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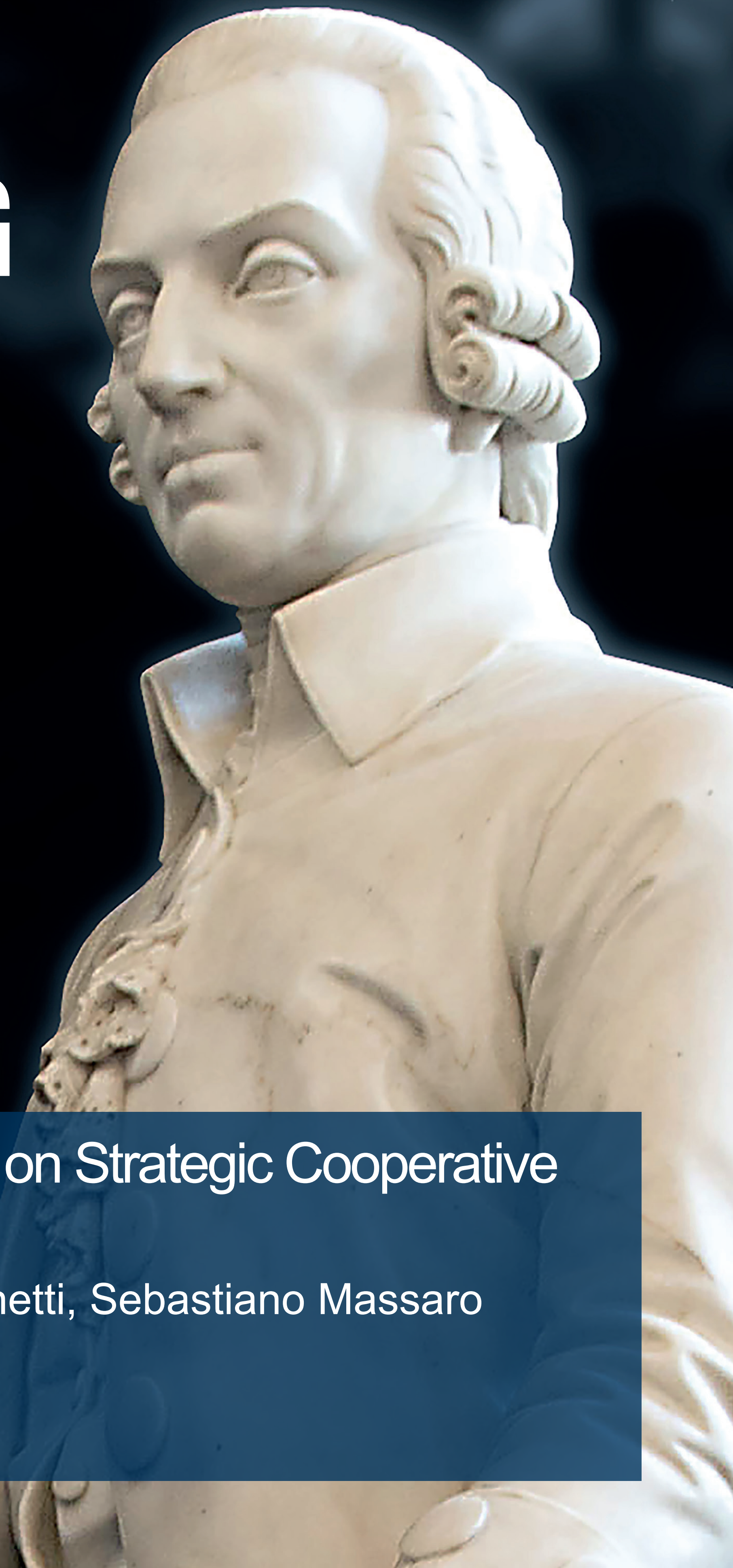

The Influence of Anger on Strategic Cooperative Interactions

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THE INFLUENCE OF ANGER ON STRATEGIC COOPERATIVE INTERACTIONS

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Abstract

We investigate the effect of anger on performance and strategic cooperative interactions. In a laboratory experiment, we induced anger in participants playing an indefinite repeated Prisoner's Dilemma game against each other, showing resulting declines in performance and individual profit. We assess the dynamics of strategic cooperative decisions and behaviors, revealing that anger-induced subjects used suboptimal strategies. We further describe the underpinning mechanism of automatic emotional regulation by analyzing participants' heart rate variability indexes. Finally, we extend our findings in an online experiment with an independent sample, increasing generalizability and helping explain how anger influences participants' ways of strategizing. Altogether, our contribution advances theoretical and practical implications regarding the impact of discrete emotions on strategic outcomes.

Keywords: anger; behavioral strategy; heart rate variability; indefinite repeated Prisoner's Dilemma; strategic cooperative interactions

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INTRODUCTION

The recent revival of the Carnegie School's agenda (e.g., Cyert and March, 1963; March and Simon, 1958; Simon, 1947) has brought the role of individuals' behaviors and interactions back to the center stage of strategic management research (see, e.g., Felin, Foss, and Ployhart, 2015; Gavetti, Levinthal, and Ocasio, 2007; Powell, Lovallo, and Fox, 2011). By seeking to bring a more naturalistic approach to the neoclassical economics perspective—which argues that individuals' expected behaviors arise from "rational" cost-benefit computations—scholars have put forward extensive analyses on the influence of cognitive and affective states, and of behavioral interactions between decision-makers, on strategic outcomes (e.g., Gavetti, 2005; Helfat and Peteraf, 2015; Hodgkinson and Healey, 2011; Levine, Bernard, and Nagel, 2017; Lovallo, Clarke, and Camerer, 2012; Teece, 2007; Winter, 2013).

Amid these research advancements, explanations of the causal mechanisms by which discrete emotions impact strategy-driven behavioral outputs and performance have, however, been limited and far from conclusive. Undeniably, emotions enrich and characterize working life (e.g., Ashkanasy and Daus, 2002; Barsade and Gibson, 2007; Elfenbein, 2007), influence group relationships (Barsade, 2002) and shape decision-making processes (Loewenstein, 2000) and strategic implementation (Huy, 2011). Strategy researchers have thus called for a more nuanced comprehension of individuals' emotional capacities (e.g., Hodgkinson and Healey, 2011; Powell, 2014), as well as of the affective microfoundations of dynamic capabilities (Zott and Huy, 2013). Several others have approached the investigation of emotions through overarching affectivity frameworks (e.g., Delgado-García and De La Fuente-Sabaté, 2010; Håkonsson *et al.*, 2016). Yet, the theoretically and methodologically complex research questions of how and why discrete emotions directly influence strategic outcomes have thus far been accompanied by little empirical evidence.

In this article, we aim to advance this knowledge domain by specifically investigating the effects of anger on performance and strategic cooperative interactions. Anger is a multifaceted negative emotion linked to individuals' behaviors, traits, and physiological responses (Averill, 1982; Fijda, 1986). It is elicited by patterns of relationships, enduring pressure, high-stakes situations, and elements of the competitive environment that are often beyond individuals' own control (Gibson and Callister, 2010). What's particularly intriguing about anger is that research has yet to settle on its behavioral effects and outcomes in work organizations. On the one hand, anger may impair organizational performance and interactions (Allred, 1999; Fitness, 2000; Skarlicki and Folger, 1997); on the other hand, it may spark proactivity and drive sustained organizational goals (Geddes and Callister, 2007; Keltner and Gross, 1999; Lebel, 2017; Lewis, 2000). Moreover, anger conveys specific intentions to interaction partners and can thus profoundly affect cooperative efforts toward mutual objectives and value-added efficiency (Bowles and Gintis, 2002; Keltner, Haidt, and Shiota, 2006; Wubben, De Cremer, and Van Dijk, 2008).

Thus, in order to disentangle the influence of anger on strategic outputs, we must both clarify the directionality of its effect and then unravel the associated individuals' behavioral strategies and underlying mechanisms. For these reasons, we trust that a question-driven analysis is the optimal research avenue to address this issue. We conduct such an analysis and present its solution through experimental investigations that take advantage of state-of-the-art elements of behavioral science, economics, and neuroscience. We use an affective induction procedure to elicit anger (Westermann, Stahl, and Hesse, 1996) and an indefinite repeated Prisoner's Dilemma game (Dal Bó and Fréchette, 2011) to assess collective and individual strategic outcomes. Moreover, we integrate implicit and explicit assessments of emotional response by using self-reported and heart rate variability (HRV) data (Massaro and Pecchia, 2017). In this way we seek to both increase methodological accuracy and appreciate the psycho-physiological mechanisms at stake in anger-induced individuals.

We unfold the remainder of this paper as follows. First, we review existing knowledge that motivates our exploratory investigation on the effects of anger on performance and strategic cooperative interactions. Next, we explain our experimental design and analytical approach. In summary, in a laboratory setting, we performed a between-subjects experiment over multiple sessions, inducing anger in one group of subjects. We asked participants to perform a repeated cooperative game, while measuring in real time their physiological responses. We examine and discuss the results of this study to show that anger reduces overall performance as well as individual profit. This evidence is driven by a behavioral mechanism that lowers strategic cooperative interactions and optimal strategies. Moreover, HRV analysis shows significant shifts in the neurophysiological indexes associated with regulated emotional responding. We then extend the behavioral results in an independent sample in which online participants are matched against computers. This study allows us to provide further generalizability to our overall findings and show that anger leads subjects to display suboptimal responses to more sophisticated strategies. Finally, we consider the overall results' contribution to the advancement of the behavioral strategy research program. We conclude with several implications and future research avenues that our work brings to the forefront of strategic management.

THEORY AND RESEARCH MOTIVATION

In recent years, the field of strategy has strived to advance realistic and naturalistic assumptions about individuals' cognition, emotions, and social interactions (Powell *et al.*, 2011). Gavetti *et al.* (2007) and Gavetti *et al.* (2012), among others, have highlighted that a behavioral approach can benefit from both a closer look at the postulates of the Carnegie School and the integration of theories and experiments currently used in cognate disciplines (e.g., economics, psychology). Herbert Simon's message (1947), and the later insights by Cyert and March (1963), advanced the idea that strategists are called upon to help manage multiple organizational units, each with interdependent goals, resources, motives, and actors. These interactions necessarily involve cooperative processes which take place among different and multiple individuals (e.g., Lawrence and Lorsch, 1967; Miles *et al.*, 1978). In this respect, the Carnegie School set a vital theoretical apparatus to associate the interdependencies and behavior of boundedly rational individuals (Simon, 1945) with strategic outcomes (e.g., Argote and Greve, 2007).

More recently, there has been growing evidence that human information-processing abilities, including those related to strategizing and decision making (Huy, 2012; Powell *et al.*, 2011), are strongly controlled by emotions and their regulatory processes (Bechara, Damasio, and Damasio, 2000; Forgas and George, 2001). Strategy scholars have thus urged researchers to acquire a more nuanced comprehension of emotional capacities (e.g., Hodgkinson and Healey, 2011; Powell, 2014) and mechanisms of emotionally influenced strategy (Zott and Huy, 2007). Nonetheless, also due to methodological limitations (see Ashkanasy, Humphrey, and Huy, 2017), discrete emotions have received limited attention in management research thus far (Barsade, Brief, and Spataro, 2003). Instead, research has favored broader negative versus positive affectivity frameworks. For one example, Håkonsson *et al.* (2016) have recently put forward an experimental study explaining the positive effect of team positive affectivity on exploring new routines. For another, Delgado-García and De La Fuente-Sabaté (2010) have explained that in the banking industry, managers' negative affective traits are associated to more conformist strategies, whereas positive affective traits promote more innovative outcomes. By placing attention on envy, Nickerson and Zenger (2008) have offered one theoretical exception to this attention on general affectivity. They explain that organizational failures can be understood in terms of individual action, interaction, and, ultimately, human cognition and affect. Yet, among this growing body of literature, very little research has experimentally investigated why and how discrete emotions influence strategic outputs.

In this article, we build knowledge in this knowledge realm by specifically focusing on anger. Mankind has long sought to understand this complex emotion: As Aristotle wrote, anger is an “impediment to reason” (*Politics* 1312b 31–34) that does not follow “a rational principle” (*Politics* 1312b 26–30), thereby representing what we might call today an archetypical construct for behavioral investigations. Yet, as Gibson and Callister (2010) have suggested, the scholarship has encountered several challenges to conceptualize this multifaceted emotion (Blair, 2012; Russell and Fehr, 1994). Anger represents a discrete, “basic” emotion that can be well differentiated from generalized negative affective states. It is characterized by specific neurophysiological components and a relatively limited set of antecedent events, and it is consistent across multiple situations and cultures (Ekman, 1992). In organizational contexts, the main antecedents of anger are episodes perceived to be unjust, conflictual, or unfair (Beal *et al.*, 2006; Spielberger, 1999; Weiner, 1995). Moreover, anger can be conceptualized both as a state and as a trait: State anger is a temporary situation consisting of feelings ranging from annoyance to intense rage (Glomb, 2002); trait anger is the propensity to perceive situations as anger provoking and to frequently feel this emotion (Spielberger, 1999). Anger can also be experienced as a response to others’ actions and be directed toward others (Averill, 1982; Clore and Ortony, 1991). Thus, anger in the workplace unfolds into interactions between individuals and the environment they are exposed to (Frijda, 1993; Lazarus, 1991; Weiss and Cropanzano, 1996).

The ways and mechanisms in which anger may affect individual, interpersonal, and strategic outputs have, however, remained largely polarized in the literature. On the one hand, anger is known to impair information-processing abilities and even one’s capacity to exert behavioural control (i.e., lack of impartiality, sympathy, or attention), and can even create danger (Mohr *et al.*, 2007). It has also been associated to overall reduction in organizational performance (Skarlicki and Folger, 1997) and a worsening of interpersonal interactions (Allred, 1999; Fitness, 2000). On the other hand, research has suggested that anger can promote proactivity and be a drive to reach superior organizational goals (Geddes and Callister, 2007; Keltner and Gross, 1999; Lebel, 2017; Lewis, 2000).

Because experienced anger can influence individuals' interdependencies (Wubben *et al.*, 2008) and overall organizational efficiency, we believe that it is critical to disentangle both the directionality and the causal mechanisms through which it may affect strategic cooperative interactions. These interactions are the set of symbiotic decisions and behaviors that involve strategic cooperation between two (or more) agents toward superior strategic outcomes and are fundamental constituent of the organizational life. Moved by this exploratory boldness, and devoted to the theoretical precepts of the Carnegie School, we will empirically test whether anger can perturb such interactions in a natural and performance-efficient equilibrium outcome. To do so we will use a game theory device (Camerer, 1991)—the indefinite repeated Prisoner's Dilemma game (Dal Bó and Fréchette, 2011) —to generate experimental studies in a situation in which mutual cooperation is the efficient outcome for individuals and groups. We will perform two independent experiments in which actors will strategically interact with humans in one case, and with computers in another. This two-fold approach will allow us to build further empirical and theoretical knowledge of the ways and mechanisms in which actors' strategizing can be affected by anger.

Moreover, due to both the methodological benefits in capturing "implicit" aspects of emotions (Barsade, Ramarajan, and Westen, 2009; Håkonsson *et al.*, 2016) and the superiority of inferential power over self-reported data, we will integrate our explanation with an inquiry on the dynamics of the involuntary neurophysiological mechanisms at play when people experience significant anger in strategic cooperative interactions. Eventually, as

Simon once put it (1976, p. 35): “intense stimuli often produce large effects on the autonomic nervous system…. It is to these effects that the label “emotion” is generally attached.”

METHODOLOGY

This research was conducted across multiple sessions in two subsequent studies.[§] We first performed a laboratory-based study; this was followed by an online study on an independent sample. In sum, we conducted between-subject experiments by randomly allocating participants to either the treatment (i.e., anger induction) or the control condition (i.e., no emotional induction) and asked them to perform a repeated cooperative game. Throughout the research we used an incentivized approach, following established norms of experimental economics research (see footnote 1).

We ran the first study at the behavioral economics laboratory of a large, public, research-intensive UK university. Here, upon informed and voluntary consent, participants[**] wore a small bio-patch externally placed on their chests (the FDA-approved BioHarness M3-1; ZephyrTech). This device is a highly reliable, wearable, and wireless tool designed for research purposes, that enables real-time recording of an electrocardiogram (ECG). From an ECG it is possible to perform HRV analyses, which assess beat-to-beat changes in heart rhythm over time and allow us to draw inferences about the outflow of the autonomic nervous system (ANS), the involuntary part of the nervous system. This methodology permits us to objectively appreciate neurophysiological changes associated with emotional responses, while ensuring ecological validity (Massaro and Pecchia, 2017).

[§] Strategic management research has recently placed growing attention on the use of experimental approaches. With parsimony in mind, given that the relevance of using an experimental take have already been widely covered elsewhere, we refer readers to the thorough analyses put forward by Croson, Anand, and Agrawal (2007), and Levine et al. (2017, see in particular pp. 2040–2041). These works cover the use of experimental economics in strategic management, and the same considerations support our current study. Similar considerations also apply to, and benefit from, the use of incentivized payoffs (e.g., Smith, 1976).

[**] Thirty-two subjects volunteered to wear the ECG bio-patch. Quintana (2017) recommends that in order to achieve 80% power and detect large effect sizes with HRV analysis, a sample of about twenty participants is required. Due to the poor quality of the ECG recording, signal-processing issues (e.g., signal noise and confounding breathing influences), and unbalanced distribution between groups, we analyzed 20 subjects equally split among the control and treatment groups.

In a follow-up study, we extended the behavioral results in an independent heterogeneous sample recruited through the online platform Amazon Mechanical Turk (Buhrmester, Kwang, and Gosling, 2011). This was done to both provide a robustness check to our findings and to further explain in what ways anger-induced subjects strategize.

This research received approval from our Institutional Review Boards. Informed consent, data storage, recruitment, and anonymization procedures were in place throughout, according to best research practice and international guidelines.

Laboratory Study

Recruitment and Sample. Subjects were recruited across a wide population of students and alumni[††] (N > 3,500) using our institution's SONA recruitment software, a cloud-based participant pool management platform (http://www.sona-systems.com/default.aspx). This software enabled us to randomly assign participants to the control and treatment sessions, and to exclude subjects whose areas of study would make them familiar with the experimental design we used (i.e., behavioral science, economics, or psychology). The following criteria were also used for exclusion to avoid possible confounding effects on the modulation of the ANS: a) consumption of addictive substances (e.g., coffee, tobacco); b) self-reported cardiovascular diseases; c) self-reported history of cardiac and psychopathological conditions; d) pregnancy status; e) professional or intensive sportsmanship.

We performed the behavioral experiment on a total of 62 participants (Age: 23 ± 4.4; Female = 33) who were all volunteers and experienced in using personal computers. As far as the decision task is concerned, the statistical power of the data is related to 6,508 unique strategic decisions.

[††] There is substantial evidence that students and executives perform indistinguishably in managerial, economic, and behavioral tasks (see, e.g., Bolton, Ockenfels, and Thonemann, 2012; Levine et al., 2017; Fréchette, 2015, 2016).

Procedure. We presented participants with an introduction document, briefed them on the instructions of the experiment, and informed them that it would last up to 75 minutes. Time intervals of experimental events were collected to allow for later analysis.

After gathering informed consent, we asked participants to wear the bio-patch. To preserve privacy, we made a changing room available where they could apply the device to their chests. Whenever needed, female participants were assisted in this task by one female research assistant, and males by a male research assistant. Participants then took their position in their assigned computer cubicles to begin the experiment.

We coded and ran the experiment using z-Tree (Fischbacher, 2007), a well-known and widely used software for laboratory-based experimental research.

Anger Induction. We implemented an affective induction procedure (AIP) to stimulate anger by showing a short video clip. This procedure has been validated relative to its effectiveness, specificity of the induced emotion, and demand effect (e.g., Westermann *et al.*, 1996). Philippot (1993) showed that AIPs allow researchers to experimentally induce discrete emotions regardless of the theoretical standing a researcher might take (e.g., circumplex or appraisal models).[‡‡]

Participants watched a five-minute video clip on their assigned computers while wearing headphones.[§§] In the treatment condition, participants watched a clip called "The Bully Scene," from the movie *My Bodyguard* (Bill, 1980). This clip, in which a young man is beaten up by a group of older pupils, is acknowledged to elicit anger specifically (Gross and Levenson, 1995; Rottenberg, Ray, and Gross, 2007). In the control condition, participants viewed an excerpt from *Alaska's Wild Denali: Summer in Denali National Park*, a

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[‡‡] Faithful to our question-driven approach, we did not take any a priori theoretical standing on the theoretical model of emotions.

[§§] We selected video clips lasting at least five minutes in order to appreciate reliable physiological variations in the heart series (Massaro and Pecchia, 2017).

documentary directed by Hardesty (1997), which shows nature scenery from Alaska. This is recognized to be an emotionally neutral stimulus (Rottenberg *et al.*, 2007).

Note that the effect of this AIP lasts for around 20 minutes (Isen, Clark, and Schwartz, 1976). Therefore, the subsequent strategic task was purposively designed to take place within this time span.

Indefinite Repeated Prisoner’s Dilemma. Once participants had watched the videos, they played a version of the indefinite repeated Prisoner’s Dilemma game (Dal Bó and Fréchette, 2011).

The Prisoner’s Dilemma is a standard instrument in game theory, which helps to show that two rational agents might fail to cooperate even though they would achieve a better outcome by doing so. We used its indefinite repeated version because we reasoned that individuals are often expected to maintain long-lasting relationships and partnerships within and outside their firms. Many of these exchanges do not have a natural termination and require continuous interactions, the length of which is often unknown. The indefinite repeated Prisoner’s Dilemma game is thus particularly useful because it offers a parsimonious theoretical and formal framework to analyze such strategic cooperative interactions. The game is repeatedly and simultaneously played between two players, and the termination time is not known. Thus, given conforming parameters, it can be designed so that cooperation can be sustained in equilibrium, as it can lead to higher individuals’ payoffs and overall higher gains relative to defection. Needless to say, within an organization, cooperation is the oft-sought equilibrium outcome.

In our research the participants played a sequence of the indefinite repeated Prisoner’s Dilemma described below. Each time a participants’ dyad played (i.e., made their decisions), the software would draw a random number in the interval [0;1]. If this number fell below the set continuation probability, the game would continue into a subsequent round (i.e., a stage game). We set the probability of continuing the repeated game into a further stage game to $\delta = 0.75$ across all sessions. Moreover, participants were anonymously matched with one another through their computer terminals following the strangers design. This method prescribes subjects to be randomly matched with one another after the end of each repeated game. In each session, subjects played as many repeated games as possible within the session's time.

Each repeated game constitutes a supergame, while each round (i.e., each time a dyad makes a decision) is considered a stage game within a supergame. The stage game of our experiment is shown in Table 1. Here, the payoffs are presented in experimental units, with one unit corresponding to £0.003. We incentivized every individual choice by paying participants the total sum of their payoffs from all rounds of all supergames (i.e., their profit), converted into British pounds.

----- {Insert Table 1 about here} -----

The parameters of the game (i.e., payoffs and continuation probability) match those recently used by Dal Bó and Fréchette (2011) and Proto, Rustichini, and Sofianos (2017). We used these parameters because they entail an indefinite Prisoner's Dilemma game where cooperation is both subgame perfect and risk dominant (Dal Bó and Fréchette, 2011). As explained above, this means that, from a rational economics perspective, cooperation should prevail because agents should implement a strategic behavior that takes advantage of the more profitable outcomes associated with cooperation.

In order to prevent noise and ensure comparison across sessions, we randomly drew numbers to determine the length of each supergame prior to the study and implemented them across the experimental sessions. As a result, the length of the supergames did not vary across sessions.[***] On average, during each supergame, participant played four rounds; the minimum and maximum were one and 12 rounds, respectively. The number of supergames reached in each session varied depending on the participants' speed of play.

Subsequent Tasks. Following completion of the game, we asked participants standard demographic questions (e.g., gender, age, education, language). Moreover, because recent research has shown that cognitive ability and personality can affect cooperation (Proto *et al.*, 2017), we included the Big Five personality traits questionnaire (John and Srivastava, 1999) and an adapted version of the Raven's Progressive Matrices test. The former provides a measure for the personality traits of openness, conscientiousness, extraversion, agreeableness, and neuroticism, while the latter is a proxy for cognitive ability.[†††]

In this study we induced anger as a reaction to an episode. Yet, as reviewed above, anger can also be prompted by individuals' dispositional traits rather than situational cases. To account for this contingency, we asked participants to complete the State-Trait Anger Expression Inventory (STAXI-2). This survey assesses one's disposition to anger (Schamborg, Tully, and Browne, 2016) and has been validated across a variety of samples (e.g., Lievaart, Franken, and Hovens, 2016; Etzler, Rohrmann, and Brandt, 2014), suggesting its overall generalizability.

Manipulation Check and Conclusion. Following Rottenberg *et al.* (2007), we asked participants to answer a final set of questions to evaluate whether the AIP was successful. Respondents were asked to self-report, on an incremental nine-point scale, the degree to which they experienced different discrete emotions while watching the video excerpt. We probed participants' emotions only once the Prisoner's Dilemma game was completed to

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[***] Across all sessions, the first supergame consisted of six rounds, the second supergame of seven rounds, and so forth.

[†††] Raven's Progressive Matrices measure abstract reasoning and fluid intelligence. Our version consisted of 30 choices, listed in order of increasing difficulty. For each, participants were shown a set of pictures in the form of a 3x3 matrix, where the picture in the bottom right was missing. Participants were asked to identify the missing element that completed the pattern.

avoid demand effects that might invalidate the whole experiment (Zizzo, 2010). We also asked participants whether they had watched the video before and if they had closed their eyes during the video, to ensure that the AIP was not affected.[‡‡‡]

Finally, the participants removed the wearable bio-patch and we compensated them according to their profits. They earned an average of £20 inclusive of a fixed show-up fee of £5.

Online Study

Following the analysis of the laboratory study's results, we performed a follow-up study on an independent sample. This study closely followed the one outlined above, aside from some differences that we now explain.

Recruitment was accomplished through Amazon Mechanical Turk, a relatively novel platform that allows researchers to collect high-quality behavioral data (Buhrmester, Kwang, and Gosling, 2011). After exclusion of dropouts, participants reporting technical issues, and noncontinuous play, we retained 73 participants (Age: 36 ± 11.56; Female = 44), with 4,140 total decisions.

We coded and ran this experiment with the Python-based open-source o-Tree software because of its superior compatibility with the Amazon Mechanical Turk platform (Chen, Schonger, and Wickens, 2016; see also for an analysis of complementarities and differences between the z-Tree and o-Tree software). Clearly, we could not engage in face-to-face interactions with the participants and thus did not measure physiological responses.

Participants underwent the same AIP described for the laboratory study. We asked them to pay close attention to the video clip, turn their device speakers' volume on, and perform the task alone, without interruption, in a comfortable and quiet environment. Once

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[‡‡‡] No participant reported having seen the video previously or closing their eyes while watching the video, suggesting that the induction procedure was not affected by these contingencies.

participants had watched the videos, they played the same version of the indefinite repeated Prisoner's Dilemma game as before. The experimental units were converted into multiples of $0.001 to prospectively match the average hourly earnings of the Amazon Mechanical Turk platform; these were paid as a profit to the participants at the end of the experiment.

In contrast to the laboratory study, where participants were matched against other human beings, participants in the online study were matched against computers. Participants were informed that every supergame was played against a different computer. We designed the study in this way in order to retain experimental control over one player's strategic decisions throughout (i.e., the computer). Thus, we coded the game so that the computers used the same type of individual strategies that we estimated in the laboratory study (see also "Analyses and Results"). Following the work by Dal Bó and Fréchette (2017), we focused on four strategies that subjects can play during this version of the indefinite repeated Prisoner's Dilemma game.[§§§] These are : a) "Always Cooperate" (AC), which prescribes cooperation regardless of the partner's decisions; b) "Always Defect" (AD), which entails defection regardless of the partner's decisions; c) "Tit-for-Tat" (TFT), which means that an agent will first cooperate, and then he or she will imitate the partner's immediate previous decision; and d) "Grim Trigger" (GT), which implies that the agent will start by playing cooperation, but will change to defection until the end of the repeated game if the partner defects. We implemented the game presented in Table 2.

----- {Insert Table 2 about here} -----

In other words, we created a controlled experimental setup in which in each supergame the computers were playing as if they were different human participants playing against the online participants. We retained the same manipulation check and included

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[§§§] Dal Bó and Fréchette (2017) experimentally find that in the same version of this game the majority of players (>85%) play one of these four strategies. By using a direct method of strategy elicitation, they are able to validate the recovery of the strategies implemented in the game through statistical estimation.

additional open-ended questions on the content of the videos to ensure that the participants had truly watched them.

Measurements and Variables

Payoff, profit and performance. We computed the payoff for each participant at the end of every round. This value depends on each individual's decision as well as on his or her partner's choice. The overall payoff that an individual earns during the entire game (i.e., all rounds across all supergames) is the individual's profit. Performance is measured by the aggregated profit of all subjects in either the treatment or control condition.

Strategic cooperative interactions and strategies. Strategic cooperative decisions (SCDs) are measured by computing the cooperation rates in the Prisoner's Dilemma game. These are calculated as the proportion of cooperative decisions over the total decisions made by one individual in a given time span. Strategic cooperative behavior (SCB) represents the conditional cooperation of an individual player. In other words, it constitutes the SCDs that each individual undertakes given his or her partners' past decisions (i.e., whether the previous partner cooperated/defected). Finally, an individual's strategy is the plan of action that a player undertakes ex-ante given all the possible circumstances that might arise within the entire repeated game.

Anger and neurophysiological measures. We created the variable "self-reported anger" from the emotional induction questionnaire to capture the "explicit" level of anger elicited by the AIP. We assessed the "implicit" level of anger by computing neurophysiological correlates of emotional response for each subject through analysis of the HRV features extracted from the ECG data acquired. Physiological features are increasingly used in the management and affective literatures as "implicit measures" of emotions, given that they consistently correlate with self-reported data (e.g., Håkonsson *et al.*, 2016).

Moreover, the affective scholarship agrees that neurophysiological activity is an important component of an emotional experience (see e.g., Cacioppo *et al.*, 2000).

We mainly focused on an HRV feature that is widely known to uniquely reflect the parasympathetic branch of the ANS (also known as “vagal tone”).[****] Namely, our chosen variable was the absolute power, expressed in ms^2, of the high-frequency band of the HRV spectrum [0.15 Hz; 0.4 Hz], hereafter “HF.”

Importantly, HRV features related to the vagal tone offer reliable biomarkers to assess a person’s regulated emotional responding (Appelhans and Luecken, 2006). In other terms, appreciating the variations of the HRV features across conditions provides not only a methodological tool, but also a theoretical framework to understand the neurophysiological mechanisms at play in anger-induced subjects.

As Falk *et al.* (2017) suggest, given the high between-subject and low within-subject variation, we computed the difference of HF across conditions. This procedure serves to correct for potential level imbalances among subjects and to enhance the power of the statistical test even in the presence of relatively small samples (McKenzie, 2012). In other words, per each subject and per each HRV feature extracted, we calculated the differences between the values recorded when participants were playing the Prisoner’s Dilemma game and those recorded in the respective baselines.

Control variables and observables. We analyzed four demographic variables (age, gender, language, numeracy education) as dummy variables[††††] from the demographic questionnaire. Propensity to anger, cognitive ability, and personality variables were

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[****] All existing emotional psycho-physiological theories leveraging HRV focus on measurements associated to the parasympathetic branch of the ANS (see Laborde, Mosley, and Thayer, 2017). The parasympathetic branch of the ANS (i.e., vagal tone) can be referred to as the part of the nervous system responsible for “rest and digest” and is opposite in its functions to the sympathetic one. Under stressful and emotionally salient conditions, the HRV indexes associated to the vagal tone are generally depressed.

[††††] Language takes the value of 1 if the participant’s mother tongue is English; numeracy education takes the value of 1 if the participant’s major is quantitative.

calculated from the associated tests and surveys.

ANALYSES AND RESULTS

We begin by analyzing the behavioral results of the laboratory study. We test the effectiveness of the AIP and find that anger induction reduces overall performance as well as individuals' earnings. We show that these effects are due to differences in strategic cooperative interactions and estimate the players' strategies. We then perform HRV analysis. We further confirm the success of the AIP and show that anger significantly shifted indexes of vagal tone across experimental conditions during the decision tasks. Next, we present the findings of the online study. These results confirm in an independent sample that anger reduces individual earnings. Moreover, given the computers' fixed strategies, we are able to show that anger induced subjects to strategize in suboptimal ways.

Statistical analyses were performed in Stata 2014; the individuals' strategies were estimated in Matlab 2016. We processed, analyzed, and present HRV data and analyses with the software Kubios Premium (Version 3.2) (Tarvainen *et al.*, 2014).

Laboratory Study

AIP Effectiveness. We assess the effectiveness of the AIP by checking whether the treatment, compared to the control condition, induced anger in participants (Drouvelis and Grosskopf, 2016; Kirchsteiger, Rigotti, and Rustichini, 2006).

----- {Insert Figure 1 about here} -----

Distribution of self-reported anger scores (Figure 1) and comparison of differences in the scores' mean between conditions (control: 0.10 ± 0.04; treatment: 0.58 ± 0.05) indicate that subjects in the treatment condition experienced anger. A Mann-Whitney *U* test confirms that the difference in the ranked distribution of self-reported anger between groups is statistically significant ($|\rho|$=5.07, implying a p-value of 0.000). Thus, subjects in the treatment condition reported experiencing significant levels of anger, while subjects in the control did not.

Performance and profits. Anger negatively correlates with performance across experimental conditions. Performance was considerably lower in the treatment sessions as compared to the control ones. While subjects in the control condition achieved a total of 166,620 units of experimental currency (i.e., £499.90), those in the treatment obtained only 115,275 units (i.e., £345.80). Participants' profits in the control group were on average 5,554 units (i.e., £16.62), while in the treatment they gained 3,602 units (i.e., £10.80).

Strategic cooperative decisions. We analyze strategic cooperative decisions (SCDs) at different instances of the game. We focus on a) the total SCDs, to understand the overall impact of anger on game play; b) SCDs in the first supergame, to understand the immediate effect of anger; c) SCDs per supergame, to appreciate the nuanced dynamics of cooperation per experimental condition; and, d) SCDs computed for the first period of each supergame, indicating how one subject starts playing with a new partner. Table 3 provides an overview of these SCDs by treatment.

----- {Insert Table 3 about here} -----

In the top panels, we show SCDs by treatment for the first supergame. For both the first round and all rounds of the first supergame, despite not being statistically significant, cooperative decisions are about 10% lower in the treatment than in the control condition. The bottom panel shows the average SCDs for all supergames. SCDs are lower in the treatment than in the control condition: In the first rounds, they are approximately 14.5% lower than in the control, while the difference increases to almost 18% for all rounds of all supergames. These differences are statistically significant at 5% (exact p-value of 0.01) and 1% significance levels (exact p-value of 0.00), respectively.

Next, we assess the effect of anger on SCDs and on the average payoffs by running OLS regressions. In this way we can account for other observables that might impact the strategic outputs under investigation.

----- {Insert Table 4 about here} -----

Table 4 reports the results of four key models. The dependent variable in Model 1 and 2 is the average of SCDs per individual across all rounds, while in Models 3 and 4 the dependent variable is the average payoff per individual across all rounds. Altogether, we show that the effect of the treatment significantly reduces both average SCDs and payoffs in all models. Not only is the treatment effect statistically significant (p-values in the interval [0.00; 0.03]), but it also holds a substantial impact. That is, the average of SCDs is reduced by around 17%, leading to lower average payoffs. Specifically, the treatment reduces average payoffs of around 4 units per round.

The additional regressors are gender, age, education, language, and other individual features (i.e., cognitive ability, propensity to anger, and personality). The coefficients of these variables are not significant in any model. The only exceptions are the coefficients for age and extraversion in Model 3, which imply higher payoffs (0.23 and 5.76, respectively at a 0.10 level of significance). Propensity to anger does not directly affect either SCDs or payoffs, despite the fact that the direction of the effect is consistently negative across all models. [‡‡‡‡]

SCDs and payoffs dynamics. We examine the dynamics of SCDs and of the average payoffs by supergame to appreciate how these variables develop over time.

----- {Insert Figure 2 about here} -----

Figure 2 shows the SCDs (i.e., the panel on the left) and the average payoffs (i.e., the panel on the right) by supergame, comparing treatment and control. The former panel shows

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[‡‡‡‡] The interaction term “Propensity to anger x Treatment” yielded no significant results across all models.

that subjects in both conditions began to play at different levels of cooperation, and this difference continued over the course of the task. Moreover, while subjects in the control group converged toward the cooperative equilibrium, those in the anger-induced condition did not. The latter panel shows that differences in SCDs lead to lower average payoffs in the treatment condition. Subjects in the control condition played more supergames than those in the treatment condition.

Strategic cooperative behavior. We advance our analysis by observing the strategic cooperative behavior (SCB), or conditional SCDs, by supergame per condition, as exemplified in Figure 3.

----- {Insert Figure 3 about here} -----

The top left panel shows that, although individuals engaged in a similar initial SCB in both the treatment and control, as the game proceeded, this behavior diverged. We can appreciate that an anger-induced subject is 7% less likely to cooperate if in the previous round the partner had cooperated. The panel at the bottom left shows that anger did not affect subjects' behavior when both players had cooperated in the previous round. For both experimental conditions, cooperation is around 98%. However, when both players had defected in the previous round (bottom right panel), their SCBs differed. We can argue that participants in the control condition mutually learned over time to defect when this was the dyad's outcome in the previous round; however, participants in the treatment did not.

Estimated strategies. We then estimated the strategies that participants implemented across conditions, following work by Dal Bó and Fréchette (2011). We estimate the prevalence of each of these strategies through a maximum-likelihood estimation. We use the

Strategy Frequency Estimation Method (STEM) proposed by Dal Bó and Fréchette (2011) across conditions for clutches of five supergames (Table 5).[§§§§]

----- {Insert Table 5 about here} -----

The estimates show that AD is played at a higher frequency in the treatment than in the control. The difference in frequencies is between 9% (in the first five supergames) and 19% (supergames [10;15]). Moreover, we estimate that participants in the treatment condition implemented more sophisticated strategies with lower frequency. These are strategies that take into account the partner's previous SCDs (e.g., GT and TFT). Across the five batches of supergames we examined, individuals in the treatment implemented, on average, more sophisticated strategies 15% less often than subjects in the control condition.[*****]

Heart Rate Variability. We performed HRV analysis from five-minute time segments (nominal 330 seconds) of the ECG recordings, following international guidelines (Task Force, 1996). After performing a quality check on ECGs, we extracted HRV data. Based on our experimental timeline, we selected multiple segments to capture physiological signals for the baselines and for the Prisoner's Dilemma tasks. We then computed HF as a biomarker of the vagal tone through autoregressive modelling.[†††††]

[§§§§] As in Proto *et al.* (2017), we implement STEM in different batches of supergames. This procedure is necessary because subjects might change their strategies across supergames, e.g., due to experience. Importantly, we estimate the strategies at the same point in the game (i.e., supergames). In this way we can directly compare the estimated strategies across treatments so that the differences are not being driven by individual experience.

[*****] The noise in estimating the strategies, which is captured by the parameter δ, varies across conditions. The higher δ, the higher the noise in the estimation of the strategies. While δ is similar in the first batches for both treatment and control, as the game proceeds, it consistently diminishes in the control condition only.

[†††††] We optimized the segments' selection by looking for the highest possible coherence and stationarity of the spectral output of the entire heart rate series without artifacts. We excluded records with NN/RR ratio below 99%, as explained in Massaro and Pecchia (2017). To minimize experimental biases and validate our procedure, we were assisted by two experts in HRV signal-processing research who were blinded to our research question. Technical and/or physiological artifacts were removed with a fairly conservative filtering [0.25 s; 0.05 s] and an a priori detrended smoothing was applied (λ=500; f_c=0.035 Hz). For the autoregressive model, following indications by Boardman et al. (2002), we used the optimum p=16 without factorization [see also Burr and Cowan (1992) and Pichon et al. (2006) on the benefit of using an autoregression model over a Fast Fourier Transform analysis].

We conduct a within-subject Wilcoxon signed-rank test and show that anger induction resulted in a statistically significant reduction in HF compared to the baselines ($|\rho|$=2.40; p-value = 0.02). Consistently with the meta-analysis by Kreibig *et al.* (2010), this parasympathetic reduction confirmed the efficacy of the AIP by means of an “implicit” assessment of each subject’s emotional response.

Next, we compare the relative change of HF between conditions in the segments associated to the Prisoner's Dilemma game.

----- {Insert Figure 4 about here} -----

As shown in Figure 4, there are considerable changes in HF across conditions. To refine this evidence, we perform a Poincaré plot analysis, an advanced geometric nonlinear evaluation. This analysis, which returns a scatterplot of the successive interbeat intervals versus the previous ones, offers a real-time representation of the chaotic nature of heart rate signals’ dynamics and adds further inferential power to the neurophysiological mechanisms at stake. The Poincaré plot is analyzed by fitting an ellipse and computing the standard deviation of the points perpendicular to and along the identity line (SD1 and SD2 respectively). These features decrease following a sympathetic stimulation with a concomitant change of shape in the plot. SD1 is specifically associated to the parasympathetic system and short-term variability (i.e., five minutes and below).

Thus, we confirm that the decrease in the vagal tone is highly statistically significant in the treatment group compared to the control (HF: $|\rho|$=3.48, implying a p-value of 0.00; SD1: $|\rho|$=2.72, implying a p-value of 0.01).[‡‡‡‡‡]

Online Study

[‡‡‡‡‡] To further confirm our findings, we performed parallel analyses with other HRV features associated to vagal tone, including SDNN and pp50 ($|\rho|$=2.19, implying a p-value of 0.03), as well as RMSSD ($|\rho|$=2.72, implying a p-value of 0.01).

The analysis of the online study extends our behavioral findings in an independent sample. Once again, we observe that subjects in the treatment condition experienced anger. In this case, participants could also provide a short statement on the content of the videos and how they felt while watching them. The responses were overall consistent with the AIP. For instance, one subject in the treatment condition reported, “I saw some guys (one in particular) bullying another guy, which made me feel angry,” while one in the control group wrote, “I saw a bunch of Alaskan water, ice, and animals, so it was a relaxing video.” This qualitative evidence assured us that participants had truly watched the videos and experienced the emotional states of interest.

We found that participants in the anger-induced condition had reduced earnings (on average a reduced payoff of 1.20 units per subject per round; p-value of 0.01). Moreover, SCDs were on average significantly reduced by 5% in the treatment compared to the control condition (p-value of 0.003), as shown in Figure 5.[§§§§§]

----- {Insert Figure 5 about here} -----

As far as the players’ strategy is concerned, we found that there was no significant difference across conditions when players were matched with computers playing simple strategies (i.e., AC and AD). However, when the computers were playing more sophisticated strategies (i.e., GT and TFT) anger-induced participants on average defected more, despite the fact that it would have been more profitable to cooperate (average SCDs: control = 0.6, treatment = 0.55; Mann-Whitney U test ($|\rho|$=4.85 implying a p-value of 0.00). This evidence suggests that anger made participants play suboptimal strategies.

DISCUSSION

[§§§§§] We ran OLS controlling for other observables (i.e., gender and age) given the high heterogeneity in the sample.

We investigated the effect of anger on strategic cooperative interactions in two independent samples and studies to advance behavioral strategy research on discrete emotions. We examined associated behavioral and physiological dynamics through a question-driven, interdisciplinary, and experimental approach. Overall, we found that anger causes a reduction in both performance and individual earnings. As we shall now discuss, the underlying psycho-physiological mechanisms by which this phenomenon occurs may influence individuals' ways of strategizing and regulating emotional responding.

Anger-induced subjects had lower earnings than those in the control. This evidence arises because anger makes subjects reduce their SCDs throughout (Figures 2 and 5). In the laboratory study, we significantly retrieved the conclusion that anger is the sole factor driving down both average payoffs and SCDs (Table 4). Moreover, we saw that anger-induced participants found it more challenging to coordinate their strategic decisions on the efficient equilibrium, while subjects in the control condition reached it nearly after 20 supergames (see Figure 2; the ups and downs of SCDs in the treatment condition are considerably more frequent and abrupt). In other terms, this means that anger made it more demanding for players to strategize by coordinating on the efficient equilibrium, thereby preventing them from achieving it. Added to this, we found that the influence of anger on SCDs occurs both at the beginning and during the game (Table 3). This finding is notable because the way in which a player opens the repeated game is not dependent on any history of play with that partner.

Altogether, these results encouraged us to further unravel the strategic cooperative behavior of the anger-induced players. Thus, we considered the players' strategic behavior given one partner's previous decision to either cooperate or defect (i.e., conditional cooperation). When a partner had previously cooperated, anger made subjects defect more than those in the control (see top-left panel of Figure 3). In both conditions, once the cooperative equilibrium was reached, subjects tended to cooperate rather than defect (see bottom left panel of Figure 3). Yet, when a partner had previously defected, we did not find higher defection in the treatment group (see top-left panel of Figure 3). Here, we could instead detect a reduced cooperation compared to when the partner had previously cooperated, which is consistent with the fact that SCDs are largely influenced by previous play. If both partners defected in the past, there was a reduction in the cooperation in both conditions (see bottom-left panel of Figure 3). While participants in the control condition learned to defect over time, those in the treatment did not, which is clearly a suboptimal strategic behavior.

This explanation is highly informative, yet it remains partial because it is focused on specific instances of strategic interactions. Thus, we estimated the frequency of individuals' strategies in order to further disentangle the behavioral mechanisms at play. The estimated distribution of individuals' strategies in the laboratory study not only consistently corroborates what we have discussed thus far, but it also offers a more nuanced justification of why anger lowers SCDs. That is, we can argue that anger-induced participants played less effective and efficient strategies. It appears that individuals played overall less sophisticated strategies—those that do not take into account the partners' SCDs and that are associated to lower payoffs. Moreover, these players were less consistent in the implementation of their strategies, thereby further reducing their profits.

We corroborated these findings in the online study. Here, we experimentally fixed the strategies that the computers (i.e., the participant's partners) would play. The online study is important for two reasons. First, given that participants were playing against computers, we can rule out, at least in this research, that the effect on anger on strategic outputs is due to social mechanisms between players in the laboratory, such as emotional contagion or affective mentalizing.

Second, this study allowed us to disentangle how one actor strategizes in presence of simple (i.e., AD and AC) and more sophisticated strategies (i.e. TFT and GT). Anger-induced participants on average defected more when the computers were playing more sophisticated strategies, despite the fact that it would have been more profitable to cooperate. This evidence indicates that anger may just trigger an “interruption mechanism” (Simon, 1976) in the participants, and as a consequence, they play suboptimal strategies. This evidence is also consistent with the fact that in the laboratory study, participants in the treatment decided more slowly (i.e., completed a lower number of supergames, see Figure 2) than those in the control group, regardless of the nature of their decisions. This result is intriguing because it excludes the possibility that strategies in the treatment group can be the result of impulsive reactions. Rather, it suggests that anger may promote individual mechanisms associated to one’s capacity to regulate his or her own emotional responses.

We sought to offer a step forward to understanding this possible behavioral mechanism. In the laboratory study, we performed HRV analysis, which also provided a methodological assessment of “implicit” anger and allowed us to confirm the effectiveness of the AIP. Consistently with the physiological literature (see Kreibig, 2010) we found a steady pattern of HRV depression in the treatment condition in both the frequency and the time domains. We further confirmed this evidence by accounting for nonlinear changes in heart dynamics (Figure 4).

The HRV results indicate that subjects exposed to anger induction experienced a considerable depression in the biomarkers associated to their vagal tone. This recution is clearly shown in the depression of HF, which is a well-established marker of ANS parasympathetic activity (e.g., Thayer and Lane, 2007). Theoretically, this biomarker provides a rigorous assessment of the myelinated heart-brain connection. Autonomic influences on heart rate are regulated remotely by a distributed network of brain areas

(Benarroch, 1993) and are closely associated with the neural regulation of emotional processing (Appelhans and Luecken, 2006). Coherently with psycho-physiological theories on HRV (see Porges, 2007; Thayer and Lane, 2000), our evidence suggests that subjects exposed to anger engage this heart-brain connection by reducing their vagal tone and producing automatically driven emotional regulation mechanisms. These mechanisms depend on one's capacity to adjust physiological arousal on episodic bases (Gross, 1998). As Thayer and Lane (2000) frame it, "when the vagal modulation of cardiac function is decreased, the organism is less able to track the rapid changes in environmental demands and less able to organize an appropriate response" (Thayer and Lane 2000, p. 206).

Thus, because reduced HRV can predict accuracy in complex executive cognitive tasks (Hansen *et al.*, 2003), we can suggest that in the presence of anger, and while engaged in strategic cooperative interactions, one's nervous system regulates the timing and magnitude of the subject's emotional responses through vagal modulation, in turn eliciting an emotional suppression mechanism (Gross, 1998). This mechanism would then make players perform more slowly and with less complex strategies.

Overall, we show that anger induces subjects to reduce their strategic outputs. We argue that this outcome is likely driven by a less efficient way of strategizing, in particular when actors face sophisticated strategies. This cognitive and behavioral standby may be sustained by physiological evidence associated to involuntary and "implicit" emotional regulation processes.

Limitations and Future Research

This research should be evaluated in light of its limitations and potential for future research. One possible issue regards the AIP we used. Because closely related emotions, such as sadness and disgust, often take place simultaneously to anger, the AIP can invoke them, as some of our participants in the laboratory study reported. Yet, because of the statistical significance of the self-reported anger scores, and thanks to the use of HRV data and the qualitative probing on the online sample, we ensured that our AIP truly worked.

Other restraints are related to the samples. On the one hand, due to laboratory constraints we were limited by the homogeneity of the SONA population; on the other hand, we had little control over the intrinsic issues associated to the use of the Amazon Mechanical Turk population in research (see, for a review, Stewart et al., 2015). While we generalized our main findings by purposively using samples from two different populations, transferring these insights into a real-life managerial environment and cross-validating our results across multiple sites will add further strength to our contribution. Indeed, it is important to acknowledge the highly contextual nature of emotions in organizations (Ashkanasy *et al.*, 2017).

Experimentally, one issue that could be further investigated is what would happen if the parameters of the Prisoner's Dilemma game were to be changed. For instance, performing a treatment with a lower continuation probability (e.g., $\delta = 0.5$, where cooperation is harder to sustain) or using negative payoffs might offer intriguing additional insights to our discussion. Future empirical research might also focus on the role of other discrete negative emotions, as well as borrow other procedures from game theory (e.g., public good game). We are confident that our work will offer a reliable blueprint toward such research pursuits. Moreover, inclusion of formal modeling will prove valuable in proposing predictive mechanisms by which discrete emotions influence strategic interactions. In the future these might integrate biomarker variables as well.

As far as the neurophysiological insights of this paper are concerned, we recognized the possible behavioral aspecificity of HRV analysis, which we tackled by using a controlled design coupled with set of refined indexes uniquely associated to the ANS vagal tone. In the future, the use of HRV analysis as both a methodological *and* theoretical framework will enhance knowledge of other constructs that are key to behavioral strategy research, such as learning and attention.

Implications and Conclusions

As Simon wrote (1976, p. 39) "theories must be endowed . . . with the properties . . . characterizing human thinking: intimate association of cognitive processes with emotions and feelings, and determination of behavior by the operation of a multiplicity of motivations operating simultaneously." We believe that our work has made a small, yet substantial step toward achieving this goal by enriching existing research on the role of emotions in strategic cooperative interactions. We provide experimental evidence that discrete negative emotions, in this case, anger, can strongly affect performance and strategic cooperative interactions. Specifically, we move forward current affectivity frameworks and long-standing debates on the directionality of the effect of anger in the workplace by causally proving that this emotion directly lowers performance and strategic cooperative decisions. We generalize this evidence across different samples, and show that this effect is accomplished by a reduction of strategic cooperative decisions.

Moving to the behavioral aspect of the research, we explain that anger makes people engage in suboptimal strategies. This finding is relevant for strategy because it adds an empirical analysis to the long-standing question of what qualities make a great strategist. Surely, the ability to more efficiently regulate emotional responses to episodic anger will prove a useful feature for promoting more optimal strategizing.

This work also contributes to the growing body of strategic management research mapping the unfolding of implicit affective processes (Håkonsson et al., 2016). By using HRV analysis, we explain the underlying physiological mechanisms associated to anger induction when individuals are engaged in strategic cooperative interactions. That is, we provide suggestive evidence that individuals experiencing anger automatically engage in a recruitment of competing cognitive resources to modulate emotional suppressor and regulatory mechanisms. This insight may thus explain a reduced ability of people to engage in effective strategizing, particularly when they are faced with sophisticated decisions.

Moreover, to the best of our knowledge, we introduce the use of the indefinite repeated Prisoner's Dilemma game as well as of HRV in strategic management. We also contribute to the broader literature with the application of HRV dynamics on individual emotional processes associated to cooperative games. For these reasons, we believe that our contribution may extend beyond management per se and feed future research in emotions and experimental economics as well.

In addition to the scholarly advancement we provide, we must also recognize our work's implications for practice. Beyond suggesting a possible use of HRV neurofeedback in real-life work settings (see, for discussion, Massaro and Pecchia, 2017), this work provides fresh insight into how negative discrete emotions can influence managers' and executives' decisions. Indeed, our findings are highly relevant for situations that involve strategic exchanges, such as work collaborations and repeated negotiations. For one example, understanding how anger unfolds can be a useful managerial tool for encouraging more efficient strategic outcomes (Gibson and Callister, 2010), and appreciating how anger regulates can be useful for strategic change (Huy, 2002). Moreover, it is also possible that our results will help to shape behavioral intervention programs in the workplace. For instance, having in mind the diffusion achieved by anger management programs, outward communication of angry feelings might represent a quick fix to the decrease in strategic cooperative interactions we uncovered in our studies.

In conclusion, aligning with the guiding message of the Carnegie School, we are hopeful that our research will help elucidate a more integrated understanding of human strategic behavior. We remain confident that this research will enable both scholars and practitioners to better grasp the systemic processes of emotional influence on strategic outcomes, and possibly shed light on how to manage them toward sustained competitive advantage.

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TABLES AND FIGURES

Table 1: Prisoner's Dilemma stage game.

	Cooperate	Defect
Cooperate	(48;48)	(12;50)
Defect	(50;12)	(25;25)

Table 2: Research design of the online study.

Supergame	1	2	3	4	5	6	7	8	9	10	11	12
Rounds	6	7	2	2	2	7	2	3	3	8	8	8
Strategy	TFT	TFT	AC	AD	AC	TFT	AC	TFT	AD	TFT	AD	GT

The strategies are: Always Cooperate (AC), Always Defect (AD), Grim Trigger (GT), and Tit-for-Tat (TFT).

Table 3: Strategic cooperative decisions across conditions.

First supergame		
	First round	All rounds
Control	90.00	82.78
Treatment	78.13	73.44
Difference (Δ)	11.87	9.34
Exact p-value	0.22	0.27
All supergames		
	First round	All rounds
Control	95.82	89.96
Treatment	81.38	72.68
Difference (Δ)	14.44	17.68
Exact p-value	0.01	0.00

Exact p-values and statistical significance were computed with a logit regression, using a dummy variable for treatment. Standard errors are clustered at the individual level.

Table 4: OLS estimator showing the effect of the treatment, propensity to anger, cognitive ability, personality and other individual characteristics on strategic cooperative decisions and payoffs.

	SCDs		Average payoffs	
	(1)	(2)	(3)	(4)
Treatment				
	-0.16 (0.03)	-0.18 (0.01)	-3.88 (0.00)	-4.30 (0.00)
Demographics				
Age	0.01 (0.26)	0.01 (0.39)	0.23 (0.08)	0.17 (0.17)
Gender	0.03 (0.73)	0.02 (0.72)	1.07 (0.36)	0.68 (0.50)

Language	-0.02 (0.81)	0.01 (0.85)	-0.85 (0.49)	-0.71 (0.54)
Numeracy education	-0.02 (0.77)	-0.01 (0.85)	-0.85 (0.49)	-0.71 (0.54)
Propensity to anger	-0.29 (0.42)	-0.21 (0.46)	-3.88 (0.48)	-2.58 (0.55)
Cognitive ability	0.00 (0.95)	0.00 (0.79)	0.04 (0.71)	0.00 (0.99)
Personality traits				
Agreeableness	-0.11 (0.71)		-3.86 (0.38)	
Extraversion	0.23 (0.30)		5.76 (0.10)	
Openness	-0.06 (0.82)		-0.09 (0.98)	
Neuroticism	0.03 (0.91)		-1.25 (0.73)	
Conscientiousness	-0.13 (0.60)		-4.08 (0.28)	
Constant	0.81 (0.09)	0.84 (0.00)	42.74 (0.37)	42.08 (0.00)
R^2	0.17	0.15	0.37	0.31

N=62. The dependent variables are SCDs (Model 1 and 2) and average payoffs (Model 3 and 4) at the individual level across all interactions. Cognitive ability and personality traits scores are normalized between 0 and 1. Exact p-values are reported in brackets.

Table 5: Maximum likelihood estimation of strategies by treatment and supergame.

	AC	AD	TFT	GT [a]	δ [b]
Supergames [1;5]					
Control	0.12 (0.05)	0.10 (0.03)	0.73 (0.06)	0.05	0.41 (0.03)
Treatment	0.22 (0.12)	0.19 (0.04)	0.56 (0.14)	0.03	0.39 (0.04)
Supergames [6;10]					
Control	0.12 (0.05)	0.03 (0.20)	0.81 (0.05)	0.03	0.36 (0.02)
Treatment	0.10 (0.06)	0.19 (0.04)	0.66 (0.06)	0.05	0.38 (0.04)
Supergames [11;15]					
Control	0.14 (0.07)	0.03 (0.02)	0.79 (0.08)	0.03	0.25 (0.02)
Treatment	0.13	0.22	0.65	0.00	0.32

	(0.06)	(0.04)	(0.06)		(0.02)
Supergames [16;20]					
Control	0.16	0.03	0.78	0.03	0.27
	(0.08)	(0.02)	(0.09)		(0.02)
Treatment	0.07	0.19	0.74	0.00	0.36
	(0.06)	(0.04)	(0.07)		(0.06)
Supergames [21;25]					
Control	0.19	0.00	0.81	0.00	0.22
	(0.10)	(0.00)	(0.10)		(0.02)
Treatment	0.22	0.13	0.65	0.00	0.40
	(0.09)	(0.05)	(0.10)		(0.04)

Each coefficient represents the estimated proportion of the corresponding strategy presented in batches of five supergames per condition. Bootstrapped standard errors are reported in brackets.[a] The coefficient for GT is computed from the others' estimated coefficients since they sum up to 1. [b] δ is the amount of noise captured in the maximum likelihood estimation procedure.

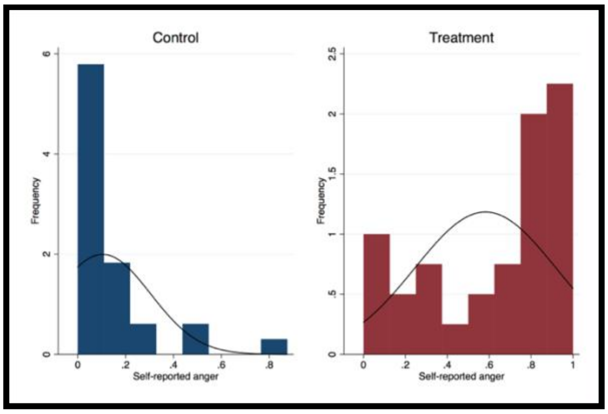


Figure 1: Comparison of the distribution of self-reported anger between conditions.

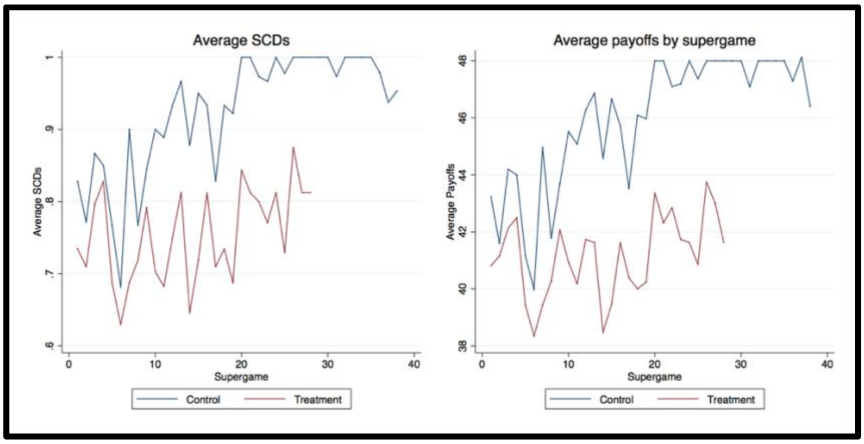


Figure 2: Average strategic cooperative decisions and payoffs by supergame over time.

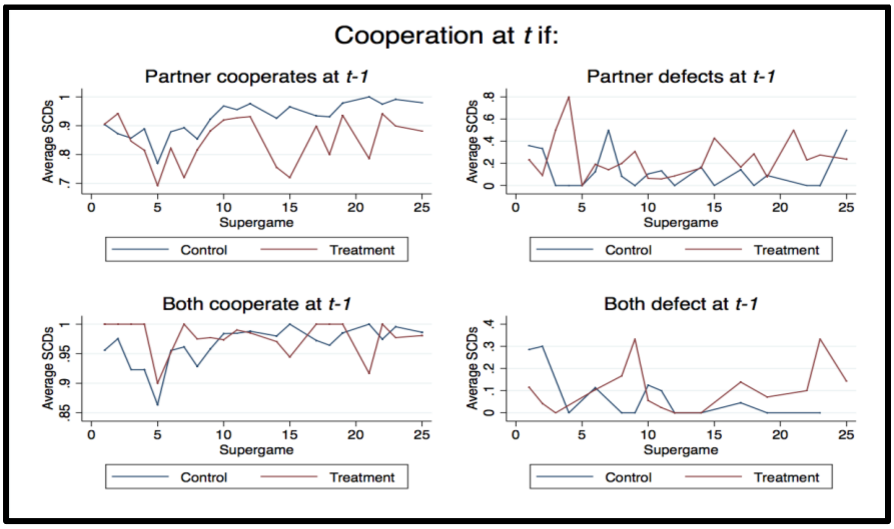
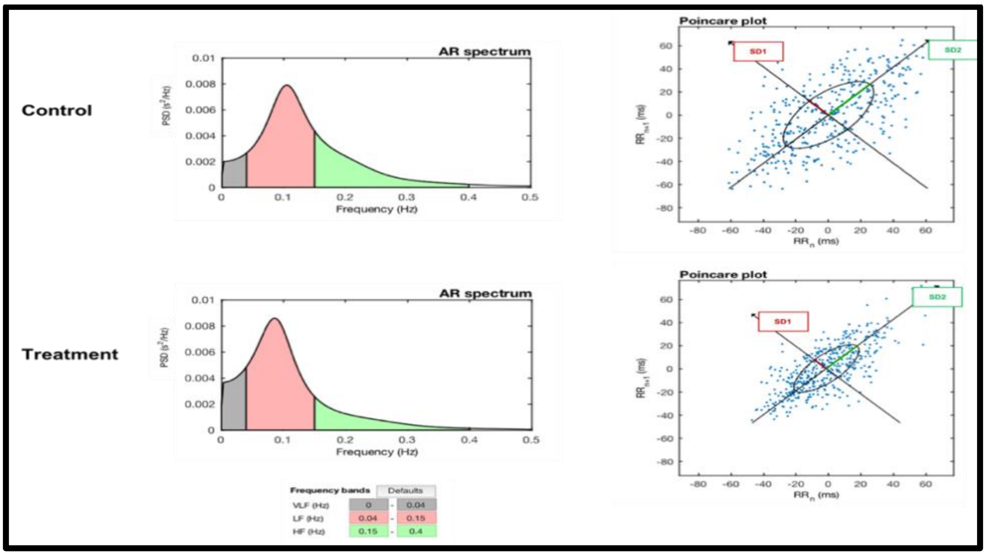


Figure 3: Strategic cooperative behavior by supergame.



Note: A subject’s HF absolute spectral power (i.e., the green areas of the spectrum) is substantially depressed in the treatment condition. Note the reciprocal shift and increment in the low-frequency power (i.e., the pink areas of the spectrum), which is mostly, yet not exclusively, associated to sympathetic stimulation.

Figure 4: Illustrative HRV Power spectrum (left) and Poincaré plot (right) analyses of subjects in control and treatment conditions.

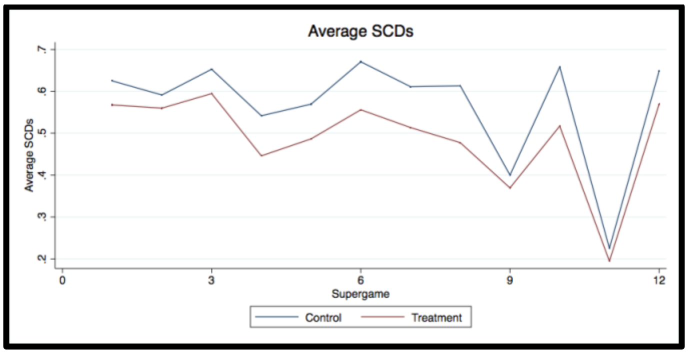


Figure 5: Average strategic cooperative decisions by supergame in the online study.