	-	-	3
Stage 2	-	-	-	-	6
Stage 3	-	-	-	-	4

Secondly, *causal misattribution bias* may have contributed to the observed confidence snowballing. Causal misattribution bias manifests itself through attributing positive events to internal factors such as skill, personality and expertise and negative events to external factors such as luck and other people’s faults (Mezulis, Abramson, Hyde, & Hankin, 2004). At the end of the experiment, we asked subjects the question, “On a scale of 1 to 7, did luck or skill determine your performance in the Circle Task? (1 entirely luck, 7 entirely skill)”. Figure 5 presents evidence of causal misattribution bias. For subjects who received feedback (left-hand panel), when in the TopTop condition they rate the task as more influenced by skill (*mean (sd) = 4.61 (2.01)*) compared to the ones in the BottomBottom condition (*mean (sd)= 3.04 (1.73)*). In the additional analysis reported in Table 4, we control for the effect of these misattributed beliefs on confidence snowballing and check for any interaction effects for those who attributed feedback to skill versus luck. We find that there is marginally significantly higher snowballing from positive feedback for those who misattributed feedback more to skill than luck; this significance disappears, however, when we control for additional individual characteristics (socio-demographic and economic preferences). No similar result holds for those receiving negative feedback. So, while some causal misattribution bias exists in our data, we do not find that it is an important contributor to confidence snowballing in our study.

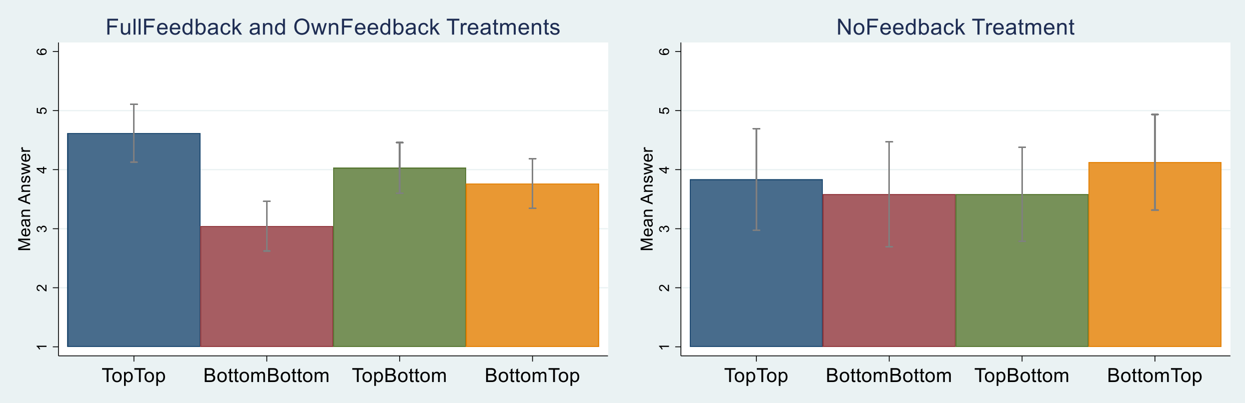


Figure 5: Causal Misattribution to Skill or to Luck depending on the feedback received
Mean answers to the question: On a scale of 1 to 7, did luck or skill determine your performance in the Circle Task? (1 entirely luck, 7 entirely skill)".

Finally, we test for asymmetric updating behaviour depending on the feedback received.[7] Positive asymmetric updating (also known as a *good-news-bad-news effect*) would predict that the change in confidence from Stage 1 to Stage 3 would be lower in magnitude after receiving negative feedback than after receiving positive feedback, with the opposite pattern for negative asymmetric updating. We test for asymmetric updating by regressing the absolute change in confidence on the feedback condition dummy (TopTop vs BottomBottom) and results are reported in Table 5. Contrary to the good-new-bad-news effect, we find some

[7] Positive asymmetric updating predicts overweighting of positive feedback and underweighting of negative feedback when updating beliefs (Moutsiana, Charpentier, Garrett, Cohen, & Sharot, 2015; Sharot, Korn, & Dolan, 2011).

evidence of negative asymmetric updating with a tendency for subjects to update less in the TopTop condition compared to the BottomBottom condition (see the negative coefficient on the treatment dummy in Table 5 which is significant at the 5% level in both specifications).

Our design also permits another form of test for differential responses to positive and negative feedback by examining the effects of mixed feedback in the TopBottom or BottomTop conditions. If asymmetric updating were in operation, we would observe a significant change in confidence in both of these conditions. As demonstrated in the bottom panels of Figure 4, there is no change in confidence from Stage 1 to Stage 3 in either the TopBottom or in BottomTop conditions of either of the feedback treatments. Hence in these conditions, we observe no asymmetry in updating. This adds to the mixed evidence relating to asymmetric information processing with recent studies showing either no asymmetry (Buser, Gerhards, & van der Weele, 2018; Grossman & Owens, 2012), positive asymmetry (Eil & Rao, 2011; Möbius et al., 2014) or negative asymmetry (Coutts, 2019; Ertac, 2011).

Table 4: Snowballing Confidence and Causal misattribution

The dependent variable is the change in confidence from the first to the last stage:
Confidence Stage 3 - Confidence Stage 1

	Model 1	**Model 2**
Skill_Attr	-.208 (3.06)	-.44 (2.97)
TopTop	6.28 (2.89)**	6.71** (3.18)
BottomBottom	-14.75*** (4.72)	-16.52*** (4.42)
TopTop×SkillAttr	7.44* (3.72)	4.37 (3.91)
BottomBottom×SkillAttr	5.08 (7.61)	7.23 (7.02)
Constant	0.833 (2.70)	-34.00** (14.54)
Controls	No	Yes
N	288	288

** p <0.10, ** p < 0.05, *** p < 0.01; standard errors are in parenthesis and are clustered at session level. Includes controls such as gender, age, self-reported competitiveness, risk-seeking and self-reported confidence. Skill_Atrr is a dummy taking value 1 if above median. Pooled results for OwnFeedback and FullFeedback treatments.*

Table 5: Testing for asymmetric updating

DV: Absolute value of (ConfStage3-ConfStage1)	Model 1	Model 2
TopTop (vs BottomBottom)	-6.18** (2.68)	-6.06** (2.75)
Constant	20.97*** (2.24)	-17.39 (14.80)
Controls	No	Yes
N	144	144

** p <0.10, ** p < 0.05, *** p < 0.01; standard errors are in parenthesis and are clustered at session level. Includes controls such as gender, age, self-reported competitiveness, risk-seeking and self-reported confidence. Pooled results for OwnFeedback and FullFeedback treatments.*

4 Concluding Discussion

We contribute to the literature studying confidence biases and how feedback affects them. Most of the previous related work has studied feedback as a tool to eliminate these biases. Moore & Cain, (2007), Murad, (2016) and Rose & Windschitl, (2008), find that repeated full feedback is only partially successful in eliminating confidence biases.[8] When feedback is noisy, Coutts, (2018), Ertac (2011) and Möbius et al., (2014) show that people treat positive and negative feedback asymmetrically and update beliefs insufficiently to de-bias their judgements completely. Burks, Carpenter, Goette, & Rustichini, (2013) and Eil & Rao, (2011) show that people exhibit dislike or are indifferent to new information when expecting negative feedback and hence they don't learn from it. Eberlein, Ludwig, & Nafziger, (2011) and Buser, Gerhards, & van der Weele, (2018) demonstrate heterogeneity in how conservative (or otherwise) individuals are in updating their relative confidence judgements. We study the specific environment of updating relative confidence beliefs with respect to others in one's group, in a task where confidence is initially well-calibrated. In contrast to almost all existing studies examining how confidence biases are affected by *informative* (but sometimes noisy) relative performance feedback, we investigate whether *uninformative* relative performance feedback can induce confidence biases.

[8] More experiments on absolute confidence biases (overestimation) have also studied feedback as a remedy to cure overconfidence (Arkes, Christensen, Lai, & Blumer, 1987; Petrusic & Baranski, 1997; Pulford & Colman, 1997; Subbotin, 1996).

In all three treatments of our three-stage experiment, as subjects move from stage 1 to stage 3, we change group composition so that new groups contain either only top performers or only bottom performers, from the previous round. Between treatments, we manipulate whether subjects know about their own past relative performance or that of their current matched group members. In the NoFeedback treatment, they know neither of these things and confidence remains calibrated and stable across the stages. In both of the other two treatments, we provide feedback on own performance and, in both of these treatments, confidence snowballs significantly in the direction of the feedback: confidence consistently rises among top performers and falls among bottom performers. In one of these treatments - the OwnFeedback treatment, which we interpret as inducing full reference group neglect – subjects are not told about how their reference group is changing. In the FullFeedback treatment, however, subjects do have a basis for judging that their own performance feedback is essentially uninformative, yet we still find strong evidence that confidence snowballs and only limited evidence that snowballs are weaker than those arising from full reference group neglect.

Our evidence is potentially relevant for behaviour in a wide range of naturalistic environments. For example, consider new students starting at college or financial traders starting a new job. To begin with, they do not have much basis for judging their relative abilities (Gervais & Odean, 2001) but, over time, they receive relative performance feedback both about themselves and their reference groups: e.g. students being able to observe both their own and their peers' grades/performances, traders being exposed to their own and to market performance information. In such cases, our results point to the possibility of confidence biases emerging. For example, students will become discouraged and underconfident when finding themselves in classes with extremely able students, neglecting the fact that their reference group is more skilled than average. The opposite will be true for those students that are in classes with low ability students (see the 'Big-Fish-Little-Pond effect' of Marsh, 1987). This will, in turn, affect their study motivation and future performance (Fischer & Sliwka, 2018; Murphy & Weinhardt, 2018). Similarly, in work environments, employees and firms will disregard the feedback they receive about their competitors, responding mainly to feedback about their own performance and resulting in potentially suboptimal decision making (e.g. in relation to pricing, marketing strategies or promotions decisions).

Finally, our results also help to explain some well-attested confidence anomalies, such as the frequently cited example of systematic overconfidence among drivers, most of whom rate themselves as above average in ability (Svenson, 1981). Picture the typical driver who most days completes their daily drive to work or the school gates without incident. This regular positive, accident-free, experience may be a source of growing confidence in their own ability, notwithstanding that most drivers, most days receive essentially the same positive signal and become similarly more experienced as drivers. On this interpretation, this common bias may be diagnosed as a case of confidence snowballing caused by a conjunction of uninformative feedback and reference group neglect.

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Appendix A1: The Circle Task

The Circle task has been used previously in Hollard et al., (2016) to study calibration between absolute confidence and success rates. The task involves seeing a pair of black circles with white dots in them for one second and judging which circle has more dots. We were specifically attracted to this task because we wanted to measure confidence in a skill task that is insensitive to effort. As a skill task, it requires a minimum effort level to achieve the maximum performance after which additional effort does not improve performance. This reduces the possibility of incentive effects caused by the feedback that may affect effort and performance in the task. We also aimed to use a gender-neutral task both in terms of actual performance and perceptions about the task. We pre-tested the task for these properties in a standard experimental session format with 30 subjects recruited via Orsee (Greiner 2004). The experiment was computerized and programmed with Ztree (Fischbacher 2007). The pre-test was conducted one month prior to the main study.

Four difficulty levels of a task were pretested: 50&51, 50&55, 50&60, 50&65, 50&70 dot circles presented in sets of 20 circle pairs per each difficulty level. We randomized the order in which the sets were presented. We also presented two of the difficulty levels (50&51 and 50&60) to the subjects three times, in order to check whether there were learning effects. We had two between-subject treatments, low and high incentives, to check whether incentives improve performance by promoting effort. The Low incentive scheme paid £0.05 per correct answer plus a fixed payment of £5. The high incentive scheme paid £0.50 per correct answer and no fixed payment. Subjects were paid for one randomly selected set.

We did not find a difference in performance between the two incentive levels across the difficulty levels. We did not find any difference in the answers of subjects to the questions "how hard did you try", and "how focused were you on a task" across incentive levels either, indicating that the subjects did not consciously vary effort depending on the rewards. The maximum average performance was observed in 50&70 dots set (19.81 in low and 19.75 in high incentive, Wilcoxon ranksum *p-value* = 0.729) and the minimum average performance was in 50&51 dot set (11.3 in low and 10.9 in high incentive, *p-value* = 0.437). We chose these two difficulty levels as our easy and difficult treatments for the main experiment. These two difficulty levels also showed the lowest variance in performance among subjects. We tested for learning effects and found that performance within a difficulty level did not improve from earlier to later sets (Cuzick, (1985) test for trend *p-value* = 0.432).

Previous studies have presented mixed evidence of whether task type being perceived to be "female" or "male" in nature can affect confidence levels between genders (Grosse & Riener 2010; Cardenas, Dreber, Essen & Ranehill 2011; Gunther, Ekinci, Schwieren & Strobel 2010). To avoid a possible gender effect in our study we checked whether there were differences in performance, response times, and perceptions about the difficulty level of the task across genders. To check for the perceptions about the task after each set of a task and at the end of the pre-test session we asked several questions (e.g. on a scale of 1 to 7, "how difficult did you find the task?", "how much did luck or skill determine your performance in the set?", "how hard did you try?"). We did not find any gender differences either in performance (*p-value* = 0.125), response times (*p-value* = 0.587) or in the perceptions of the task (*p-value* = 0.214). Table A2 reports the regression of average performance scores on observable characteristics of subjects.

Based on the pre-testing, we concluded that the Circle task is well suited to study confidence snowballing because:

i. incentives (and thus effort) play no role in actual performance,
ii. learning effects are absent,
iii. there are no gender differences
iv. performance and perceptions are not correlated with other measures of socio-economic variables.

Table A1: Performance at Each Difficulty and Incentive Level

Difficulty Level	**High Pay**	**Low Pay**	***p-value***
50&51	10.9	11.3	*0.437*
50&55	15.0	15.0	*0.941*
50&60	18.1	18.2	*0.767*
50&65	19.0	19.7	*0.119*
50&70	19.8	19.8	*0.729*
N	15	15	

p-values are from Wilcoxon ranksum test

Table A2: DV average performance score

Female	-0.86 (.77)
Age	-.12 (0.09)
Belief_LuckSkill	.50 (.311)
Risk_General	.15 (.21)
Confidence_General	.05 (.24)
Competitiveness	-.29 (.28)
Eyesight	-.08 (1.08)
Wearing Glasses	-1.19 (.91)
Constant	17.9 (0.30)***
N	22
R^2	0.643

** 10%, *** 1% significance levels. N=22 as some subjects chose not to report their gender.*

Appendix A2: Confidence Elicitation Tool

The elicitation tool (Figure 2 in the main text) is designed as a mechanism to elicit individual confidence (*Conf*). It has the attraction of being both simple to understand and incentive-compatible under both the Expected Utility and Rank Dependent Utility (RDU) models of choice under risk. Unlike some other incentivised methods for eliciting confidence (see Murad, Sefton, & Starmer, 2016), it does not rely on the assumption that individuals are risk-neutral. To see this consider the following analysis using the more general case of RDU where Options A and B refer to the options in Figure 2 and $u(.)$ and $w(.)$ are, respectively, utility and probability weighting functions. Applying RDU, the overall values of the options in the elicitation task of Figure 2 are given by:

$$RDU(Option\ A) = u(£10)w(Conf) + u(£3)(1 - w(Conf))$$

$$RDU(Option\ B) = u(£10)w(p) + u(£3)(1 - w(p))$$

We identify a *Probability Equivalence* (PE) as the value of p at an individual's switch point in any table. At that point, we assume $RDU(Option\ A) = RDU(Option\ B)$ – although this is only approximately true of course, given that we adjust p in the table in discrete steps. On this assumption, we may write:

$$u(£10)w(Conf) + u(£3)(1 - w(Conf)) = u(£10)w(PE) + u(£3)(1 - w(PE))$$

Rearranging gives,

$$u(£10)[w(Conf) - w(PE)] = u(£3)[\big(1 - w(Conf)\big) - \ \big(1 - w(PE)\big)]$$

Assuming that u and w are both increasing, it follows that $Conf = PE$.

Hence, we elicit $Conf$ from the switch point in a way that is independent of the specific forms of $u(.)$ and $w(.)$. We note that individual ambiguity attitudes could also affect the choice in our elicitation table. However ambiguity attitudes may be considered as conceptually related to confidence and even to the extent that it is a distinct phenomenon, as we are primarily interested in confidence snowballing across stages, some ambiguity-sensitive preference would not confound our main conclusions, so long as it is constant within-individual for the duration of the experiment.

The PE elicitation method is robust to Benoit & Dubra (2011) and Benoit, Dubra & Moore (2015) critique of apparent overconfidence. In their 2015 paper, they argue that belief and confidence elicitation methods should satisfy the following five conditions. There should be: (i) a well-defined scale that subjects are responding to behaviourally rather than with self-reports; (ii) a well-defined group they are comparing themselves to; (iii) a well-defined performance task they are asked to report their confidence about. They recommend elicitation of whole belief distributions about rankings (rather than expected rankings) (iv) and finally the propose that (v) elicitation should be appropriately incentivized. Our design satisfies all of these requirements.

In our experiment, subjects fill in a Multiple Price List and choose lotteries with objective probabilities, satisfying condition (i). In relation to condition (ii), subjects always have a well-defined group they are comparing themselves to and receive full information on how groupings are determined in each stage (satisfying condition ii). Subjects carry out a well-defined performance task which they practice before the start of the payoff-relevant experiment (satisfying iii). By eliciting their confidence about scoring in the top half of their group we elicit their full subjective probability distributions since scoring in top and bottom halves are mutually exclusive events: subjects are then assumed to assign belief of *(100 - Conf)%* to scoring in the bottom half (satisfying iv). And finally, the belief elicitation is incentivized by an incentive-compatible mechanism which controls for risk attitudes, as explained above (satisfying v).

Appendix B:

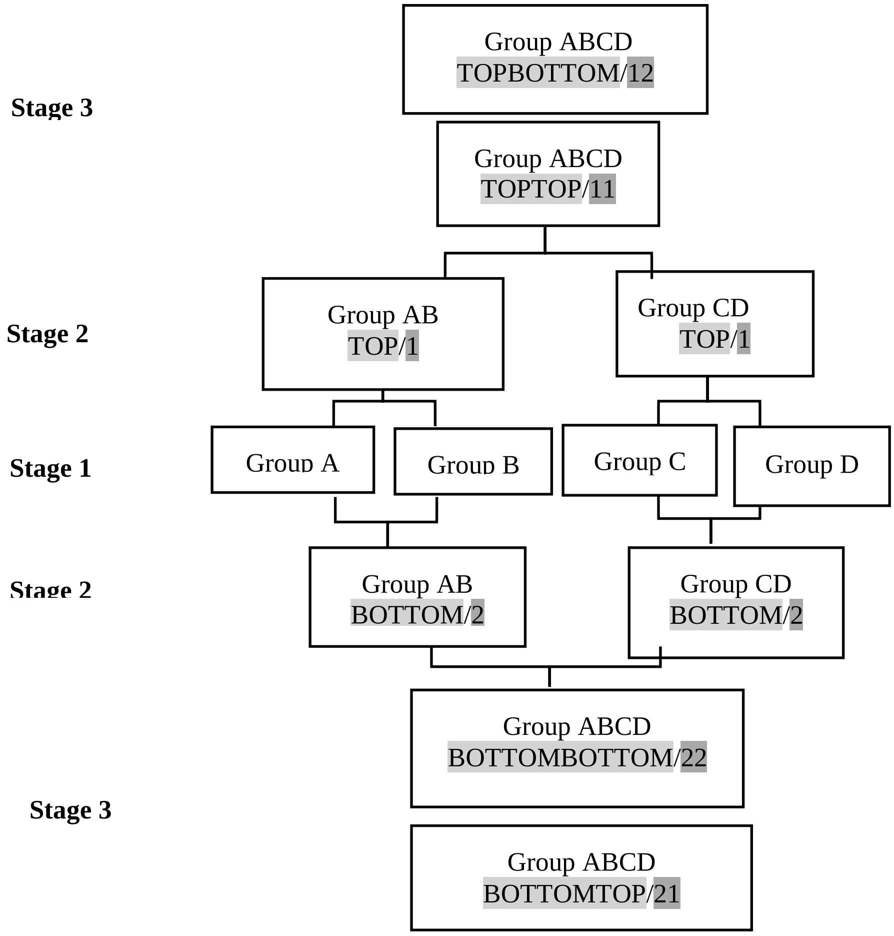


Figure B1: Matching at Each Stage of the Experiment
Depending on the treatment subjects saw the words Top/Bottom or the numbers 1/2.

Instructions

Welcome!

You are about to participate in an experiment. There are 16 people participating in the experiment. You must not communicate with anyone. If you have a question at any time during the experiment, please raise your hand and someone will come to your desk to answer it.

The use of electronic devices such as mobile phones, music players, and tablet computers is strictly prohibited. Please make sure that all such devices are turned off and put away out of sight.

If you break these rules, you will be excluded from the experiment without receiving any payment and be disqualified from future experiments with CeDEx.

The Circle Task

In this experiment you will complete the Circle task. In this task you will see a pair of circles on your screen for 1 second. One of the circles contains 50 dots and the other contains 51 dots. After the circles disappear from your screen, you will be asked to judge whether the right or the left circle contained more dots. You have to indicate your judgement by pressing on the "Left" or "Right" button. When you press the button of your choice, you will move to the next pair of circles.

To acquaint you with the task, you can practice the task before we proceed with the remainder of the instructions. You will practice one set of 20 tasks. The practice set will not affect your final outcome. You can start the practice set by pressing the TASK 1 button.

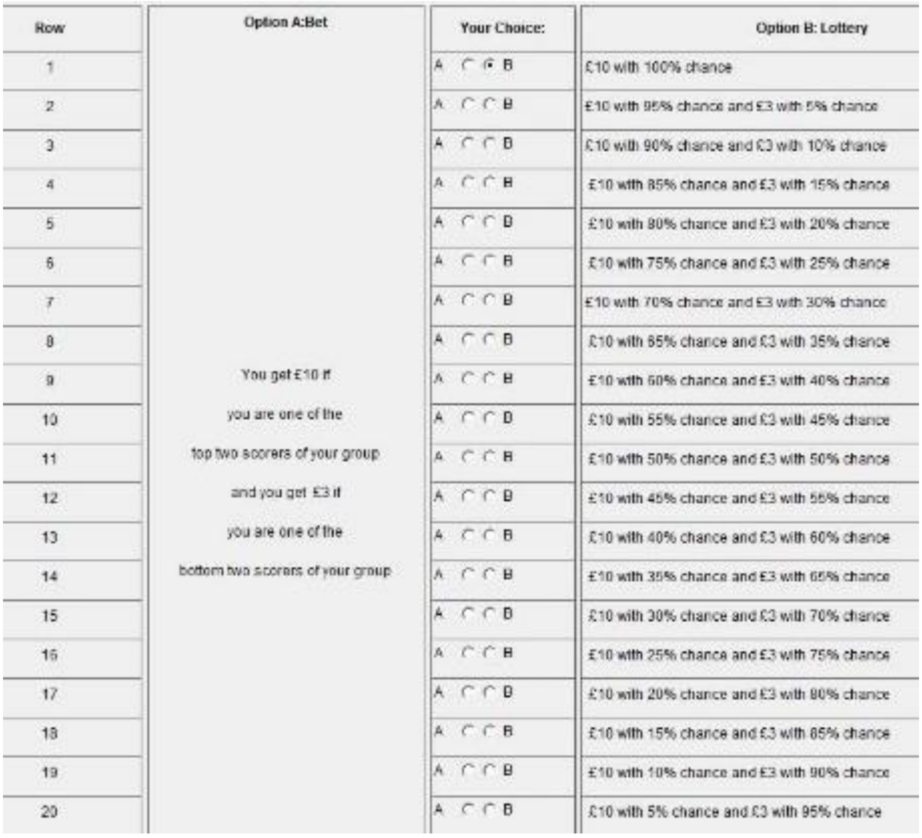
[After everyone has finished the practice set:]

[Instructions for FullFeedback treatment]

The experiment will consist of 3 stages. At each stage you will be in one of four groups consisting of four people. At each stage, you will have to do two things: fill out the Table and then complete the Circle Task.

Stage - Table:

For every row of the table you must make a choice between Option A and Option B. You should consider which of these two options you would prefer to have for each row then mark your choice by ticking the circle corresponding to your preferred option. In each table, we ask that you start with the top row and work your way down the rows. Option A will pay off £10 if you are one of the top two scorers of your group in this stage and £3 if you are one of the bottom two scorers of your group in this stage. (You will complete the Circle task and find out if you are in the top two or bottom two after you have filled the table.) Option B is a lottery which will pay off £10 or £3 with the chance of £10 progressively decreasing as you move down the rows. The chance of winning £10 from Option B in the first row is 100%. This is at least as good as the chance of being in the top two of your group, so we think that you will want to choose Option B in the first row. But, since Option B gets progressively worse as you move down the rows (while Option A stays exactly the same), there may come a row where the chance of winning £10 of Option B is sufficiently small, that you prefer Option A. If you find such a row, you should then choose Option A for that row and the rows below it (since Option B continues to get worse all the way down the table).



Row	Option A:Bet	Your Choice:	Option B: Lottery
1	You get £10 if you are one of the top two scorers of your group and you get £3 if you are one of the bottom two scorers of your group	A ○ ● B	£10 with 100% chance
2		A ○ ○ B	£10 with 95% chance and £3 with 5% chance
3		A ○ ○ B	£10 with 90% chance and £3 with 10% chance
4		A ○ ○ B	£10 with 85% chance and £3 with 15% chance
5		A ○ ○ B	£10 with 80% chance and £3 with 20% chance
6		A ○ ○ B	£10 with 75% chance and £3 with 25% chance
7		A ○ ○ B	£10 with 70% chance and £3 with 30% chance
8		A ○ ○ B	£10 with 65% chance and £3 with 35% chance
9		A ○ ○ B	£10 with 60% chance and £3 with 40% chance
10		A ○ ○ B	£10 with 55% chance and £3 with 45% chance
11		A ○ ○ B	£10 with 50% chance and £3 with 50% chance
12		A ○ ○ B	£10 with 45% chance and £3 with 55% chance
13		A ○ ○ B	£10 with 40% chance and £3 with 60% chance
14		A ○ ○ B	£10 with 35% chance and £3 with 65% chance
15		A ○ ○ B	£10 with 30% chance and £3 with 70% chance
16		A ○ ○ B	£10 with 25% chance and £3 with 75% chance
17		A ○ ○ B	£10 with 20% chance and £3 with 80% chance
18		A ○ ○ B	£10 with 15% chance and £3 with 85% chance
19		A ○ ○ B	£10 with 10% chance and £3 with 90% chance
20		A ○ ○ B	£10 with 5% chance and £3 with 95% chance

Stage - Circle Task

After you have completed the table you will complete the Circle task. You will have 20 tasks to complete similar to the practice set. After everyone has completed the task, your scores will be calculated. For each correct answer, 1 point will be added to your score so that you can score up to 20 points. Your score will be compared to the scores of the other members of your group and at the end of the stage you will be informed of whether you were in the TOP or BOTTOM two of your group for that stage. Ties will be randomly broken. You will then be assigned to a new group according to your performance and the next stage will begin.

Stages

There are 3 stages in this experiment. At each stage, all 16 participants will be divided into groups of 4. At each stage, you will complete the Circle task and receive a score based on your performance. Similarly, each other group member will complete the Circle task, seeing an identical set of circles, scoring 1 point for each correct answer, and so scoring up to 20 points. Before completing the Circle task of each stage you will fill out the table as described above. The groupings at each stage are explained below.

Stage 1:

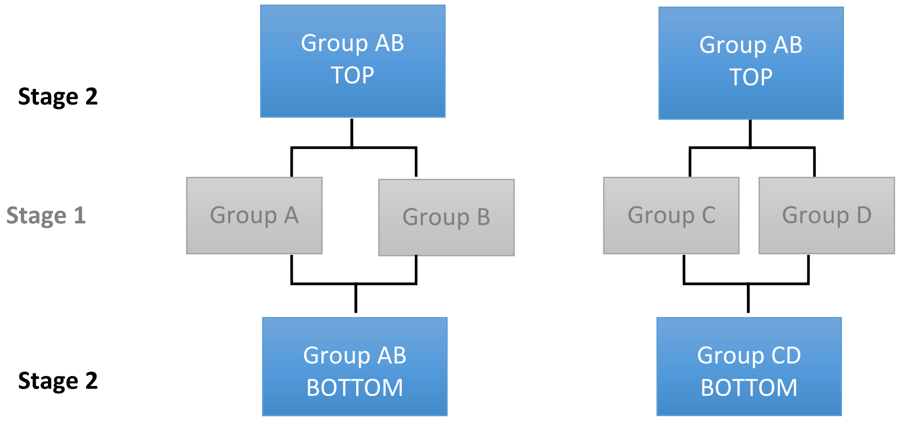
In Stage 1, you will be randomly matched with 3 other participants to form a group. There will be four groups: Group A, Group B, Group C and Group D. You will see which group you are in on your screens.

Stage 1
Group A
Group B
Group C
Group D

Stage 2:

In Stage 2, you will be placed in a new group according to your scores in Stage 1.

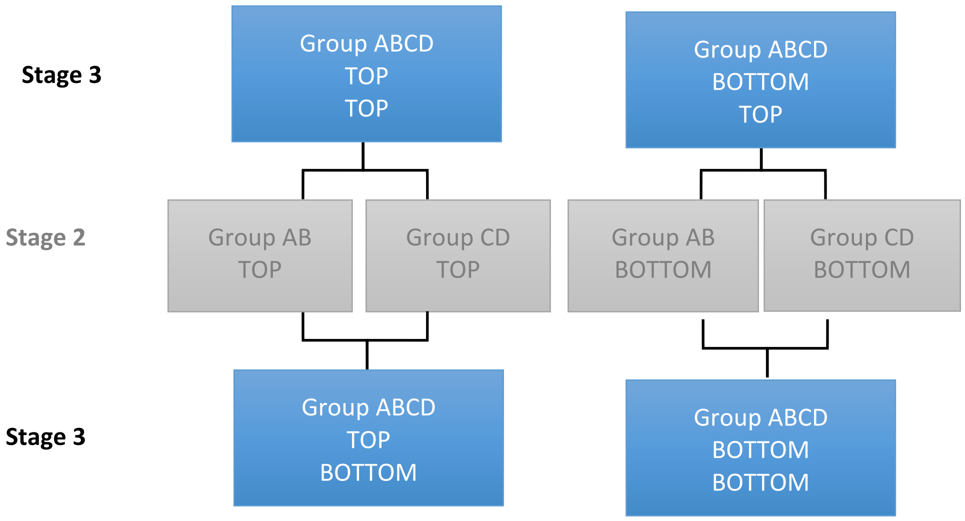
- The top two scorers of Group A will be matched with the top two scorers of Group B to form the **Group AB_Top**.
- The top two scorers of Group C will be matched with the top two scorers of Group D to form the **Group CD_Top**.
- The bottom two scorers of Group A will be matched with the bottom two scorers of Group B to form the **Group AB_Bottom**.
- The bottom two scorers of Group C will be matched with the bottom two scorers of Group D to form the **Group CD_Bottom**.



Stage 3:

In Stage 3, you will be placed in a new group according to your scores in Stage 2.

- The top two scorers of Group AB_Top will be matched with the top two scorers of Group CD_Top to form the **Group ABCD_TopTop**.
- The bottom two scorers of Group AB_Top will be matched with the bottom two scorers of Group CD_Top to form the **Group ABCD_TopBottom**.
- The top two scorers of Group AB_Bottom will be matched with the top two scorers of Group CD_Bottom to form the **Group ABCD_BottomTop**.
- The bottom two scorers of the Group AB_Bottom will be matched with the bottom two scorers of Group CD_Bottom to form the **Group ABCD_BottomBottom**.

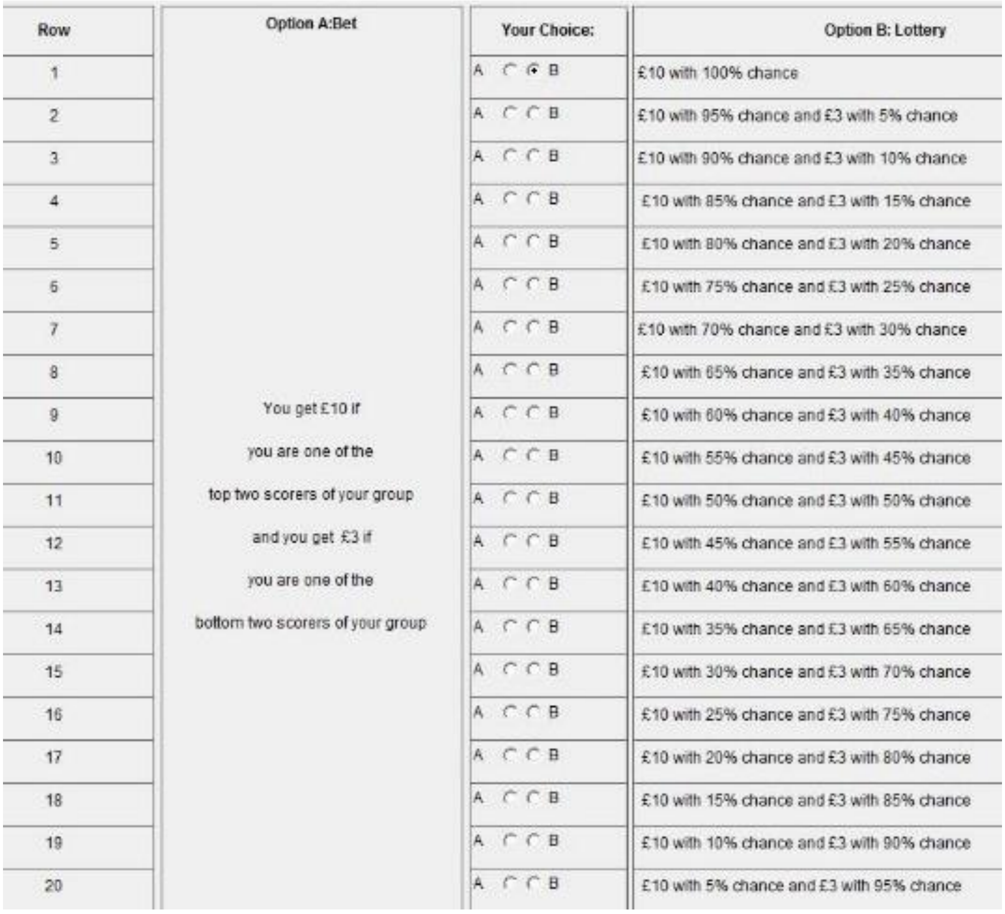


[Instructions for NoFeedback treatment]

The experiment will consist of 3 stages. At each stage you will be in one of four groups consisting of four people. At each stage, you will have to do two things: fill out the Table and then complete the Circle Task.

Stage - Table:

For every row of the table you must make a choice between Option A and Option B. You should consider which of these two options you would prefer to have for each row then mark your choice by ticking the circle corresponding to your preferred option. In each table, we ask that you start with the top row and work your way down the rows. Option A will pay off £10 if you are one of the top two scorers of your group in this stage and £3 if you are one of the bottom two scorers of your group in this stage. You will complete the Circle task and find out if you are in the top two or bottom two after the end of the experiment. Option B is a lottery which will pay off £10 or £3 with the chance of £10 progressively decreasing as you move down the rows. The chance of winning £10 from Option B in the first row is 100%. This is at least as good as the chance of being in the top two of your group, so we think that you will want to choose Option B in the first row. But, since Option B gets progressively worse as you move down the rows (while Option A stays exactly the same), there may come a row where the chance of winning £10 of Option B is sufficiently small, that you prefer Option A. If you find such a row, you should then choose Option A for that row and the rows below it (since Option B continues to get worse all the way down the table).



Row	Option A:Bet	Your Choice:	Option B: Lottery
1	You get £10 if you are one of the top two scorers of your group and you get £3 if you are one of the bottom two scorers of your group	A ○ ● B	£10 with 100% chance
2		A ○ ○ B	£10 with 95% chance and £3 with 5% chance
3		A ○ ○ B	£10 with 90% chance and £3 with 10% chance
4		A ○ ○ B	£10 with 85% chance and £3 with 15% chance
5		A ○ ○ B	£10 with 80% chance and £3 with 20% chance
6		A ○ ○ B	£10 with 75% chance and £3 with 25% chance
7		A ○ ○ B	£10 with 70% chance and £3 with 30% chance
8		A ○ ○ B	£10 with 65% chance and £3 with 35% chance
9		A ○ ○ B	£10 with 60% chance and £3 with 40% chance
10		A ○ ○ B	£10 with 55% chance and £3 with 45% chance
11		A ○ ○ B	£10 with 50% chance and £3 with 50% chance
12		A ○ ○ B	£10 with 45% chance and £3 with 55% chance
13		A ○ ○ B	£10 with 40% chance and £3 with 60% chance
14		A ○ ○ B	£10 with 35% chance and £3 with 65% chance
15		A ○ ○ B	£10 with 30% chance and £3 with 70% chance
16		A ○ ○ B	£10 with 25% chance and £3 with 75% chance
17		A ○ ○ B	£10 with 20% chance and £3 with 80% chance
18		A ○ ○ B	£10 with 15% chance and £3 with 85% chance
19		A ○ ○ B	£10 with 10% chance and £3 with 90% chance
20		A ○ ○ B	£10 with 5% chance and £3 with 95% chance

Stage - Circle Task

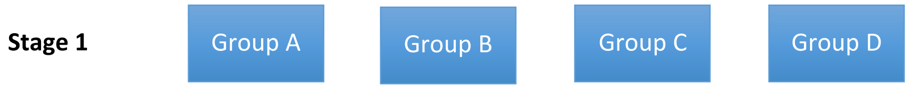
After you have completed the table you will complete the Circle task. You will have 20 tasks to complete similar to the practice set. After everyone has completed the task, your scores will be calculated. For each correct answer, 1 point will be added to your score so that you can score up to 20 points. Your score will be compared to the scores of the other members of your group and this will determine whether you are in the TOP or BOTTOM two of your group for that stage. Ties will be randomly broken. You will then be assigned to a new group of four participants and the next stage will begin. You will not learn if you were in the TOP or Bottom of your groups until the end of the experiment.

Stages

There are 3 stages in this experiment. At each stage, all 16 participants will be divided into groups of 4. At each stage, you will complete the Circle task and receive a score based on your performance. Similarly, each other group member will complete the Circle task, seeing an identical set of circles, scoring 1 point for each correct answer, and so scoring up to 20 points. Before completing the Circle task of each stage you will fill out the table as described above. The groupings at each stage are explained below.

Stage 1:

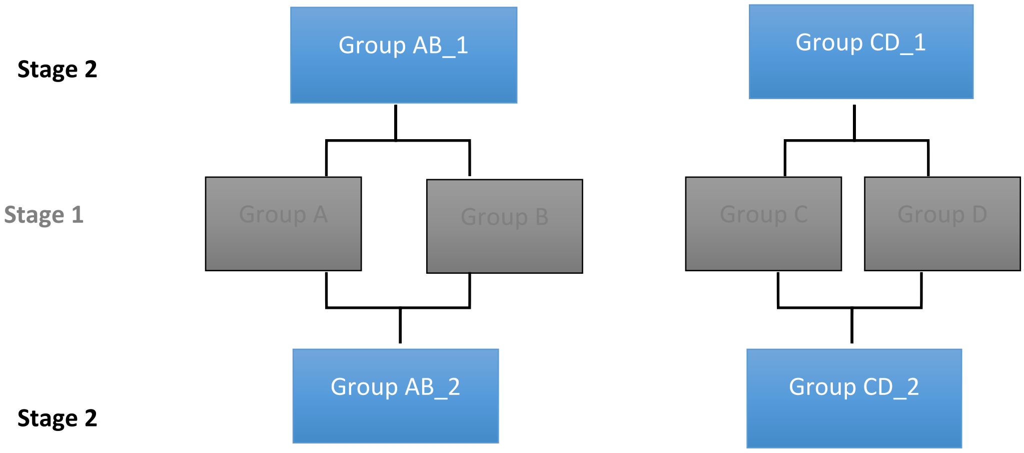
In Stage 1, you will be randomly matched with 3 other participants to form a group. There will be four groups: Group A, Group B, Group C and Group D. You will see which group you are in on your screens.



Stage 2:

In Stage 2, you will be placed in a new group

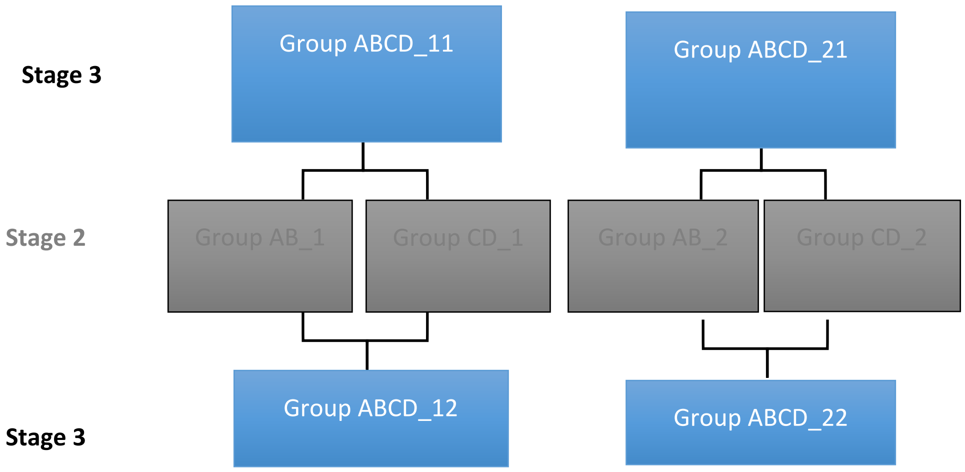
- Two participants of Group A will be matched with two other participants of Group B to form the **Group AB_1 and AB_2**.
- Two participants of Group C will be matched with two other participants of Group D to form the **Group CD_1 and CD_2**.



Stage 3:

In Stage 3, you will be placed in a new group.

- Two participants of Group AB_1 will be matched with two other participants of Group CD_1 to form the **Group ABCD_11 and ABCD_12**.
- Two participants of Group AB_2 will be matched with two other participants of Group CD_2 to form the **Group ABCD_21 and ABCD_22**.

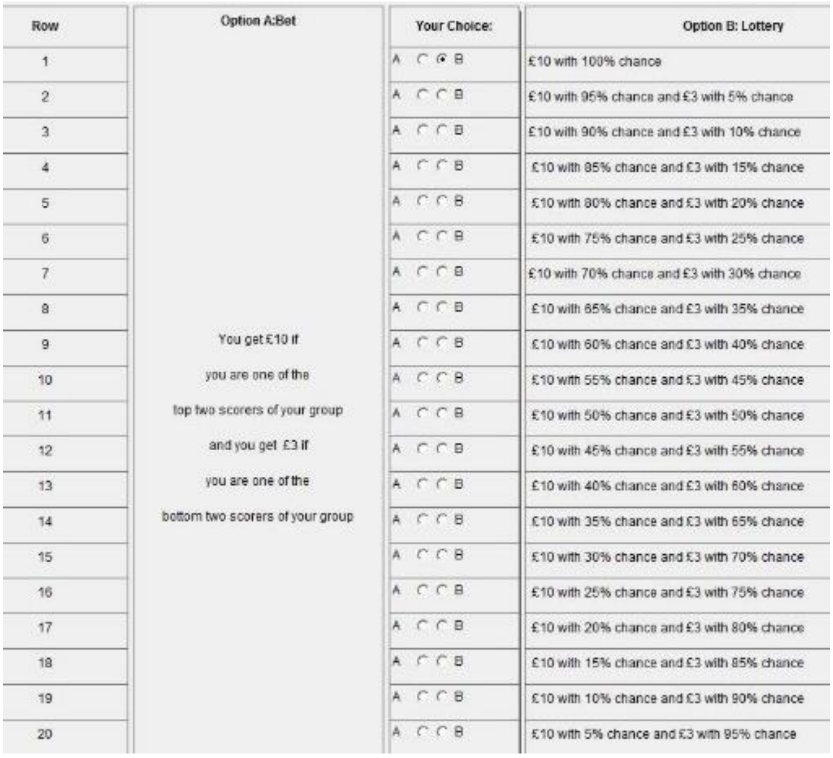


[Instructions for OwnFeedback treatment]

The experiment will consist of 3 stages. At each stage you will be in one of four groups consisting of four people. At each stage, you will have to do two things: fill out the Table and then complete the Circle Task.

Stage - Table:

For every row of the table you must make a choice between Option A and Option B. You should consider which of these two options you would prefer to have for each row then mark your choice by ticking the circle corresponding to your preferred option. In each table, we ask that you start with the top row and work your way down the rows. Option A will pay off £10 if you are one of the top two scorers of your group in this stage and £3 if you are one of the bottom two scorers of your group in this stage. You will complete the Circle task and find out if you are in the top two or bottom two after you have filled the table. Option B is a lottery which will pay off £10 or £3 with the chance of £10 progressively decreasing as you move down the rows. The chance of winning £10 from Option B in the first row is 100%. This is at least as good as the chance of being in the top two of your group, so we think that you will want to choose Option B in the first row. But, since Option B gets progressively worse as you move down the rows (while Option A stays exactly the same), there may come a row where the chance of winning £10 of Option B is sufficiently small, that you prefer Option A. If you find such a row, you should then choose Option A for that row and the rows below it (since Option B continues to get worse all the way down the table).



Row	Option A:Bet	Your Choice:	Option B: Lottery
1		A ○ ● B	£10 with 100% chance
2		A ○ ○ B	£10 with 95% chance and £3 with 5% chance
3		A ○ ○ B	£10 with 90% chance and £3 with 10% chance
4		A ○ ○ B	£10 with 85% chance and £3 with 15% chance
5		A ○ ○ B	£10 with 80% chance and £3 with 20% chance
6		A ○ ○ B	£10 with 75% chance and £3 with 25% chance
7		A ○ ○ B	£10 with 70% chance and £3 with 30% chance
8		A ○ ○ B	£10 with 65% chance and £3 with 35% chance
9	You get £10 if	A ○ ○ B	£10 with 60% chance and £3 with 40% chance
10	you are one of the	A ○ ○ B	£10 with 55% chance and £3 with 45% chance
11	top two scorers of your group	A ○ ○ B	£10 with 50% chance and £3 with 50% chance
12	and you get £3 if	A ○ ○ B	£10 with 45% chance and £3 with 55% chance
13	you are one of the	A ○ ○ B	£10 with 40% chance and £3 with 60% chance
14	bottom two scorers of your group	A ○ ○ B	£10 with 35% chance and £3 with 65% chance
15		A ○ ○ B	£10 with 30% chance and £3 with 70% chance
16		A ○ ○ B	£10 with 25% chance and £3 with 75% chance
17		A ○ ○ B	£10 with 20% chance and £3 with 80% chance
18		A ○ ○ B	£10 with 15% chance and £3 with 85% chance
19		A ○ ○ B	£10 with 10% chance and £3 with 90% chance
20		A ○ ○ B	£10 with 5% chance and £3 with 95% chance

Stage - Circle Task

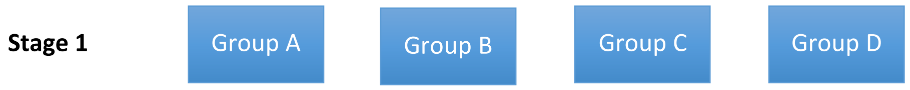
After you have completed the table you will complete the Circle task. You will have 20 tasks to complete similar to the practice set. After everyone has completed the task, your scores will be calculated. For each correct answer, 1 point will be added to your score so that you can score up to 20 points. Your score will be compared to the scores of the other members of your group and this will determine whether you were in the TOP or BOTTOM two scorers of your group for that stage. Ties will be randomly broken. You will then be assigned to a new group of four participants and the next stage will begin.

Stages

There are 3 stages in this experiment. At each stage, all 16 participants will be divided into groups of 4. At each stage, you will complete the Circle task and receive a score based on your performance. Similarly, each other group member will complete the Circle task, seeing an identical set of circles, scoring 1 point for each correct answer, and so scoring up to 20 points. Before completing the Circle task at each stage you will fill out the table as described above. After each stage, you will get feedback whether you were in the top or bottom of your group. The groupings at each stage are explained below.

Stage 1:

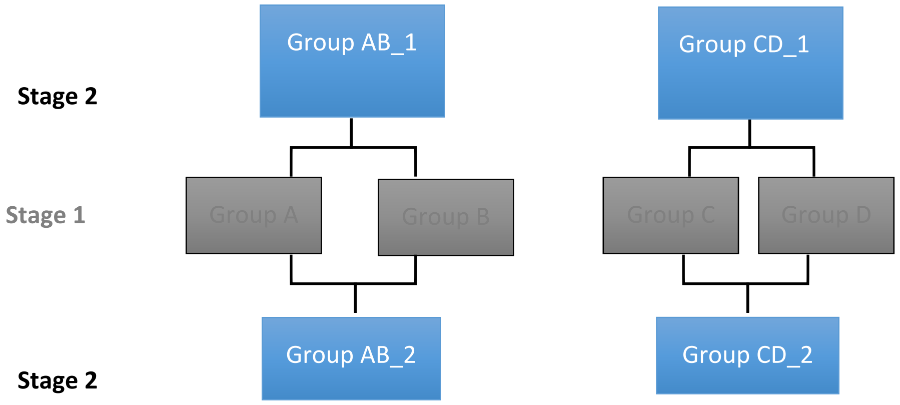
In Stage 1, you will be randomly matched with 3 other participants to form a group. There will be four groups: Group A, Group B, Group C and Group D. You will see which group you are in on your screens.



Stage 2:

In Stage 2, you will be placed in a new group.

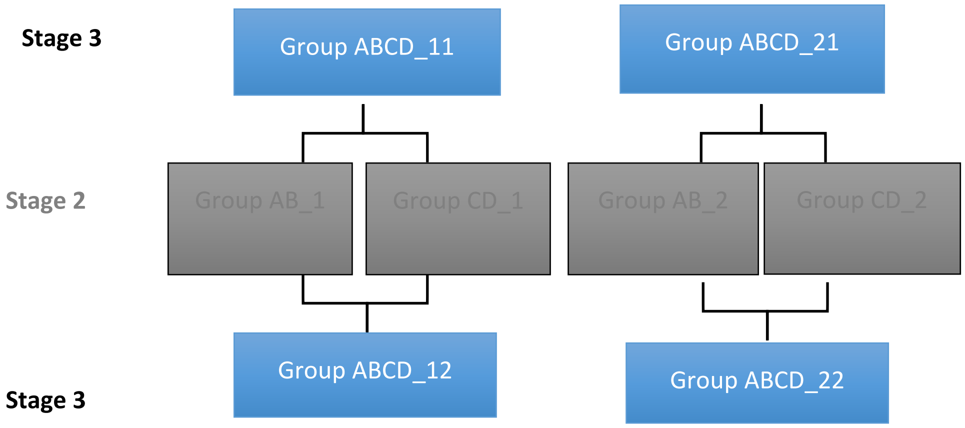
- Two participants of Group A will be matched with two other participants of Group B to form the **Group AB_1 and AB_2**.
- Two participants of Group C will be matched with two other participants of Group D to form the **Group CD_1 and CD_2**.



Stage 3:

In Stage 3, you will be placed in a new group.

- Two participants of Group AB_1 will be matched with two other participants of Group CD_1 to form the **Group ABCD_11 and ABCD_12**.
- Two participants of Group AB_2 will be matched with two other participants of Group CD_2 to form the **Group ABCD_21 and ABCD_22**.



[All treatments]

Payment

At the end of the session, a 6-sided die will be rolled. Depending on the outcome, you will be paid based on one of the stages and either the table or your performance in the Circle task.

Roll	Paid according to:
1	Stage 1 – Table
2	Stage 1 – Circle
3	Stage 2 – Table
4	Stage 2 – Circle
5	Stage 3 –Table
6	Stage 3 – Circle

If a table is selected, a 20-sided die will be rolled to select a row of that table and you will be paid according to your choices on the selected row. If you have chosen Option B on the selected row, you will play out the lottery of the selected row. If you have chosen Option A on the selected row, you will be paid £10 if you were in the top two of your group and £3 if you were in the bottom two of your group according to your scores in the selected stage.

If the Circle task is selected, you will get £0.50 for each correct answer so that you can earn up to £10.

This payment structure has been designed so that you have an incentive to do your best in the Circle task and to think carefully about each and every choice you have to make in the Table.

If you have read and understood the instructions you may start the experiment. If you have any questions, please raise your hand and someone will come to your desk to answer it.

Appendix C

	Instructions for the Circle Task: Practice the Circle Task		
	Instructions for all of the experiment		
Stage 1	**Groupings**	You are in Group A/B/C/D	
	Confidence	Fill in Confidence Elicitation Table	
	Task	Complete set of Circle Tasks	
	Feedback	“Press Continue to start the next Stage”	NoFeedback
		“Your Circle task Performance was in TOP/BOTTOM half of your group. Press Continue to start the next Stage”	OwnFeedback & FullFeedback
Stage 2	**Groupings**	You are in Group AB_1/AB_2/CD_1/CD_2	NoFeedback & OwnFeedback
		You are in Group AB_Top/AB_Bottom/CD_Top/CD_Bottom	FullFeedback
	Confidence	Fill in Confidence Elicitation Table	
	Task	Complete set of Circle Tasks	
	Feedback	“Press Continue to start the next Stage”	NoFeedback
		“Your Circle task Performance was in TOP/BOTTOM half of your group. Press Continue to start the next Stage”	OwnFeedback & FullFeedback
Stage 3	**Groupings**	You are in Group ABCD_11/ABCD_12/ BCD_21/ABCD_22	NoFeedback & OwnFeedback
		You are in Group ABCD_TopTop/ABCD_BottomBottom/ ABCD_TopBottom/ABCD_BottomTop	FullFeedback
	Confidence	Fill in Confidence Elicitation Table	
	Task	Complete set of Circle Tasks	
	Feedback	“Press Continue to start the next Stage”	NoFeedback
		“Your Circle task Performance was in TOP/BOTTOM half of your group. Press Continue to start the next Stage”	OwnFeedback & FullFeedback
		Post-Study Questionnaire	

Figure C1: Experimental Flow

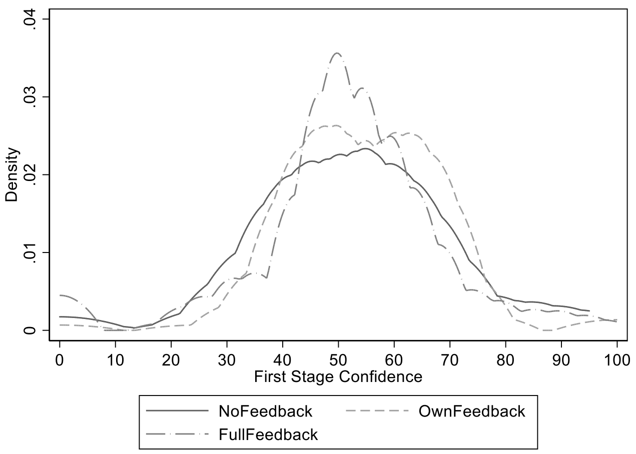


Figure C2: Kernel Density Estimates of Stage 1 Confidence

Table C1: Testing confidence snowballing interacting with the task difficulty

	TopTop	BottomBottom	TopTop	BottomBottom
Stage 2	6.18***	-5.07**	7.77***	-4.31
	(1.69)	(2.18)	(2.18)	(3.97)
Stage 3	11.74***	-12.50***	14.30***	-7.92*
	(1.92)	(3.16)	(2.74)	(5.00)
Difficult			-4.76	0.86
			(3.95)	(4.73)
Stage 2 × Difficult			-3.19	-1.52
			(3.38)	(4.38)
Stage 3 × Difficult			-5.14	-9.17
			(3.82)	(6.25)
Constant	17.95	53.92*	21.30	53.39*
	(20.77)	(31.91)	(21.63)	(32.00)
Controls	Yes	Yes	Yes	Yes
N	216	216	216	216
Adj R_sq	0.111	0.087	0.141	0.088

** 10%, ** 5%, *** 1% significance levels. Robust standard errors clustered at subject levels in parentheses. FullFeedback and OwnFeedback treatments. Control variables include actual performance score, gender and nationality dummies, age, general willingness to take risk, general level of confidence and competitiveness and whether any issues with eyesight was reported.*