Journal of Economic Behavior and Organization 213 (2023) 128–141

Contents lists available at ScienceDirect

Journal of Economic Behavior and Organization

journal homepage: www.elsevier.com/locate/jebo

Anger impairs strategic behavior: A Beauty-Contest based analysis[☆]

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ARTICLE INFO

JEL classification:
C92
D90
D91

Keywords:
Anger
Induced emotions
Strategic interactions
Beauty-contest

ABSTRACT

The frustration-aggression hypothesis posits that anger affects economic behaviour essentially by temporally changing individual social preferences and specifically attitudes towards punishment. Here, we test a different channel in an experiment where we externally induce anger to a subgroup of participants (following a standard procedure that we verify by using a novel method of textual analysis). We show that anger can impair the capacity to think strategically in a beauty-contest game, in a pre-registered experiment. Angry participants choose numbers further away from the best response level and earn significantly lower profits. Using a finite mixture model, we show that anger increases the number of level-zero players by 9 percentage points, a percentage increase of more than 30%. Furthermore, with a second pre-registered experiment, we show that this effect is not common to all negative emotions. Sad participants do not play significantly further away from the best response level than the control group and sadness does not lead to more level-zero play.

1. Introduction

Anger is an important emotion that pervasively affects many basic interactions in daily life. A growing economic literature has examined the effect of anger on economic decisions. The repercussions of anger on economic behavior that have emerged in the

☆ The authors thank several colleagues for discussions on this and related research, in particular Pierpaolo Battigalli, Jan Engelmann, David Gill, Peter Hammond, Thomas Hills, Elliot Ludvig, Tigran Melkonyan, Herve Moulin, Victoria Prowse, Andy Schotter, Daniel Sgroi, and Marc Willinger. University of Warwick Economics Department IRB approval obtained on March 2019. Registration numbers in the AEA Registry: AEARCTR-000426 for the first (anger) experiment and AEARCTR-0004729 for second (sadness) experiment.

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https://doi.org/10.1016/j.jebo.2023.06.027
Received 28 February 2022; Received in revised form 18 May 2023; Accepted 26 June 2023
Available online 22 July 2023
0167-2681/

literature are generally based on the frustration-aggression hypothesis (Dollard et al., 1939; Selten, 1978), which posits that anger results in hostile behaviour towards others regardless of whether the targeted person is responsible for the feeling of anger or not.[1] In general, this literature hinges on the hypothesis that anger and frustration induce a temporary change to individual social preferences, namely resulting in a different attitude towards punishment.[2] This paper examines the effects of anger from another angle: by looking at how such emotion affects the strategic ability. We see our approach as complementary rather than a substitute of the former.

Our results show that anger negatively affects the capacity to think strategically. This finding is puzzling given how pervasive anger is in life. Consistently with the argument in the psychology literature, anger, like other emotions, can serve as a credible commitment device in situations of conflict (e.g. Elster, 1998; Frank, 1987; 1988; Hirshleifer, 1987), and thus, can lead to greater evolutionary success in strategic interactions. If angry individuals do not think carefully about the consequences of their actions, as our results suggest, then others have reason to be wary when facing an angry individual in a strategic situation.[3]

Our work is in line with the cognitive psychology literature where it is posited that anger may lead to the impairment of cognitive processes. For example, it has been experimentally shown that anger promotes heuristic processing of information at the expense of more systematic processing.[4] Tiedens and Linton (2001) find that being angry leads to lower information processing as individuals rely more on persuasive messages and stereotypes, rather than on the strength of the arguments.[5] The effect emotions have on economic decision making has also received wide attention (e.g. Kőszegi, 2006; Loewenstein, 2000). Relatedly, it has been found that the perception or appearance of being angry can influence the behaviour of others around the angry individual (Andrade and Ho, 2009; Meshulam et al., 2012). Gneezy and Imas (2014) go a step further and show that individuals are able to strategically anticipate the effects of anger. They find that in a task where anger is beneficial, participants perform better, while in a task where anger is disadvantageous, participants perform worse. Interestingly, when given the opportunity to anger their opponent, participants elect to do so when this is performance impairing for their opponent and not when it would potentially be advantageous.

Our main hypothesis is that anger decreases the capacity to reason strategically. To test this, we conduct two experiments involving a beauty-contest game. In Experiment 1, we have an 'anger' group where prior to the start of the game we induce anger and a control group where no anger is induced but a placebo exercise is used instead. In order to evaluate whether any effects on strategic reasoning stem specifically from the feeling of anger and not from negative emotions in general, we conduct Experiment 2. The experimental design is identical to the first experiment but we instead induce sadness in the treated group.[6]

Our emotion-induction procedure involves asking participants to recall and write about previous experiences that led them to feel angry or sad. These procedures rely on methods and techniques validated and commonly used in the social psychology literature. Furthermore, to analyse the emotional content of participant answers to the induction questions, we use textual analysis (to the best of our knowledge we are the first to do that). We should highlight that our emotion-induction procedure induces incidental anger (or sadness) rather than provoking a conflict between players. This is a conscious design choice as our aim is to distinguish our proposed mechanism from anger that hinges on social preferences for punishment.[7]

We choose the beauty-contest game to assess the strategic ability across the treated and control groups, as social preferences are unlikely to affect behavior in this game (Eyster, 2019). In fact, as Carpenter et al. (2013) and Gill and Prowse (2016) show, the capacity to effectively play this game depends on cognitive skills. The capacity of performing well in a beauty contest depends on cognitive skills in two ways: the strategic ability of forming higher-order beliefs (level-k thinking, see: Duffy and Nagel, 1997; Ho and Su, 2013; Nagel, 1995; Stahl, 1996) and the capacity of forming correct beliefs about the strategic ability of opponents and best responding to them.[8] Since performing well in the beauty contest game conflates the effect of cognitive skills through these two avenues, we focus our

[1] For research examining another player in a game as a source of the anger, some examples include: Xiao and Houser (2005); Rotemberg (2005); Anderson and Simester (2010); Carpenter and Matthews (2012); Winter (2014); Winter et al. (2016); Akerlof (2016); Van Leeuwen et al. (2017); Passarelli and Tabellini (2017). For research examining the situation in which the other player is not the source of anger, some examples include: Card and Dahl (2011); Munyo and Rossi (2013). Gurdal et al. (2013) conduct research examining a situation in which the other player is probably the source of anger, while Battigalli et al. (2019) develop a general framework to analyse the frustration-aggression hypothesis. Related to our study, Ho et al. (1996, 1998) link very high choices in the repeated beauty contest game to the frustration-anger hypothesis. They find that previous losers express their frustration and annoyance by making the most wrong choice possible.

[2] The wider role of emotion on economic behaviour is recognized by a growing body of work. For example, Loewenstein and Lerner (2003) and Rick and Loewenstein (2008) consider the link between emotion and decision-making. Relatedly, Xiao and Houser (2005); Heilman et al. (2010) and Proto, Sgroi, Nazneen (2019b) analyze the link between emotion and social interactions. Furthermore, Oswald et al. (2015) and Bellet et al. (2019) show evidence of a positive effect of happiness on productivity.

[3] For example, if an angry individual does not properly weigh the future, they might inefficiently decide to abandon a bargaining process prematurely resulting in a loss for everyone involved.

[4] For a review, see Litvak et al. (2010).

[5] More generally, research in cognitive and affective sciences has emphasized strong interactions between emotions and cognitive processes (see Engelmann and Hare, 2018, for a review).

[6] According to a common characterization of emotions (Ekman, 1999), the basic negative emotions are: anger, disgust, fear, and sadness. We choose to induce sadness in Experiment 2 due to its similarity with anger, which allows us to maintain the same induction procedure in both experiments.

[7] Incidental emotions are external to the relationship under consideration. See Loewenstein and Lerner (2003) for a discussion of the distinction between incidental and anticipatory emotions.

[8] Often related to the so-called *Theory of Mind*, defined as the ability to think about others thoughts and mental states when predicting their intentions and actions (Coricelli and Nagel, 2009). Recently, Fe et al. (2022), have shown that Theory of Mind is predictive of level-k behaviour.

analysis on the distance from best response (in absolute terms) to assess subject performance instead of the k-level as it is typically done in the literature.

In Experiment 1, we find a strong negative effect of anger on strategic ability when playing the beauty contest game. Participants in the anger group make choices that are further away from the best response, given other players' choices. This deviation from best response play is significantly larger compared to participants in the control group. Furthermore, using structural estimation analysis, we find that there is an increase in the proportion of level-zero players in the anger group compared to the control group. In Experiment 2, we find that sadness has no significant impact on behaviour in the beauty contest game. Interestingly, our structural estimation analysis reveals that, if anything, sadness decreases the proportion of level-zero players. Furthermore, we find that sadness does not have a significant negative effect on profit. As sadness (a similar and related negative emotion to anger) lacks any effect on behaviour, we conclude that anger, and not negative emotions in general, diminishes strategic thinking capacity. A plausible concern could be that the induction procedure influenced the beliefs about how others would play the game. We do not believe this is a major cause for concern as we explicitly inform the participants that the emotional induction questions they are asked are not the same for everyone, thus, eliminating the possibility that they anticipate angry opponents.

Establishing a clear link between anger and strategic reasoning is important for at least three reasons. First, from a theoretical perspective, it provides an insight on how to incorporate anger in economic models of behavior. Second, it has implications for behavioural policies at the individual level. Third, because the effects of incidental emotions are pervasive in many economically relevant decisions (Lerner et al., 2004; Tice et al., 2001), and because such emotions may have an enduring and unconscious impact (Vohs et al., 2007; Andrade and Ariely, 2009), anger may represent a relevant negative externality for social interactions. This, in turn, represents a potentially important negative externality for a poor economy, who may be more likely to experience negative shocks (see e.g. Koren and Tenreyro, 2007), or among poorest socioeconomic classes, even in an otherwise vibrant economy, likely have little capacity to insure themselves from negative shocks that can generate potentially vicious, widespread cycles of anger and frustration.

The remainder of the paper is organized as follows. Section 2 describes our experimental design. Section 3 presents our experimental results. Section 4 structurally estimates the proportion of level-k thinking by condition and experiment. In Section 5, we illustrate the possible underlying mechanisms and discuss the potential confounding factors that may explain the results. Section 6 offers final remarks and conclusions. The online Appendix provides supplementary analysis and tables.

2. Experimental design

We study how anger affects strategic reasoning. Importantly, we want to be able to disentangle any effect of anger from the effects of negative emotions in general. We design an experiment encompassing three features: (1) exogenously manipulate emotions of participants, (2) assess the effect of emotion inducement on strategic thinking, and (3) compare the emotion inducement effect of two different negative emotions.

We administer two experiments in which participants are randomly allocated either to a treatment or a control group. Participants in the treatment group complete an emotional induction task (described in Section 2.1.1). In Experiment 1, the task induces anger, while in Experiment 2 the task induces sadness. Participants in the control group are asked to complete a similar placebo exercise, where no specific emotion is induced. Group members of both the treatment and control group are then matched in groups of three. These groups play together a p-beauty contest game for 10 rounds. Through studying the effect of both anger and sadness in the two experiments we can cleanly assess the effects of each of these negative emotions on strategic reasoning. In this way, we can infer whether any effect that anger has on cognitive reasoning is unique to the emotion of anger itself, or whether it is an effect of negative emotions in general.

Both experiments were pre-registered in the AEA Registry: AEARCTR-000426 for Experiment 1 and AEARCTR-0004729 for Experiment 2. In particular, pre-registration entailed a detailed description of the experimental design and the number of expected participants per condition. Moreover, the pre-registration underlined, as it will be carefully explained below, that the primary outcomes of the exercise would be both choices in the game as well as individual payoffs to understand the causal impact of anger and sadness on these outcomes. The University of Warwick Economics Department IRB approval was obtained on March 2019.

2.1. The experiment

At the outset of the experiment, participants are randomly allocated to a computer terminal. The participants, university students, are asked to complete a demographic questionnaire that includes information about their age, country of birth, university department, year of study, gender, and high school marks. Participants are then asked to complete the Positive and Negative Affect Schedule (PANAS) questionnaire (Schamborg et al., 2016; Watson et al., 1988). This questionnaire consists of two 10-item scales that measure positive and negative affect. Each item is rated on a five-point Likert scale. We add three further questions from the PANAS-X questionnaire (Watson and Clark, 1999). Two of these additional questions assess the emotions of interest: anger and sadness.[9] This questionnaire provides us with a measure of their overall emotional state before the induction takes place.[10]

[9] We also include a question about happiness as a control check.

[10] From now on, for the sake of simplicity, we refer to this set of questions as the PANAS questionnaire.

2.1.1. Emotional induction

Participants are randomly assigned to be part of the treatment or control group in both experiments. Those in the treatment group complete an emotion induction task designed to elicit the emotion of interest: anger (Experiment 1) and sadness (Experiment 2). Participants in the treatment group are asked to answer two questions about past life experiences. They have 10 minutes to respond to these questions and are not allowed proceed to the next part of the experiment until this time expires. Prior to reading and responding to the emotional induction questions, we highlight two things to the participants. First, we tell them that the exact questions they will be asked to answer are randomized which means that others will not necessarily be faced with the same questions. Specifically, the participants are told: "The specific questions you will be asked will be randomized. Therefore, you might not be asked the same questions as other people here in the room". Second, we inform them that they can answer these questions in their native language (the screenshot of how this is explained is in section B.1 of the online Appendix).[11]

In the anger manipulation in Experiment 1, the first question asks the participants to recall and list up to five events during which they had experienced feelings of anger. The second question asks them to carefully describe one of these events. Similarly, in the sadness manipulation in Experiment 2, we ask the participants to recall up to five events during which they had experienced feelings of sadness and to write in detail about one of these events.[12] Participants in the control group in both experiments are asked to recall up to five things they did earlier in the day and to describe in detail how they typically spend their evenings.

This method to induce emotions is known as "autobiographical recall" in the psychology literature. It is based on the idea that recalling an event that caused an individual to feel a specific emotion will make that individual recreate and relive that emotion.[13] We choose this method for several reasons. First, there is ample evidence in the psychology literature showing that autobiographical recall effectively induces anger and sadness.[14] Second, compared to the other methods, autobiographical recall more specifically induces the emotion of interest with limited arousal of related but different emotions (Lerner et al., 2003; Strack et al., 1985; Tiedens and Linton, 2001). Finally, this method allows us to ex-post perform text analysis to evaluate the effectiveness of the emotional induction.

2.1.2. Matching protocol

Following the emotional induction procedure, participants are randomly matched in groups of three. Each group consists of three participants that complete either the emotion manipulation, or the placebo exercise. That is, each trio consists of either one treatment group member and two control group members, or two treatment group members and one control group member. Importantly, participants are told only that they are matched with two other players. As we describe above, participants do not know the exact questions we ask the other group members. They are told that the questions that participants have to respond to are randomized, while participants are not informed about the exact matching protocol. This design, where participants are mixed in terms of the induction they received (in contrast to one where all participants receive the same induction) allows us to note to subjects that the other group members had a potentially different induction. This allows for beliefs about other responses to not be particularly affected by their own induction.

2.1.3. The beauty contest game

The participants play the p-beauty contest (Nagel, 1995). We follow closely the design in Gill and Prowse (2016). Participants in groups of three play the p-beauty contest for 10 rounds with fixed-group matching. In each round, participants choose an integer between zero and 100. The participants whose chosen number is closer to 70% of the mean of the three numbers earns £10.00, whereas all others earn nothing. If there is more than one winning number, then the winners equally split the £10.00, while the loser earns nothing.[15] In each round of this game, the unique Nash equilibrium is to choose zero.[16] In order to avoid wealth effects, participants are only paid one randomly chosen round out of the total of 10 rounds they play.

In each round, participants type the number in a given box; there is no time constraint. After all participants in a group make their choices, each participant is shown the following information about the game in that round: 1) the three chosen numbers in the group, 2) the 70% of the mean of the chosen numbers, 3) the winning number(s), and 4) their own earnings in that round.[17]

2.1.4. Other tasks

Upon completion of the game, participants respond to a few questions. They are asked to complete the PANAS questionnaire once

[11] Given the relatively large number of participants who are not native English speakers, we offer this option to encourage writing. In this way, we can prevent people from not answering because they were not comfortable with writing in English. Only one participant chose to write in a language other than English.

[12] Appendix B provides the screenshots of the induction task for each experimental condition. The induction questions are based on Small and Lerner (2008).

[13] Other methods, generally referred to as "mood induction procedures," include asking individuals to look at images, watch video excerpts, listen to music, and imagine certain scenarios. Additionally, other methods also rely on situational procedures (e.g., consumption of bitter drink to induce disgust). For a review see Lench et al. (2011) and Westermann et al. (1996).

[14] For a recent review see Siedlecka and Denson (2019).

[15] The monetary incentive offered for a round of the game is comparable with what is offered in the literature. For example, Gill and Prowse (2016) offer $6.00 for each round of the game. We choose to offer payment for only one randomly selected round to avoid any income effects. Importantly the monetary incentives offered are identical across conditions and experiments.

[16] See e.g. Gill and Prowse (2016) and López (2001) for the formal proof that takes into account that numbers in the game can only be discrete.

[17] In Appendix B we provide the screenshots of the instructions for the p-beauty contest game.

again. This allows us to assess the induction procedure by contrasting the responses to this questionnaire before and after the induction took place. Participants then self-report, on a nine-point scale, the degree to which they experienced different discrete emotions while they were writing about their personal past-life experiences (Rottenberg et al., 2007). Third, in Experiment 1, participants complete the State-Trait Anger Expression Inventory 2 (STAXI-2) questionnaire (Schamborg et al., 2016), which assesses ones disposition to anger (i.e., anger as a trait). Finally, the two last questions are regarding any previous experience with the p-beauty contest game and a non-incentivized general willingness to take risks question (Dohmen et al., 2011).

2.2. Experimental procedure

The experimental sessions were conducted from May to October 2019 at the economics laboratory of the University of Warwick. Overall, we recruited 351 participants through the university's SONA System for recruitment of participants in experiments. We conducted 11 sessions with 171 participants in Experiment 1, and 12 sessions with 180 participants in Experiment 2. Sessions lasted roughly 35 minutes. Participants earned an average payment of £8.33 including the show-up fee of £5.00. We coded and conducted the experiment using the oTree software (Chen et al., 2016). Tables A.1 and A.2 provide descriptive statistics of the sample. Tables A.3 and A.4 show that there are no significant differences across conditions in observable characteristics in the experiment.

At the onset of each session, participants were randomly allocated to a computer terminal, and the experimenter read aloud general instructions about the session. After that, detailed instructions about the experimental tasks were shown on the computer screens. A reminder of the instructions for each part of the experiment was shown at the bottom of each page. Participants were encouraged to ask questions to the experimenter at any point.

3. Results

In this section we show that the anger treatment induces participants to play further from the best response, given the choices of the other two players, and, consistently, leads to lower profits. Meanwhile, the sadness treatment has no effect on guesses and profits. Before presenting these results, we analyze whether the induction procedure itself was successful in inducing the emotions of interest.

3.1. Emotion induction

To analyse the emotional content of the answers to the induction questions, we use the Linguistic Inquiry and Word Count (LIWC) 2015 software. The LIWC software reads a specific text and counts each time a word in the text corresponds to a word present in the built-in dictionary.[18] The dictionary matches each word with psychologically relevant categories (e.g., affect word, social word, etc.). For instance, the word "cried" matches the following dictionary categories: Sadness, Negative Emotion, Overall Affect, Verb, and Past Focus. The software then computes the percentage of total words that match one of these categories. Following our example, if the word "cried" was found in the text, the scores for these five categories would increase.

We evaluate the emotion induction for our two emotion treatments, anger and sadness. Table 1 shows some examples of words in these categories and the number of words included in each of these.

In Figure 1, we present the results of the text analysis. In Experiment 1, the treated participants use significantly more angry words compared to those in the control group ($\Delta = 2.077$, p-value< 0.001; top-left panel of Figure 1).[19] Similarly, in Experiment 2, the participants treated with the sadness induction use more words associated with sadness than those in the control group ($\Delta = 2.628$, p-value<0.001; top-right panel of Figure 1). Importantly, in Experiment 1, the difference in the anger content of the text written between the treated and control group is significantly larger than the difference in the sadness content between the treated and control group ($\Delta = 1.633$, p-value<0.001; top-left vs. bottom-left panels of Figure 1). Similarly, in Experiment 2, the difference in the use of sad content between the treated and control group in Experiment 2 is significantly larger than the difference in the anger content between them ($\Delta = 2.094$, p-value<0.001; top-right panel vs. bottom-right panel of Figure 1).

These results highlight that, at a minimum, participants wrote about the episodes that they had been asked to address in the exercises.[20] This should have caused participants to relive the recalled event and experience once again the emotions related to it (see Section 2.1.1). We can confirm this using our data. We analyze self-reported measures of an array of discrete emotions felt in the experiment. In particular, we compare the responses to the PANAS questionnaire before and after the induction procedure.[21] Figure 2 reports the results of this comparison. There is an increase in reported anger in the anger treatment which is significantly different to the negligible change in the control ($\Delta = 0.280$, p-value$=0.004$; top-left panel), while the difference in sadness is not statistically

[18] The dictionary recognizes about 6400 English words.

[19] In this subsection, we compute Mann-Whitney tests to assess the differences in the emotions across conditions and experiments.

[20] In Appendix C we perform further text analyses by measuring total and negative affect in the texts by condition and experiment. Results are similar. Interestingly, if we look at the presence of words indicative of anxiety in the texts, levels are significantly lower compared to those for anger in the treated group of Experiment 1, and for sadness in the treated group of Experiment 2 (see Figure C.15).

[21] Given that we elicit the second iteration of the PANAS questionnaire after the beauty contest game is completed there could be some spillover effects of anger/sadness due to the game itself. However, we prefer this design to avoid that the effect of the emotional induction dissipated before the game itself was played. This is because there is some evidence in the literature that suggests that the duration of emotional states may be limited to only a few minutes (Gillies and Dozois, 2021; Isen et al., 1976; Verduyn et al., 2015).

Table 1
Anger and sadness categories in LIWC.

	Example	Words in Category
Anger	Hate, Kill, Annoyed	230
Sadness	Crying, Grief, Sad	136

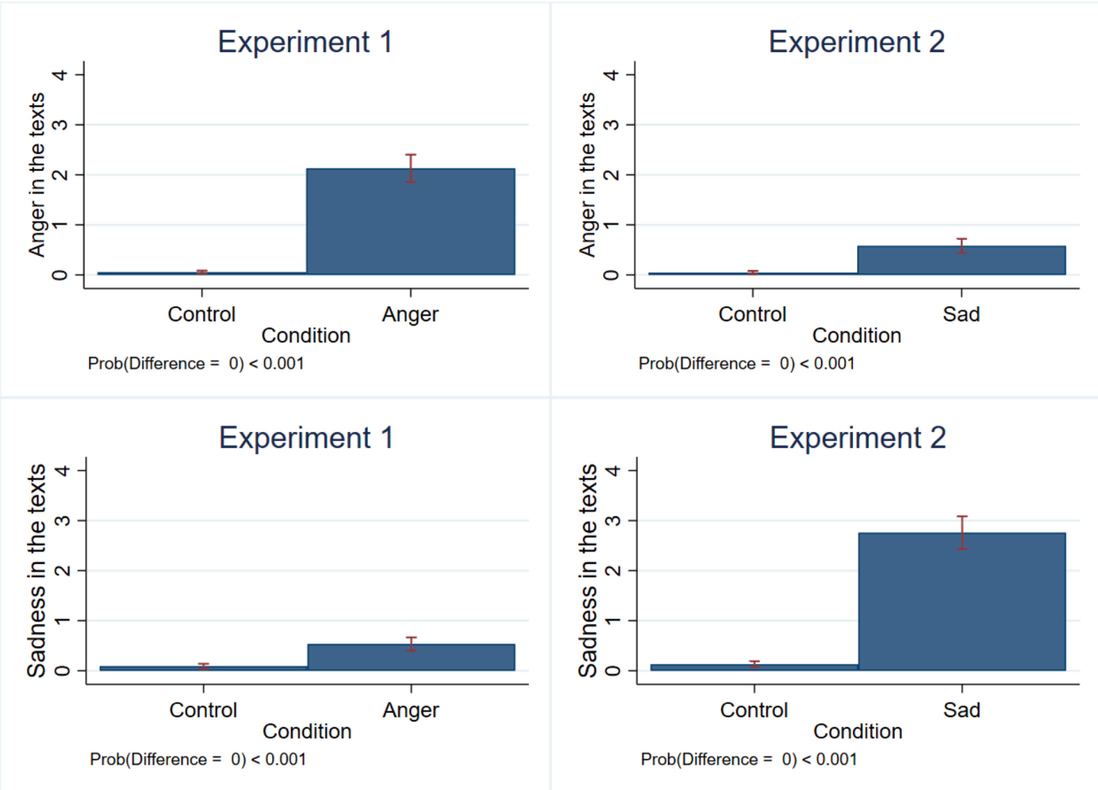

Fig. 1. Anger and sadness measured using text analysis. Notes: The bars report the averages of anger and sadness from the participants' written words for the different inductions. The bands represent the 95% confidence interval. The analysis is based on the Linguistic Inquiry and Word Count (LIWC2015) dictionary (Pennebaker, 2015). The p-values reported come from the corresponding Mann-Whitney test.

significant ($\Delta = -0.071$, p-value=0.478; bottom-left panel). In Experiment 2, the difference in reported levels of sadness, before and after the induction, is significantly greater in the sadness treatment compared to the control ($\Delta = 0.263$, p-value=0.014; bottom-right panel). We also find a slightly higher change in anger in the sadness treatment compared to the control, but this is not significant at conventional significance levels (p-value=0.078; top-right panel).[22]

In Appendix D.1 we further confirm that the induction procedure worked as intended by studying the answers to the Rottenberg et al. (2007) questionnaire. The analysis reported in Figure D.16 is consistent to our analysis in Figures 1 and 2. Additionally, in Figure D.17 in Appendix D.2, we report the responses to the first PANAS questionnaire to compare the general affect of the participants. There is no significant difference in either positive or negative affect at the baseline across conditions in both experiments. This is a further check that randomization into the treatment conditions produced balanced groups. More importantly, it shows that our experimental results cannot be driven by differences in affect at the baseline.

3.2. P-beauty contest game

Having shown that the induction procedure was successful in inducing the emotions of interest, we now analyze the effect of anger

[22] It is important to highlight that the differences we are comparing across here are between subjectively reported emotions. Individuals are not necessarily able to perform perfect emotion differentiation (e.g, Demiralp et al., 2012; Kashdan et al., 2015). Thus, we believe it is reasonable to observe slight changes in the emotion that was not the target, but importantly the main and statistically significant change is in the intended emotion.

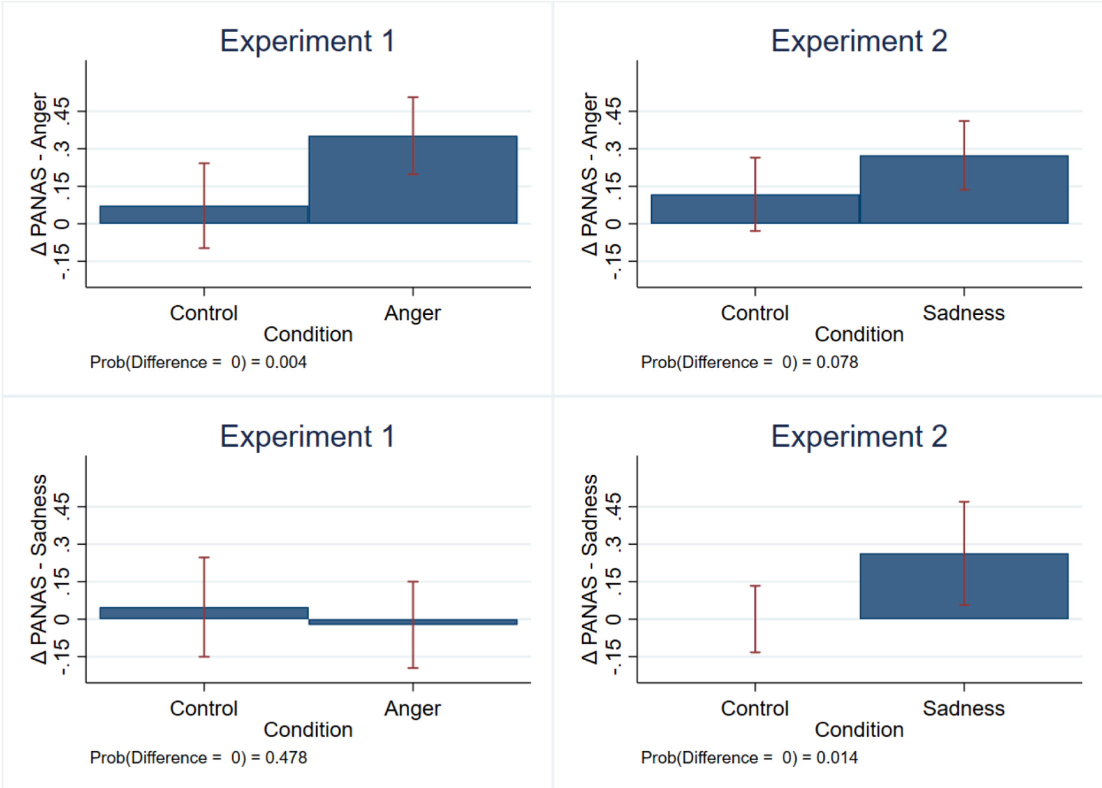

Fig. 2. Anger and sadness felt before and after the induction. Notes: The bars report the average difference between the level of anger or sadness participants reported feeling before and after the induction. The bands represent the 95% confidence interval. The question posed was "How much anger (sadness) are you feeling now?". Responses were coded from zero (low) to five (high). The p-values reported come from the corresponding Mann-Whitney test.

and sadness in the p-beauty contest game. This game allows us to assess how the different emotions induced influence strategic skills. These skills are characterized by the capacity of optimally reacting to others' actions and in predicting those actions.[23]

Accordingly, in what follows we assess strategic ability by measuring the capacity to best respond to others' guesses and payoffs from the game. Both of these are directly related to a participant's ability to optimally guess and predict the behaviour of others. Our three variables of interest are: proximity to the best response, payoffs, and guesses. We include the analysis of guesses in Appendix D.3. Furthermore, in Appendix D.3, we analyse the proximity to the Nash Equilibrium, zero, by studying average guesses.[24]

3.2.1. Best responses and payoffs

We first analyze the effect of the treatments on payoffs[25] and best responses in the two experiments. These variables are good proxies for an individual's capacity to anticipate others' behavior and to respond optimally through following these beliefs.

Given the rules of the game, the best response of participant $i \in 1, 2, 3$, of group j in round $t \in 1, 2 \ldots 10$ is $BR_{i,j,t} = \frac{0.7}{3}(BR_{i,j,t} + Guess_{j,t,1} + Guess_{j,t,2})$. By re-arranging we get:

$$BR_{i,j,t} = 0.304\left(Guess_{j,t,1} + Guess_{j,t,2}\right) \tag{1}$$

$Guess_{j,t,1}$ and $Guess_{j,t,2}$ are the guesses made by the other two participants in the same group in round t. We are interested in the capacity of guessing a number as close as possible to the best response, hence we will consider the difference in absolute value between the guess of player i, j at time t, $Guess_{i,j,t}$, and $BR_{i,j,t}$:

[23] This last capacity is often referred to as Theory of Mind, the process of mental modeling about others beliefs and actions (Coricelli and Nagel, 2009). That is, when thinking about others characteristics and beliefs, people build mental models that change and develop through continuous interactions and these can be used to anticipate the behavior of others.

[24] This can be considered a measure of strategic sophistication that, following Costa-Gomes et al. (2001), can be defined as the extent to which players in a strategic interaction analyze their environment as a game by taking the game structure and other players *incentives* into account when deciding how to behave.

[25] We analyse payoffs from all rounds, not only the payoffs from the specific round that is used for payment at the end of the session.

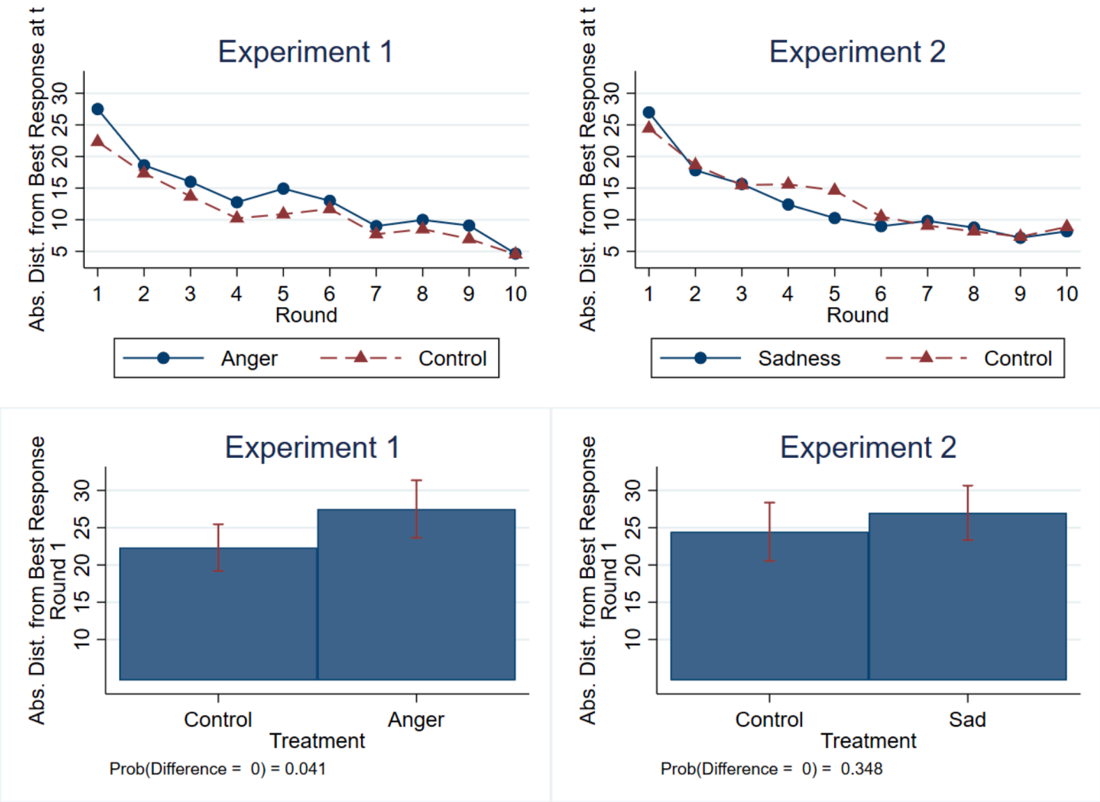

Fig. 3. The effect of anger and sadness on the average distance in absolute value from the best response. Notes: The lines in the top panels report the average distance in absolute value from the best response for each round of play by condition and experiment. The bottom panels report the average distance in absolute value from the best response in the first round by condition and experiment. The bands represent the 95% confidence interval. The p-values reported come from the corresponding *t*-test.

$$\Delta BR_{i,j,t} = \left|Guess_{i,j,t} - BR_{i,j,t}\right| \quad (2)$$

We show the average of this difference in each round and treatment in the top panel of Figure 3. The top-left panel of Figure 3 shows that the anger treatment results in more absolute distance from best response in every round. On the other hand, the sadness treatment does not have any clear effect as we can observe from the top-right panel. In the bottom panels of the figure, where we report averages for the first round only, we find that the anger treatment significantly increases the distance from best response already from the first round, while the sadness treatment does not. In fact, in the first round, the distance from the best response in the anger treatment is 27.51, which is significantly larger than in the control group, 22.32 (p-value=0.041). We also find a larger average distance for those who experienced the sadness treatment compared to those in the control group, but the effect is substantially smaller (26.99 vs. 24.46) and not statistically significant (p-value= 0.348).

The analysis on average distance from best response so far does not consider that guesses are influenced by past behavior. Therefore, in order to take into account previous game play and group fixed effects we estimate the following model:

$$\Delta BR_{i,j,t} = \beta_0 + \beta_1 Treatment_i + \beta_2 AverageGuess_{j,t-1} + \beta_3 t + \gamma_j + \epsilon_{i,j,t} \quad (3)$$

Where, i indicates the participant in group j, while t is the round of play. Our independent variable of interest is $Treatment_i$, which is a dummy variable indicating the emotion treatment individual i received in one of the two experiments. $AverageGuess_{j,t-1}$ is the average guess in the previous round, γ_j is the group-level fixed effect and $\epsilon_{i,j,t}$ is the error term.

We estimate Eq. (3) using an OLS estimation with clustered standard errors at the group level. The results are reported in Table 2. The first and second columns report the results for Experiment 1 and Experiment 2 respectively. The third column reports the results when estimating using the data from both experiments. The anger treatment has a positive and significant effect on the distance from best response. That is, anger has a negative effect on precision and strategic ability. The imprecision of participants in the anger treatment is about 1.9 units higher compared to those in the control. The sadness treatment has no significant effect on how far guesses

Table 2
The effect of the treatment on the distance from the best response (in absolute value) in both experiments.

	Experiment 1	Experiment 2	Experiments 1 & 2
	Distance BR	Distance BR	Distance BR
Anger Treatment	1.867**		1.867**
	(0.795)		(0.791)
Sadness Treatment		-0.552	–0.552
		(0.980)	(0.976)
Average Guess at $t-1$	-0.129	-0.006	-0.010
	(0.016)	(0.015)	(0.011)
Round	-1.557***	–1.378***	–1.469***
	(0.308)	(0.257)	(0.201)
Group Exp FE	Yes	Yes	Yes
N	1539	1620	3159
Individuals	171	180	351
R2	0.164	0.150	0.156

Notes: OLS estimator; Standard errors (shown in parentheses) clustered at the group level. * p-value<0.1, ** p-value<0.05, *** p-value<0.01.

are from the best response.[26]

In Figure 4, we report average payoffs per round (top panels) and first round only (bottom panels) in the two experiments. Consistently with the previous results, the anger treatment results in lower payoffs in almost every round. The sadness treatment appears to have some detrimental impact on payoffs, but this is not as clear-cut as in the anger treatment. In the bottom panels of the figure, we notice that both the anger and sadness treatments results in lower average payoff in the first round, albeit not statistically significant. Importantly, the effect of the anger treatment on average payoffs is larger in magnitude compared to the sadness treatment. In the first round, the average payoff for those who experienced the anger treatment is £2.84 which is smaller than in the control group (£3.86), though not statistically significant (p-value=0.139). We also find lower average payoffs for those who experienced the sadness treatment compared to those in the control group, but the difference is substantially smaller (£3.18 vs. £3.51; p-value=0.628).

As before, we perform OLS estimations to analyze the impact of the treatments on payoffs, while also taking into account previous game play. We estimate the following model:

$$Payoff_{i,j,t} = \beta_0 + \beta_1 Treatment_i + \beta_2 AverageGuess_{j,t-1} + \beta_3 Guess_{j,t,1} + \beta_4 Guess_{j,t,2} + \gamma_j + \epsilon_{i,j,t} \tag{4}$$

This model is similar as the one in Eq. (3) with two further controls. The guesses made by the other two participants in the same group play in the current round t, $Guess_{j,t,1}$ and $Guess_{j,t,2}$. It is important to include these as payoffs are influenced by the guesses of the other players. We again cluster standard errors at the group level.

We present the results of this estimation in Table 2. The first and second columns report the results for Experiment 1 and Experiment 2 respectively. The third column reports the results for when we combine the data from the two experiments. In the first column, we note that the anger treatment significantly reduces payoffs per round by about £0.65 (p-value=0.047). Meanwhile, in the second column, the coefficient of the sadness treatment is smaller in magnitude (£0.53) and non-significant (p-value=0.147). We find the same results when the two experiments are pooled together in one regression (third column).[27] We additionally also estimate individual random effects models with results being qualitatively similar (see Appendix D.4.4).

The results in this section show that anger impairs the capacity of thinking strategically, while sadness does not seem to have any clear effect. We have focused the analysis on distance from the best response and payoffs to measure the effects on strategic ability.[28] For completeness, in Appendix D.3, we also show that angry participants play further away from 0, the unique Nash equilibrium level.[29]

4. Structural level-k model

In the beauty contest game, players will often not play the Nash equilibrium number, zero. This is essentially due to the fact that players do not typically expect that other players are fully rational (i.e. common knowledge of rationality condition is violated).

[26] In Table D.6 in Appendix D.4.1, we also control for observables such as gender and age and find the results reported in Table 2 are robust to this specification.

[27] In Table D.7 in Appendix D.4.1, we also control for observables such as gender and age and find the results reported in Table 3 are robust to this specification.

[28] Our results are robust to controlling for demographics. In tables D.6 and D.7 in Appendix D.4.1 we present some additional regression analysis where we control for demographics: gender, age, education, risk preferences and previous experience with the game.

[29] This is a measure often used in the literature to assess the level of strategic sophistication of the participants in a beauty contest game, (e.g. Eyster, 2019, for a survey). However, this measure does not take into account the capacity of the participants to predict other participants' guesses (what we have referred to as Theory of Mind). For this reason we believe the absolute distance from best response is a better index of strategic ability in the beauty contest game.

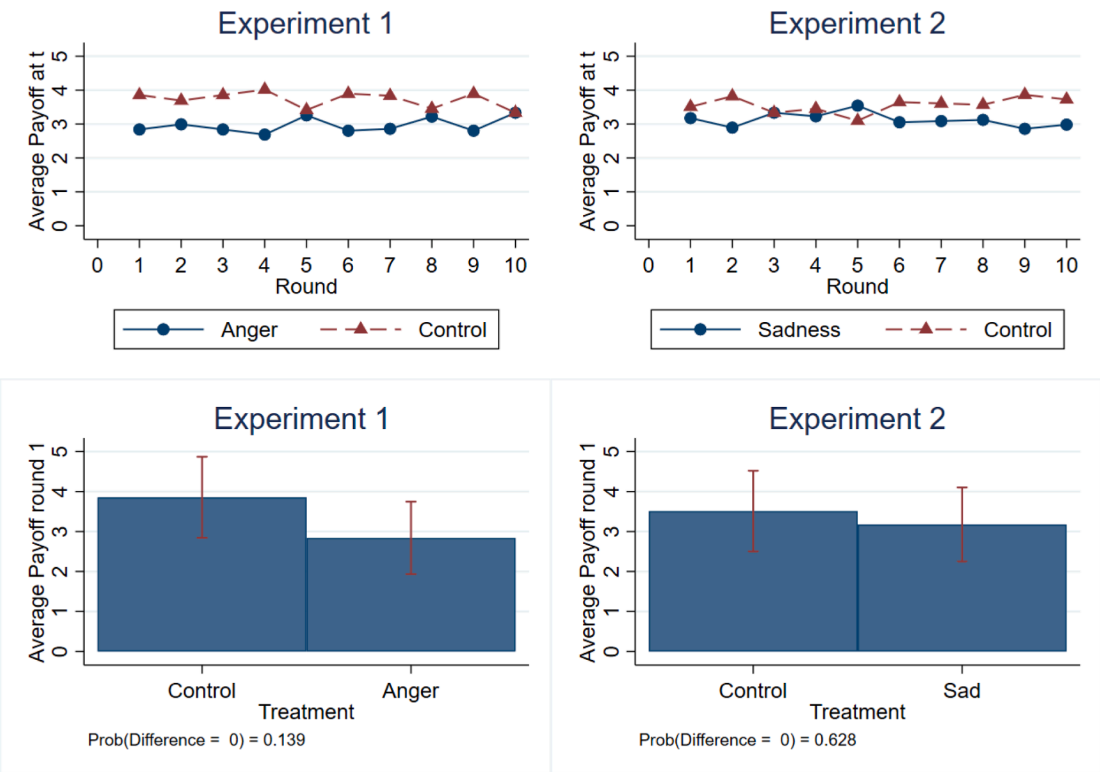

Fig. 4. The effect of anger and sadness on payoffs in both experiments. Notes: The lines in the top panels report average payoffs for each round of play by condition and experiment. The bottom panels report average payoffs in the first round by condition and experiment. The bands represent the 95% confidence interval. The p-values reported come from the corresponding *t*-test.

Table 3
The effect of the treatment on payoffs in both experiments.

	Experiment 1	Experiment 2	Experiments 1 & 2
	Payoff	Payoff	Payoff
Anger Treatment	-0.659*		-0700*
	(0.324)		(0.323)
Sadness Treatment		–0.527	–0.530
		(0.359)	(0.358)
Guess other player (1) at *t*	0.060**	0.042**	0.049**
	(0.009)	(0.007)	(0.006)
Guess other player (2) at *t*	0.034**	0.051**	0.042**
	(0.007)	(0.006)	(0.005)
Average Guess at t-1	–0.018**	–0.019**	–0.018**
	(0.003)	(0.002)	(0.002)
Group Exp FE	Yes	Yes	Yes
N	1539	1620	3159
Individuals	171	180	351
R2	0.056	0.055	0.054

Notes: OLS estimator; Standard errors (shown in parentheses) are clustered at the group level.
* p-value<0.05.
** p-value<0.01.

Therefore the ability to win is determined by the capacity of forming higher order beliefs *and* the capacity of correctly predicting the behaviour of others. In order to understand the effect of anger solely on the capacity of forming higher order beliefs, we estimate a finite mixture model, in which individuals are grouped according to the different latent k-rule chosen. Using this model, we can estimate the impact of anger on a player's level-k rule. We first describe the model and then present the estimation strategy and results.

4.1. The model

We assume that guess $x_{i,g,t}$, in which i is the participant in group g and round t, is an independent draw across rounds and participants. Let $k_{i,g,t} \in [0, 1, \cdots, \bar{k}]$ be the rule followed by participant i in group g and round t.

When the choice rule is $k = 0$, we assume that individuals guess randomly. Thus, the guess per individual and round is uniformly distributed, with probability:

$$Pr\left(x \middle| k_{i,g,t} = 0\right) = 1/101. \tag{5}$$

When the choice rule is $k > 0$, we assume that the guess of participant i in group g and round t follows a normal distribution $N(x|\mu_{k,t,g}, \sigma)$, characterized by the mean $\mu_{k,t,g}$ and the variance σ.

- For any round $t > 1$, let $\bar{x}_{g,t-1}$ be the average guess in group g for round $t-1$. We assume that individuals at round t make their guess using the average guess of their group, $\bar{x}_{g,t-1}$ (which they are informed about at the end of round $t-1$).[30] Accordingly, because participants choosing a strategic rule k best respond to the ones choosing a rule $k-1$, we assume that the mean of the distribution of their guesses is $\mu_{k,t,g} = \left(\frac{7}{10}\right)^k \cdot \bar{x}_{g,t-1}$.
- In round $t = 1$, participants choosing $k = 1$ best respond to those with $k = 0$ by estimating the mean of the uniform distribution of the guesses made by the $k = 0$ participants. Hence, $\bar{x}_{g,0} = 50$ and $\mu_{1,1,g} = \left(\frac{7}{10}\right) \cdot 50$. Participants choosing a rule $k = 2$ best respond to the ones choosing $k = 1$, with $\mu_{2,1,g} = \left(\frac{7}{10}\right)^2 \cdot 50$, and so on.

As a result, the probability of guessing any x for an individual i in g at round t and a rule $k_{i,g,t} > 0$ is:

$$Pr\left(x \middle| k_{i,g,t} > 0\right) = N\left(x \middle| \mu_{k,t,g}, \sigma\right) \tag{6}$$

Let $z(k)$ be the distribution of the choice rule among the different participants in the different rounds. The unconditional probability of any guess x of any i in group g at round t is then:

$$Pr(x) = \sum_{k>0}^{\bar{k}} z(k) N\left(x \middle| \mu_{k,t,g}, \sigma\right) + z_{k=0}(k)(1/101) \tag{7}$$

4.2. Estimation strategy

We use the experimental data from both experiments. This includes 351 participants, who make a total of 3510 guesses across the 10 rounds of play. We estimate the vector of parameters $\theta = [\sigma, z(k)]$ for each treatment and experiment.

We assume that there are up to level-4 participants (hence $\bar{k} = 4$) and that the distribution $g(x|\mu_{k,t,g}, \sigma)$ is normally distributed with mean, $\mu_{k,t,g}$, and variance, σ. Thus, θ consists of five parameters (remember that for $k = 0$, x is assumed to be uniformly distributed). Given our assumptions, the probability of all observed guesses for any individual and round, $\mathbf{x}$, is $Pr(\mathbf{x}) = \prod_{t=1}^{10} \prod_{g=1}^{N} \prod_{i=1}^{3} Pr(x_{i,g,t})$. We maximize the likelihood: $L(\theta, \mathbf{x}) = Pr(\mathbf{x})$, where $\theta = [\sigma, z(k)]$.

We perform this estimation using a standard MATLAB routine, where we maximize the sample log likelihood function. Table 3 shows the estimated level-k types by condition in Experiments 1 and 2. Notice how the anger treatment increases the share of level-0 play to about 35 percent (from 0.253 in the control), halves the share of level-2 play (from 0.177 to 0.089) and decreases the share of level-1 play (from 0.532 to 0.509). Overall, the anger treatment leads to a decrease in the average level-k from 1.001 to 0.864. We do not observe the same patterns in Experiment 2. In fact, the sadness treatment, if anything, leads to a lower share of level-0 choices.[31]

5. Heterogeneous effects, mechanism, and potential confounding factors

In Tables D.9-D.12 in Appendix D.4.3, we repeat the regression analysis of deviating from best response and payoff but now focus on the scope of heterogeneous effects depending on the composition of the groups in both experiments. Specifically, we estimate the regressions separately for groups composited by two treated and one control player (type I group) and groups composed by one treated player and two subjects in which no emotion was induced (type II group). For experiment 1, we find that in both group types there is a

[30] Gill and Prowse (2016) find that assuming that participants do not take into account the effect of their own guesses on the mean leads to a better estimation fit. We follow them in assuming the same.

[31] In Appendix E we report the results of additional structural estimations to assess the robustness of the results we report in Table 3. In Table E.16, we present the results using an alternative hypothesis on the distributional form of choices. We assume instead that choices follow a Poisson distribution and obtain qualitatively similar results. In Table E.18 we present the results in which we include an additional level-0 type player assumed to mimic the previous average guess in their group. Once again, our results remain robust to this variation. In Table E.17, we repeat the same analysis as reported in Table 3 but we censor choices above 70 (above the dominance cut-off), while in Table E.19 we again censor at 70 but also assume two level-0 types (random and mean). In both cases we find that are results are robust to these variations.

Table 4
Estimated Level-k types by treatment and experiment.

	Experiment 1		Experiment 2	
	Control	Anger	Control	Sadness
Level 0	0.253	0.343	0.302	0.218
Level 1	0.532	0.509	0.538	0.691
Level 2	0.177	0.089	0.118	0.048
Level 3	0.038	0.059	0.039	0.043
Level 4	0.000	0.000	0.002	0.000
σ	3.967	3.501	3.410	4.806
Log likelihood	-3,114	-3,408	-3,216	-3,547
Average Level-k	1.001	0.864	0.901	0.915

negative influence of anger in terms of lower payoffs, but this effect is only statistically significant for type I groups.[32] We do not find any heterogeneous effects depending on group composition in experiment 2. That is, the sadness treatment does not significantly change the deviation from best response or payoff irrespective of whether a player is part of a type I or type II group.

These results could be interpreted in light of the structural estimations conducted above. In fact, in type I groups there is more level-0 play (driven by two angry players), which makes subjects in the control more likely to take advantage of this by best responding to level-0 play and, thus, earning higher payoffs on average. In type II groups, as there is less level-0 play, higher level players compete for the prize, and thus their payoffs are lower compared to similar higher-level play in type I groups. This explains why, while the payoffs of angry players are relatively constant across the two group types, they are higher on average for control subjects in type I groups compared to type II groups.

Overall, our results show that anger negatively affects strategic reasoning and Theory of Mind. Although, in this paper we are agnostic about the exact cognitive mechanism, it is instructive to briefly discuss it.

One possibility is that anger leads players towards using System I thinking, which is faster and more instinctive, thus, less elaborated. For example, Alós-Ferrer and Buckenmaier (2021) and Gill and Prowse (2023) show that higher level-k participants take longer to think through their guesses in the beauty contest game. Another possibility is disengagement, angry players (but not sad ones) may feel disinterested on the ongoing process they are involved in and take decisions with less deliberation or, equivalently, anger can lower the value of winning, which, can lead to less effort being exerted in thinking as Alaoui and Penta (2016, 2022) posit. A third possibility is that anger can more generally impair cognitive processes. Obviously, these mechanisms are not mutually exclusive and can reinforce each other. All three possibilities point towards less deliberation when deciding on a guess.

A potential concern can be that the induction changed beliefs about the play of others in the game. For instance, participants could have anticipated the effect of the induction procedure and accordingly adapted their guesses in the game. We find this prospect unlikely. When the emotion induction procedure is described to the participants we do not inform them about whether the others in the group receive the same tasks. In particular, we explicitly inform the participants that the questions they would receive are not the same for everyone (see Figure B.3 in the Appendix). Moreover, these second-order beliefs should only matter for first-round guesses, while they should be much less relevant once participants have played the first round and have observed the guesses of others.

6. Conclusions

Our results provide strong evidence that anger impairs the capacity to think strategically. In Experiment 1, where we induce anger, we find that angry participants make significantly worse guesses in a p-beauty contest game. The angry players earn less than players in the control group. Furthermore, angry players more often use level-0 thinking. In Experiment 2, where we induce sadness instead of anger, we do not find similar effects.

The fact that anger is so pervasive in human relationships when it has a negative effect on strategic thinking capacity is puzzling. The literature (e.g. Elster, 1998; Frank, 1987; 1988; Hirshleifer, 1987) has emphasized that anger can serve as an efficient commitment device in strategic interactions. Our findings suggest that angy individuals fail to consider the potential repercussions of their actions, which gives reason for others to exercise caution when encountering an angry person in a strategic situation.

Our results have implications for behavioral policies. Ex-post anger is detrimental and it would be optimal to control it. On the other side, ex-ante, showing high anger propensity, the so-called 'madman theory' may represent a bargaining advantage. Niccolò Machiavelli argued that sometimes it is "a very wise thing to simulate madness" (Machiavelli, 2009, book 3, chapter 2).

Proto et al. (2019a) show that cooperation rates on a non zero-sum complex game, such as the repeated Prisoner's Dilemma, positively depends on the cognitive abilities of players. Putting together such results and the results in the current paper, it is natural to hypothesize that anger would have a detrimental effect on cooperation. This hypothesis is supported by the results reported in Castagnetti et al. (2018) using a repeated Prisoner's Dilemma game, where participants are induced to feel anger through the use of a standard video induction procedure. Thus, we argue that the negative effect of anger on strategic reasoning can represent a negative

[32] In type I groups, mean payoff (mean deviation from best response) is £2.90 (13.94 units) for players treated with anger, whereas it is £4.19 (10.45) for control group members. In type II groups, mean payoff (mean deviation from best response) is £3.11 (12.61 units) for the angry players, while it is £3.45 (11.95) for those in the control.

externality for an economy and a society in aggregate because it can potentially reduce cooperation in situations in which cooperation is likely beneficial. Therefore, anger can generate self-sustaining, vicious cycles, particularly in environments in which anger-producing events are more frequent such as in poorer countries, during times of negative economic shocks, and among poorer, disadvantaged socioeconomic classes.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2023.06.027.

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