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# Adaptive Rationality in Strategic Interaction: Do Emotions Regulate Thinking about Others?

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**Abstract**

Forming beliefs or expectations about others' behavior is fundamental to strategy, as it co-determines the outcomes of interactions in and across organizations. In the game theoretic conception of rationality, agents reason iteratively about each other to form expectations about behavior. According to prior scholarship, actual strategists fall short of this ideal, and attempts to understand the underlying cognitive processes of forming expectations about others are in their infancy. We propose that emotions help regulate iterative reasoning, that is, their tendency to not only reflect on what others think, but also on what others think about their thinking. Drawing on a controlled experiment, we find that a negative emotion (fear) deepens the tendency to engage in iterative reasoning, compared to a positive emotion (amusement). Moreover, neutral emotions yield even deeper levels of reasoning. We tentatively interpret these early findings and speculate about the broader link of emotions and expectations in the context of strategic management. Extending the view of emotional regulation as a capability, emotions may be building blocks of rational heuristics for strategic interaction and enable interactive decision-making when strategists have little experience with the environment.

## 1. INTRODUCTION

At least since Cyert, Dill and March (1958) "The role of expectations in organizations", management scholarship has considered alternatives to the concept of expectations as the first moments of the relevant probability distributions. Yet replacing this construct with behaviorally plausible alternatives (Gavetti, 2012) presents several challenges, in particular regarding beliefs about the beliefs of others (henceforth their *higher order beliefs*).[2]

Consider an example: a set of firms (car producers) is jointly aware that a transition to an emerging

[1] Authors listed in alphabetical order. We are grateful to Elizabeth Viloudaki for her careful copy editing.
[2]Since "expectations" is often used as a synonym for "beliefs" as well as in its statistical meaning (first moment of a probability distribution), we use "belief" when there is possibility of confusion between the two meanings.

technology (self-driving cars) may eventually occur, but the timing of the transition depends on competitors' behavior. If competitors hesitate to invest, a leading car producer who is also working on other innovations (e.g., electric cars) may also hesitate in prioritizing its investment in electric cars. If, on the other hand, this producer expects that a critical mass of competitors will push ahead with investments in self-driving cars, it, too, may be better off immediately investing in self-driving technology. The car producer's beliefs about the actions of its competitors are likely based on its beliefs about the latter's beliefs regarding the timing of the transition.

How are such higher order expectations formed? In the extreme case of unbounded rationality in the sense of game theory (Bernheim, 1984), we can model an agent A's own (i.e., first order) belief as a probability distribution. However, we can also model an agent A's belief of another agent B's belief as a probability distribution over probability distributions – which can be referred to as the second order belief. Similarly, we can also model agent A's belief of another agent B's belief of agent A's belief as a probability distribution over probability distributions over probability distributions as third order beliefs, and so on. Beyond the first one or two orders, such modeling becomes behaviorally implausible[3] since most people cannot think their way through the resulting explosion of multiple layers of possibilities. In particular, assuming common knowledge of rationality in game theory implies that beliefs contain not just first and second order beliefs, but reasoning about reasoning continues to higher and higher orders, *ad infinitum*. There is ample evidence that people differ in their *levels* of reasoning when they form beliefs in interactions (Nagel 1995). The level of reasoning simply denotes the maximal order of beliefs formed and employed in the process.[4] If confined to only the first order, the reasoning is shallower relative to formation and analysis at higher orders. The level of reasoning may be related to strategic performance (Levine, Bernard, Nagel, 2017).

However, given the level of reasoning (denoted by *k*) being unconstrained in theory, it is not obvious that an agent's performance in strategic tasks is monotonically increasing in *k;* an unbounded level of reasoning can create problems of its own. For instance, in the well-known two-generals problem (Gmytrasiewicz and Durfee 1992), General A sends a message to General B proposing a time to attack

[3]Strategists *may* follow game-theoretic prescriptions (Helfat and Peteraf, 2009; endnote 3 on p. 100), but we do not know the degree, circumstances and consequences of such behavior.
[4]Related concepts of depth of reasoning and theory of mind (ToM) also have a variety of connotations in various literatures; we use level of reasoning in this paper.

their common enemy, and he cannot be sure that General B receives this first message. He could wait for General B's reply (message 2) to be sure that the first message was received, and that the attack time is actually agreed upon between the two generals. That would mean to choose $k = 2$, where General A reasons about General B's reasoning. Yet then General B could worry if his confirming message 2 has indeed been received by General A, and so on. In practice, a mechanism for keeping the value of $k$ bounded is necessary if the generals are ever going to launch a coordinated assault on their common enemy.

Strategists who work in teams continually face a similar problem (Barsade, 2002). When does one know that the team agrees on something – for example, to focus on an existing product line instead of developing new product lines? The culture of the team may allow it to coordinate implicitly on a given level $k$ of reasoning about others without formally documenting the expectation. For instance, all team members assume agreement by all once they get confirmation from all team members (so, they choose $k = 2$); that may work well in practice, without waiting to learn that all other team members also have the confirmation of all other team members (so, $k=3$ may already be too high). To emphasize, it is socially and collectively advantageous if the team members use the same $k$.

In interactions with competitors, Menon (2018) argues that more sophisticated, deeper reasoning (which may correspond to choosing a higher $k$) can help to outsmart competitors and to establish competitive advantage. Levine et al. (2017), who explicitly study the level $k$ of reasoning, found that slightly higher $k$ indeed yields advantages in competitive trading interactions. However, outsmarting others requires one to have an accurate estimate of how "smart" the others are; errors of estimation are self-defeating.

Taken together, strategy research emphasizes the importance of higher order expectations and the advantage of slightly deeper reasoning (Muth 1961, Amershi and Sunder 1987, Geanakoplos 1992, Sunder 2002, and Golub and Morris 2017). But the team agreement and the two-generals example points to just two of many contexts in which (slightly) deeper *reasoning does not* necessarily yield more effective responses to the behavior of others[5]. More broadly, the examples suggest that agents need to employ heuristics to cope with strategic interaction. Unbounded reasoning ($k$ being infinite) can often place intractable

[5]A related argument for the functionality of lower levels of reasoning can also be derived from epistemic game theory (Brandenburger, 2007). In many contexts, choosing a bounded level of reasoning is consistent with common belief in rationality and thus unbounded iterated reasoning. Thus, strategists may often (but not always!) do well by economizing on cognitive resources by choosing a low value of $k$.

computational demands on individuals and organizations (Bettis, 2017). And even if interaction situations could be handled by equilibrium analysis of a well-defined game, real-world strategic interactions almost always occur in ill-defined environments (Ehrig, Jost, Katskiopolous, Gigerenzer, 2019). If games are not clearly defined, equilibria are not defined. It is unclear what the meaning of rationality is or should be in such ill-defined, open-ended situations (Simon 1977).

Following Bettis (2017) we understand heuristics to be decision strategies that economize on information, time, and managerial attention. The use of heuristics in strategic interaction contexts is a necessity, if situations are ill-defined, and/or game theoretical equilibria are not computable (*ibid*). Choosing a level of reasoning is a way to decide when to stop thinking; it simplifies computation, and thus qualifies as a heuristic (Spiliopoulos and Hertwig, 2020).

Heuristics have been argued to be "rational", especially in adaptive contexts when knowledge of strategists is incomplete (Grandori, 2010). Simon (1967) suggests that effective thinking must be regulated, to react to novel environments. For instance, urgent needs may require a strategist to interrupt a thinking process, and Simon (*ibid.*) argues that emotions may serve the role of functional interrupters of thinking.

The choice of a level of reasoning corresponds to a point where thinking is disrupted. Our argument rests on the assumption that the effectiveness of a given level of reasoning, or the degree of intensity of thinking, is context dependent. The examples suggest that functional levels of reasoning (a choice of $k$ that leads to best outcomes) differ. How the choice of a level of reasoning is mediated is a relevant question. We explore a possible contextual factor — the emotional state of the strategist — that may affect the level of reasoning, and then we conduct and report the results of a controlled experiment to examine the role of emotions.

In the extant organization literature, the link between expectations and emotions has been explored, but not in the context of higher order expectations and levels of reasoning. Herbert Simon early on linked emotions to decisions via attention (1945, pp. 90-91), and later proposed that emotions should regulate reasoning (1967). More recently, emotions have been argued to play a role in search behavior, and their positive role has been emphasized (e.g., Hodgkinson & Healey, 2011). Emotional regulation has long been seen to be a positive managerial capability that enhances team performance (Reus and Liu, 2004; Barsade, 2002). More broadly, neuroscience research suggests that emotions may facilitate rather than disrupt rational thinking (Camille et al. 2004; Brusoni, Laureiro-Martínez, Canessa & Zollo 2020); an argument that is also acknowledged (Turner, 2009) in sociology. Emotions may regulate when thinking processes start and stop to assist boundedly-rational behavior, as unbounded rationality by itself may be cognitively wasteful. Finally, the literature on workplace emotions (e.g., Ashkanasy and Daus, 2002) acknowledges the positive function of emotions in an organizational context (e.g., with reference to the concept of "emotional intelligence"). However, none of the cited literatures links emotions to the formation of higher order expectations, or more broadly to heuristics used in strategic interactions.

Our results indicate that levels of reasoning are indeed mediated by emotions, and that altered emotions affect expectations of and among individuals. The level of reasoning tends to increase with experience under negative emotions, and even more so under neutral emotions. Under positive emotions, experience does not lead to an increase in levels of reasoning. Moreover, in our experiment, strategists only start to reason about others (that is, they only choose $k > 1$) when they receive feedback about the aggregate outcomes of the others' actions. This suggests that interaction outcomes inside and among organizations can be influenced by their design, in particular by the ability of strategists to observe others' actions, or at least some aggregate outcomes.

After discussing the problem of higher order expectation formation from a theoretical viewpoint, we outline an experiment to measure both the level of reasoning of strategists and the possible influence of emotions on this level. We then report our results. Finally, we take our results as a starting point to speculate more broadly about possible links between emotions and expectations in organizational and strategic contexts.

## 2. BACKGROUND: FORMING EXPECTATIONS ABOUT BEHAVIOR OF OTHERS

### 2.1. Adaptive Rationality and Choosing Levels of Reasoning

Objects of expectation formation usually are external events that become observable with the passage of time, e.g., the weather in Berlin or the closing price of Gazprom shares next Monday. However, in many social settings even the ultimate observability of the object of expectations cannot be taken for granted, and higher order expectations tend to fall in this category. In a game of tennis, Player *A* may form an expectation about what Player *B* thinks of the reliability or power of *A*'s backhand volley before *B* chooses their stroke. The end of the rally does not resolve such uncertainty because, even after the end of the match, *A* may still be left with only an approximate idea of *B*'s thoughts. Yet higher order expectations are a necessary component of strategic reasoning. How may they be formed? A few possible approaches to forming higher order expectations are:

1. Mirroring: To mirror is to attribute one's own knowledge, beliefs and expectations to others: I know or believe in something, and therefore expect that others' experience is the same. In a mirrored world, second order expectations equal first order expectations. Aspects of this simplifying principle appear as the Golden Rule in most social and philosophical traditions: treat others as you expect to be treated by others (*Mahābhārata Shānti-Parva* 167:9).

2. Deduction: Second order expectations may be deduced from observed actions of others, combined with assumptions about mirrored motives. For example, one assumes that others have the same motives as self and recovers the expectations of other agents implied by their observed actions. This appears in common proverbs in various languages.

3. Direct communication. *X* tells *Y* what *X* believes, and *Y* trusts the content of the communication to accept it as their own second order belief.

4. Communications game. *X* tells *Y* what *X* believes, or *Y* deduces *X*'s belief from observing *X*'s actions (assuming mirrored motives). However, *Y* interprets what is learned or deduced as part of a strategic game with *X* and infers *X*'s beliefs in the context of the game.

5. Third party communication. *X* tells *Z* who reports the results to *Y* (and others) either individually or as part of a survey or newspaper report about many *X*'s. This report becomes *Y*'s second order belief.

All five approaches require explicit or implicit decisions by strategist *Y* about whether and how to reason about *X*'s reasoning about *Y*. For instance, if Y uses the mirror, does he assume that *X* uses the mirror, too? Would *Y*'s third and higher order expectations also follow from the mirror? Moreover, if *Y* deduces *X*'s expectations, it makes a difference what assumptions *Y* makes about *X*'s expectations of *Y*, because *X*'s behavior in interactions is also driven by their first as well as higher order expectations. In almost all[6] modes of forming higher order expectations, agents must (at least implicitly) decide when to stop thinking about the others. Standard game theory posits no limits on the level of reasoning. Behavioral game theory either suggests that repeated interactions should lead to outcomes as if the reasoning about reasoning is infinite or that the level of reasoning is associated with strategic sophistication (Levine et al. 2017). We

[6] An exception is the approach to treat others like objects and not form a theory of mind at all.

return to discuss both these possibilities.

Unlike first order expectations, repeated observations do not necessarily help to form higher order expectations without making additional assumptions. In a stock market, a short-term trader forms expectations of what other traders expect the price of a security to be in the future, in order to decide on their own trades. Yet, even after the passage of time, the trader does not learn the magnitude of error in his higher order expectations. For instance, it is difficult or impossible to know if another trader is buying because the trader believes that the stock is underpriced, or because they believe that other traders believe it to be worth even more (Hirota and Sunder 2007, Hirota et al. 2020). Thus, the buying behavior of another does not imply a clear second and third order belief. Such difficult-to-verify-ex-post expectations present problems in descriptive and normative analyses of decisions. It is useful to distinguish uncertainties which are resolved with time from those which are *unresolvable* even with the passage of time. Constructs which cannot be reliably measured and verified, even in theory, are contested as the basis of a science. Since the range of higher order expectations is unconstrained by logic, we must find plausible alternative mechanisms to keep them bounded within some measurable range.

Returning to the two-generals problem, if the knowledge of their coordination problem is common to them, they could develop a shared protocol including a specified level of reasoning. They may, for example, agree to General *A* sending a message about his planned time of attack, and General *A* to act on that plan, irrespective of whether he received a response from General *B*. However, this 'arranged in advance' argument apparently holds only if no surprises (i.e., new information) arise between the prior agreement and action. If this were strictly true, the two generals would simply agree in advance on the date and time of attack, and there would be no need for any messaging in the first place. If the timing is to be chosen based on the circumstances prevailing at the time immediately preceding the attack, it is not clear that a prior agreement on messaging about the time of attack would hold either. The two generals may find themselves in a new environment (e.g., change in weather or unexpected terrain), where they no longer know if sticking to a prior agreement still makes sense. Moreover, protocols chosen in advance have a greater chance of being leaked to the opposition.

In an organizational context, repeated interactions needed for achieving expectational coordination become even less plausible. For instance, suppose higher order expectations matter in innovation adaptation dynamic. We may posit that, in thinking about others' response to innovation, people choose their own level of reasoning by habit. But how can they know whether they are in a repeated situation and the structure of the current innovation remains unchanged from their past experience? How can they know if this time it is different, and that this knowledge is common to them? For instance, regulatory monitoring and rules may have altered the economic environment over time. Then, using order $k = 2$ expectations and not thinking beyond that, is a mistake.

Thus, strategists are forced to consciously or implicitly choose a level of reasoning. Clearly, there are situations in which higher-level reasoning helps. For instance, higher levels of reasoning may help an investor make money from riding a price bubble and get out of it before it bursts (Keynes 1936). But such examples cannot be generalized and choosing higher levels of reasoning can be both functional as well as dysfunctional. For instance, if a creative entrepreneur thinks too much about others and their reactions, they may never take the risk to develop something radically new. On the other hand, in a legal interaction, it may be wise to engage in iterative thinking before entering a court of law. Next, we explore a range of possible mediators of reasoning levels, namely: emotions.

### 2.2. Emotions and Decisions

In the affective sciences, emotions have been hypothesized to feed into the decision-making process, especially in uncertain environments, and influence behavior over and above the cognitive calculations of desirability of the consequence of actions and the probability of its occurrence. Typically, theories of anticipatory emotions (e.g., mood-as-information theory, somatic-marker hypothesis, affect heuristic view, risk-as-feeling view) suggest that thinking about outcomes of actions elicits a brief emotional state: anticipating positive outcomes produces a positive affect and anticipating threatening outcomes produces a negative affect (Bechara & Damasio, 2005; Finucane, Alhakami, Slovic, & Johnson, 2000; Loewenstein, Hsee, Weber, & Welch, 2001; Schwarz, 2012). These brief emotional responses, either conscious or unconscious, factor into the calculations about the desirability of the behavior. Positive emotions, if attributed to a stimuli (even if incorrectly, as is the case in typical affect as information experiments) when deciding whether to approach it, would elicit an approach behavior towards the stimuli; conversely a negative emotion would elicit avoidance (Clore, Gasper, & Garvin, 2001). In decision making under uncertainty, or when the cognitive computations needed for making a decision are too demanding (for example when one is required to act within a short time span), affect can thus act as a useful heuristic. For example, Schwarz & Clore (1983) showed that when asked a complex question (to report their life satisfaction), people in a happy mood report greater satisfaction than those in a negative mood; furthermore this occurred only when people are unaware of their current mood's cause (good weather, or the experimenter's mood induction procedure). Thus emotion, much like other heuristics in decision making, can also be discounted when deemed as irrelevant information (see Clore, Gasper, & Garvin (2001)).

These insights from psychology suggest that we can widen our view on rationality and the role of emotions in human interaction. Our theory rests on the idea that emotions help to simplify computations, which in turn may be a positive function of emotion, as it is often a necessity to simplify reasoning processes However, an alternative perspective to interpret our findings is the perspective of embodied cognition. As is well established in psychology and biology (Varela, Thompson & Rosch, 1991), any human cognition is embodied. The body is the "home" of a wealth of sensations, that in mammals extends beyond mere sensation to regulate physical well-being (like the feeling of hot and cold, the need to eat, etc.), to emotions like sadness, anger, and fear. Sensations and emotions guide interactions almost exclusively early in life. For instance, a mother may instinctively attend to the discomfort implied by her baby's crying without keeping track of how often she does so. The care system in mammals creates the urge to bond with the child without an elaborate cost-benefit analysis of the consequences of the maternal behavior, with such behavior regulated by hormonal changes that occur at the end of pregnancy. Later in life, emotions also regulate interactions. For instance, they regulate attraction to a potential mate, a job, or a reaction to a challenging situation. Whether or not instinctively emotional or rational thinking in such interactions is cognitively advantageous in a cost-benefit sense  and leads to better outcomes, is an open question.

Emotions may be even more fundamental to human interaction. Our findings are compatible both with the interpretation that rationality means calculation, and emotions help to simplify calculation, and the broader perspective in which emotions are fundamental to any rational response. In both perspectives, emotions may direct humans when to start and stop calculation.

## 3. WHAT REGULATES OUR LEVEL OF REASONING? OUTLINE OF AN EXPERIMENT TO TEST THE PROPOSED THEORY

In order to explore any empirical relevance of our theory, we need data from relevant contexts. Expectations are not routinely observable in field data, and survey responses are potentially contaminated by self-interest. Accordingly, we chose a laboratory task in which incentives within the experimenter's control can be designed to help examine the validity and relevance of data. The experiment had to allow for subjects to choose their own level of reasoning, and it allowed the experimenter to infer that level on the basis of established theory, and permit observations under the relevant treatments of affect and feedback. We therefore adapted Nagel's (1995) guessing game to our purpose.

### 3.1 Guessing Game and Level of Reasoning

In a laboratory guessing game (Nagel 1995; Bosch et al, 2002; Coricelli & Nagel, 2009., a set of s individual subjects is asked to independently and simultaneously pick and submit a number xi within a common knowledge range ($xL$, $xH$). They are also informed that the average of the numbers submitted by all individuals in the set will be multiplied by a given constant fraction $n$ $(0 < n < 1)$ to arrive at a target number $t$. The individual whose chosen number is closest to target $t$ receives a monetary award $A$ (which is shared in case of ties); others receive nothing.

How can the level of reasoning be captured in the guessing game? First, the participants are made aware that all participants' choices will affect the outcome of the game. Without this, we would expect the participant to pick a random number between $x_L$ and $x_H$ (set at 0 to 1000 throughout our experiment, yielding an expected value of 500 for random choices). When the participants ignore the possibility that others, too, might pick a random number from the range, it amounts to zero level of reasoning because the person ignores the presence and behavior of others completely. See Table 1 for a simple rendition of the processing levels in the guessing game. At the next level of reasoning, the participant may realize that if others also choose random numbers in 0-1000 range, the average of the chosen numbers should be near 500, and thus, thinking one step ahead of others, guessing a number close to $500n$ should increase one's chances of winning. In this case, the participants recognize the presence of others using strategies symmetrical to their own, take an extra step based on that recognition, without expecting that the others, too, will take that extra step; it amounts to mirroring in all but the last step. Third, the participants could attribute to others their own reasoning and produce the number $500n^2$. This iteration can continue further for higher levels of reasoning. Indeed, assuming common knowledge of rationality in the sense of game theory yields a unique equilibrium in the guessing game. As levels of reasoning are unbounded in this theoretical conception, $n$ is taken to ever higher powers. Given $n < 1$, unique equilibrium in this game is thus an action profile in which all players choose number zero. In a classroom setting, the winner of the game is the one who best anticipates the anticipation strategies of the other players. For instance, if all other players choose level 2, a player can win by choosing $500n^2$-1.

--- INSERT TABLE 1 ABOUT HERE ---

We use data from the guessing game experiment to gain insights in validity of two contradictory lines of thought about whether positive/negative affect may increase/decrease the level of thinking, or vice-versa. We review factors that have been shown to affect reasoning, thinking about others, problem solving, and working memory, and could therefore be theorized to affect performance in the guessing game. Since the guessing game involves an interaction between these factors, we had only an approximate a priori hypothesis regarding how emotions may influence the participant's level of reasoning at the outset. Subsequent research suggested that results in affective psychology could be used to make predictions that support both a positive as well as a negative emotional effect on a participant's reasoning level in the game. Below we first discuss how positive/negative emotions increase/decrease reasoning levels when reasoning about others. Subsequently we discuss how because positive emotions induce a strong assimilation of incoming information into prior schema and use of heuristics derived from them. Also, since negative emotions allow systematic processing of incoming information, positive compared to negative emotions produce lower reasoning levels in the guessing game task. We expect the effect of neutral emotions to lie between those of positive and negative emotions.

Positive emotions have been shown to concentrate attention on the 'big picture', and to broaden a person's perceptual attention focus. For example, when participants with an optimistic disposition or a positive mood are shown geometric shapes, they tend to pick global features (triangle; if they see a triangle comprised of a large number of small squares) (Basso, Schefft, Ris, & Dember, 1996; Fredrickson & Branigan, 2005). A positive mood also increases the variety of future courses of action considered before making a choice. For example, when choosing a snack (from a set of four) for the next 25 days, participants in a positive mood were more likely to make more frequent changes to the snack choice as compared to those subjects in a neutral mood (Kahn & Isen, 1993). Positive affect also induces a more flexible cognitive orientation. When experiencing a positive emotion, participants tend to (a) include more objects in a specified category, suggesting a greater ability to see relationships among disparate objects (Isen & Daubman, 1984); (b) show improved performance in a remote association test where the task is to find a common prefix or suffix word to a set of three otherwise unrelated words, (Isen, Daubman, & Nowicki, 1987); (c) show better performance on the Duncker's candle task that measures creative problem-solving ability (Isen et al., 1987); and (d) produce more normatively unusual word-associates (Isen, Johnson, Mertz, & Robinson, 1985). Finally,

(e) in a study when physicians were asked to read a transcript describing the symptoms of a patient with liver disease, a positive affect decreased the number of lines the physician read before diagnosing the disease correctly, indicating a superior assimilation of all the information presented (Estrada, Isen, & Young, 1997). In the guessing game, positive emotion promotes focusing on not just the narrow task of choosing numbers that happens to be close to the average of others' choices, but also on information peripheral to the given instructions. This would promote focus on others' thoughts, and their thoughts about one's own thoughts about their thoughts, and so on, which would increase one's level of reasoning and decrease the numbers chosen in the guessing game.

Conversely, negative emotions, especially fear that follows threat stimuli, narrows the focus of attention (Easterbrook, 1959; Finucane, 2011; van Steenbergen, Band, & Hommel, 2011), and reduces thought-action repertoire (Fredrickson & Branigan, 2005). We would therefore expect negative affect to narrow the attention of the subject (to choosing a number in this task) and hamper exploratory thinking about what others are thinking, not mentioned explicitly in the task instructions, might impact the outcome of the game. Thus, within this framework, by reducing other-focus, negative emotions would reduce the level of reasoning and increase the numbers chosen in the guessing game.

However, we note that a number of studies have shown that positive emotions also tend to create a disposition to process information heuristically, using prior well-developed schemas to assimilate information, and using superficial cues in the problem set to arrive at a conclusion (Worth & Mackie, 1987). For example, when reasoning about the guilt in alleged student misconducts such as assault or cheating on an examination, inducing a positive (compared to neutral) emotion prior to judgment was found to increase the participant's reliance on whether the student's ethnic-group membership was stereotypically associated with such misconducts (Bodenhausen, Kramer, & Süsser, 1994). One point of import here is that these participants did not ignore the specific individual cues; a positive category membership interacted with negative individual traits to produce a lower target's evaluation compared to negative-category, negative-individual information, and when happy participants are told that they will be asked to defend their judgment it reduces their reliance on stereotypes (Bodenhausen et al., 1994). Thus it appears that positive mood does not reduce elaboration when reasoning, but rather, in a bid to assimilate all information provided is a salutary feature of positive emotion in the guessing game; it reduces the motivation to rely on information inconsistent with one's past knowledge (also see Bless, Bohner, Schwarz, & Strack (1990)). Negative valence on the other hand, because it narrows the focus of attention, consequently makes one process information systematically, taking into account the current stimulus set, and reason in a bottom-up manner without resorting excessively to prior knowledge (Bless et al., 1990; Fiedler & Bless, 2000). For example, participants in a negative emotional valence do not utilize superficial category information at all, but rather rely on an individual's specific traits. Thus, one could expect that quick, heuristic processing in positive emotions would decrease the choice of level of reasoning participants pursue, while negative emotion's systematic thinking would increase the participant's level of reasoning.

In light of the above evidence, we hesitate to make an a priori prediction regarding the effect of emotion on the level of reasoning in the guessing game. The effect of emotion on reasoning is complex, and the guessing game contains several elements such as the theory of mind, logical reasoning, mathematical reasoning, and working memory dependence, each of which may be differentially acted upon by emotions. Keeping this in mind, we perform a two-tailed test of significance of our results.

In our initial exploration, we use the experimental data to help us think through these two mutually contradictory ideas by restricting ourselves to broad emotional categories of positive, negative and neutral valence. In the experiment, we use videos to expose participants to specific positive (amusement), negative (fear), and neutral emotions (see Gasper, Spencer, & Hu (2019) for a review of neutral emotions.) Further differentiation of possible effects of specific emotions within these three broad valence categories on the level of reasoning must be left to additional studies.

In the next section we describe the setup in which the participants play the guessing game. The experimenters' ability to get the subjects to actually play *that* game, and not some other larger game, depends on the success of fulfilling the conditions of the induced value theory (Smith 1976) in laboratory. The ultimate success in creating such conditions can only be revealed by replication of outcomes in a variety of settings and with different participants. We have provided the relevant details of the experimental design, procedure, and instructions to help the reader reach an informed preliminary judgment from our data, and to replicate the experiment on their own.

### 3.2 Effect of feedback about others' behavior

In a secondary treatment in the experiment, participants were provided information about other people's responses in the preceding round of the game. If a person is made aware of some statistics—e.g., actual numbers, mean, distribution, dispersion, etc.—about their peers' choices, this information could influence their responses. First, feedback on others' responses may make others' actions more salient, and prime one to think more deeply about others' reasoning, and this could increase their own level of reasoning about others. Second, more importantly, feedback provides the participant information about their peers' level of reasoning, and thus increases the possibility that one picks a number based not just on one's general beliefs about others' choices, but on the less ambiguous information about one's peers' level of reasoning. Finally, it could lead one to abandon reasoning beyond a certain iteration in favor of trying to adjust one's answer to the trend that the target number (the average multiplied by *n*) follows. If all the participants try to come close to the target number, and also apply reasoning to what they think others are thinking, they will choose ever decreasing numbers as shown in Table 1 as a consequence of both an increase in level of reasoning as well as a pattern of recognition in the available data (see Nagel, 1995).

The experiment was conducted using the zTree software (Fischbacher, 2007). We had the participants play the guessing game in two sets of rounds. In the first set, they played nine rounds without feedback about their peers' choices. The target value (2/3 of the group average) for the ninth round was announced to the participants for the first time, and they played the next seven (feedback) rounds with the understanding that following each round they would be shown the target number for that round (which is 2/3 of group average that includes their own chosen number). In such a setup, we expect feedback about the target number of the previous round to affect participants' reasoning about the other participants' thinking and strategy, which should in turn affect the numbers they choose, with emotions influencing the numbers chosen to the extent it affects the participants' reasoning processes.

## 4. PARAMETERS AND RESULTS

The guessing game was implemented with parameters given below. Analysis of data to test the hypotheses, as well as to document some new observations, are also given below.

### 4.1 Effect of emotions on the level of reasoning

The experiment had nine sessions: three sessions for each of the three emotion groups. A tenth session suffered software malfunction, and its data have been excluded from analysis in this paper. All data is available from the authors on request. Each emotion group had either ten (sessions 1, 2, 4, 5, 7 and 8) or nine (Sessions 3, 6 and 9) participants. No participant attended more than a single session. Each session had a total of 16 rounds, with the first 9 being no-feedback and the last 7 being feedback rounds. The 10th round was the first round the participants played after having seen the target number (of the 9th round), which makes it the first feedback round. The experiment had a total of 144 rounds across all sessions, in which a total of 87 different individuals participated.

For inducing neutral emotion, two 1-minute clips from Disney's show Earth were chosen; for the negative emotion, two 2-minute horror movie clips from The Ruins and Hostel were chosen, and for positive emotions, two 2-minute clips found on the internet depicting pranks (table topping and cake in the face) were chosen. Evidence on validity of affects induced by the neutral and negative affect videos is available from the Emotional Movie Database (EMDB) (Carvalho, Leite, Galdo-Álvarez, & Gonçalves, 2012). For a review of the effectiveness of different emotion induction procedures, see Westermann, Spies, Stahl, & Hesse, 1996).

**Results for No-Feedback Rounds.** The mean of the numbers chosen in the no-feedback round (from range 0-1000) is 321 (*SD*[7] = 204). We interpret this to mean that participants choose level 1 of reasoning. In the feedback rounds when participants learn about the target numbers, the mean number chosen across all seven rounds is considerably lower at 154 (*SD* = 195), the difference being statistically significant at ($p < 0.001$).

Without feedback about the target numbers, a one-way ANOVA compared the effect of emotions on the numbers the participants chose. The analysis revealed a marginally significant effect of emotion manipulation on the chosen numbers [$F$ (2, 771) = 2.401, $p = 0.091$, partial eta squared = 0.006]. Despite a lack of significance, since we have only 3 groups, we conducted a post-hoc Least Square Difference (LSD) test which revealed that the positive emotions group chose the smallest numbers ($M = 299.8$, $SD = 204.7$), significantly smaller ($p = 0.031$) than the negative emotions group (M= 338.3, $SD = 210.3$) . The neutral emotion group fell in between positive and negative emotion groups (M= 324.9), $SD = 196.1$), and did not differ significantly from either (see Figure 1). Since observed size of the effect is extremely small, and a further mixed model regression did not reveal a significant effect of emotion (see Appendix II), we conclude that given no feedback, emotions did not have a reliable effect on the numbers chosen over all rounds considered together. Note that our result does not replicate Weber's (2003) finding that the level of thinking increases after repetition even in the absence of feedback. The difference in our results must be resolved through future experimentation designed for that purpose.

--- INSERT FIGURE 1 ABOUT HERE---

Is there a decrease in the numbers chosen over the sequence of the 9 no-feedback rounds which might reveal an increase in the level of reasoning over the rounds of the guessing game? An ANOVA revealed

[7]Standard deviation of all the numbers chosen by the participants in the sample.

that there is no significant decrease in numbers (i.e., no increase in reasoning) over the rounds in the absence of feedback: [$F$ (8,765) = 0.994, $p$ = 0.439].

Thus, it appears that in the absence of feedback, emotions have little effect on the numbers chosen (see Figure 1). We conclude that under no-feedback: (a) the null hypothesis of no-effect (or no differential effect across emotion groups)on participants' reasoning by the three emotion treatments cannot be rejected; and (b) the null hypothesis of no-improvement in the level of reasoning (indicated by a reduction in numbers chosen) from playing the game over the nine rounds also cannot be rejected.

**Results for Feedback Rounds.** In the feedback condition where participants were given the target number resulting from their chosen numbers (2/3 of average of numbers chosen) at the end of each round, a Welch test revealed a significant effect of emotion manipulation on the chosen numbers [$F$ (2, 599) = 37.21, $p$ < 0.01, partial eta squared = 0.11]. A post-hoc Games-Howell test revealed that the neutral emotion group ($M$ = 74.1, $SD$ = 98.3) chose the smallest numbers, followed by the negative emotion group ($M$ = 152.6, $SD$ =195.7). The positive emotions group ($M$ = 233.8, $SD$ =258.1) chose the largest numbers (see Figure 1 Panel B). All group differences were significant at the $p$ < 0.01 level. A mixed model regression revealed the same result (see Appendix II).

Do the treatment groups show a similar change in the numbers chosen across the seven feedback rounds (see Figure 1)? A two-way ANOVA with emotions groups and trial number (total of 7) revealed a significant interaction between them ($p$ < 0.01). While the interactions between positive and neutral emotions ($p$ < 0.01), and between positive and negative emotions ($p$ = 0.02), are significant, the interaction between negative and neutral emotions is not significant ($p$ = 0.91). Thus, the neutral and negative emotions show similar pattern of decline across the feedback rounds, while the pattern of responding for numbers chosen by the positive emotion group differs from the other emotion groups (see Figure 1).

It appears that while in the last no-feedback round where all groups had the same average of approximately 300, in the first feedback round participants in the neutral emotion group chose the smallest numbers (178.7), followed by the positive emotion group (199.6) and the negative group (229.2). We compared the difference in the numbers chosen between neutral and negative emotion groups (of approximately 50) with the average difference between these two groups in the no-feedback rounds, and found the difference to be significant [t(8) = 2.99, $p$ = 0.02]. This was likely due to a greater level of reasoning in the neural emotion group, compared to the negative emotion group, when the first feedback number was mentally processed compared to the no-feedback rounds (see Figure 2). The rate of decline in the chosen numbers was the similar across both negative and neutral groups. On the other hand, the positive emotion group had a larger initial number chosen compared to neutral group, as well as a significantly smaller rate of decline in the chosen numbers.

--- Insert Figure 2 about here ---

**Analysis:** This experiment was designed to test the ex-ante null hypothesis that emotions have no effect on the level of reasoning. The above results show that the null is not rejected in the absence of feedback, but with round-by-round feedback on target numbers, the null hypothesis is rejected; emotions do indeed affect the level of reasoning and therefore the pattern of responding during the game. This is indicated by the observation that under negative emotions, participants tend to choose smaller numbers as compared to positive emotions under feedback. We return to the implications of this main result for organizations and strategy in the concluding section of the paper.

Beyond the test of the main hypothesis, we also present other auxiliary testing of data gathered in the laboratory, and some post-hoc analysis and theorizing that might be useful for future research independent of our experiment.

First, the data reveal that neutral emotions induce participants to deeper levels of reasoning as well as the most increase in level of reasoning over rounds (indicated by a steeper decrease in the numbers chosen) relative to both positive as well as negative emotions in the guessing game, but only when they receive feedback on target numbers at the end of each round (see lower panel of Figure 1). Indeed, in Figure 1, the negative and neutral affect groups show similar monotonic downward trajectories in the average number chosen with the latter starting from a lower number or a deeper level of reasoning. The positive emotion group however shows no significant decrease in numbers with consecutive rounds of play. Finally, participants chose numbers above 500 a total of 152 (= 11% of 1376) and chose 1,000 a total of 14 times (about 1%) of all choices made. These high choices are distributed across three affect treatments (33 in neutral, 61 in positive, and 58 in negative affect) with neutral participants least likely to choose a number above 500.

**Conclusions:** We interpret these findings as follows: In the absence of feedback, the level of reasoning seems to remain low at about 1, and emotions have no detectable effect on the level of reasoning. In contrast, under round-by-round feedback on the target number in the preceding round, the level of reasoning is generally greater, and is influenced by the affect to which participants have been exposed. Under positive affect, feedback induced a one-time increase in the level of reasoning, but this increase does not continue in subsequent rounds. Under negative affect, first increase in the level of reasoning from round 1 to 2 is continued in the subsequent six rounds. This is evidenced by an average rate of 15% per round decrease (= $(84.1/229.2)^{(1/6)}$-1) in numbers chosen. However, the most interesting new pattern in the data is that neutral affect induced even greater level of reasoning; the average numbers chosen decreased by an average of 33% per round (= $(16.0/172.6)^{(1/6)}$-1) under neutral affect (as compared to average insignificant increase of only 3% per round (= $(238.3/199.6)^{(1/6)}$-1) under positive affect).

**Does A Deeper Level of Reasoning Earn Greater Rewards?**

Does a greater level of reasoning confer a strategic advantage on the participants in the form of increasing their chances of winning rewards? As we stated above, the rewards of the guessing game, like Keynes' (1936) Newspaper Beauty Contest Game go not to the deepest thinker — that would be a guess of zero — but to the one whose level of reasoning is closest to two-thirds of the average guess.

One maximizes the chances of winning by being one step ahead of the average of others, not much more or much less. In this sense, the guessing game has elements of social coordination in it. If the average level of reasoning of other members of the group is 1, a participant maximizes its chances of winning the reward by reasoning at level 2, not at 1 nor at 3. It is disadvantageous to be behind, or too far ahead of the crowd - something that many politicians try to do in order to appear to be a "leader" and win votes in an election.

How successful were the participants in each emotion group in following the target number? We calculated the difference between the target number and the participant's chosen number for every feedback round. We conducted a Welch test with this distance from target as dependent and the emotion groups as the predictor variable. We found that the distance from target was across the neutral (M = 35.01, SD= 73.47), negative (M = 70.14, SD = 140.7) and positive (M = 126.85, SD = 221.36) emotions was significantly different, [$F$ (2, 344.5) = 18.35, $p$< 0.01]. A post-hoc Games Howell revealed that the difference between the three emotion groups were significant at p < 0.01. Thus, participants in the neutral emotion group were the most accurate in picking numbers closer to the target number, while the positive emotion group were the least accurate.

Further, as Figure 3 shows, it appears that the winners chose numbers about 30-40 percent lower than the losers in all six treatments (two feedback levels times three affects). We had expected participants demonstrating higher levels of reasoning to achieve greater success in the game, at least in the no-feedback rounds. We found a negative Kendall's Tau-b correlation between the numbers chosen and binary outcome of winning (vs. losing (Tau-b = -0.169, $p < 0.01$). Thus, the lower numbers the participants chose, the higher their likelihood of winning. In the feedback rounds, given that the target number would decrease each round due to the effect of multiplying the participants' average by a number less than 1. Since the multiplier is 2/3 in the present experiment, we expected that choosing a number smaller than the group average would be more advantageous. Indeed, we found a negative Kendall's Tau-b correlation between the numbers chosen and binary outcome of winning (vs. losing (Tau-b = -0.18, $p < .01$). Just as in the no-feedback trials, choosing lower numbers when presented with the target number increased the likelihood of winning that trial. In other words, the rounds in which participants won had smaller number chosen compared to rounds in which they lost. This was true in both the no-feedback ($p < 0.01$) and feedback rounds ($p = 0.01$), and true for all three affects as seen in Figure 3.

--- INSERT FIGURE 3 ABOUT HERE ---

**Limitations and Post-hoc theorizing about individual behavior**

Although it is not a part of our initial intent, theory, or experimental design, we note some observations about individual behavior which will have to be validated by future independent experimental observations. First, it remains to be verified whether various positive emotions - humor, exhilaration, mirth or amusement - that we used to induce positive affect indeed have identical effects of level of reasoning. It is possible that emotions like happiness, elicited by watching scenes of gratitude and love, would lead to greater levels of reasoning.

Second, humorous videos elicit an appraisal of 'benign violations' - things that are a violation of social norms, or even cognitive expectations, but are not too serious (McGraw & Warren, 2010). An appraisal of benign violation, where a situation is perceived as both a violation of expectations or norms, but not a serious enough violation to induce a negative emotion of fear or disgust is often found in the context of 'play' where participants commit apparent hostile acts (e.g. pushing away,) but also accompanied by facial expression that indicate non-hostility, indicating that the norm violation was in fact benign (Van Hooff, 1972). Following an appraisal of benign violation after our positive emotion video, instead of playing the Guessing Game as we intended them to play, some participants could have tried to (a) contradict group expectations when experiencing appraisals related to amusement emotions, and (b)such actions would induce expectations of such subversion and the consequent failure of the expectation of a drop of target numbers in consecutive rounds. This post-hoc suggestion arises from the absence of increase in the level of reasoning under positive affect with feedback and calls for further exploration of observed behavior in the guessing game for reasons other than the direct effect of positive affect on the level of reasoning.

Third, an alternative possibility is that in the feedback rounds, behavior is influenced by the differential effect of emotions on an individual participants' ability to discern patterns in the target numbers in consecutive rounds, and to choose their numbers based on the patterns they perceive. How human beings recognize patterns in data and form expectations is a complex subject which is not pursued here.

## 5. DISCUSSION: THE LINK BETWEEN EMOTIONS, EXPECTATIONS AND STRATEGY

Our results suggest that emotions do indeed affect the degree to which strategists' reason iteratively when they receive feedback about others' behavior. While induced emotions show no significant effect in the absence of feedback, given feedback about others' behavior, we found that negative emotions increase the levels of reasoning, when compared to positive emotions. In other words, strategists think more about others given induced negative emotions than given induced positive emotions. However, even deeper levels of reasoning are induced under neutral emotions. Our results provide a glimpse into the broader question of how thinking about others, bounded rationality, and emotions are linked. We will now zoom out from our experiment and speculate about this link and map the findings to strategic management research.

### 5.1. Emotions, Expectations, and Strategic Management

As we have discussed in subsection 2.1, strategists are often forced to choose a level of reasoning when the interaction context involves a degree of novelty (when they have little experience with the interaction context). Our results suggest that emotions help to choose such levels of reasoning. Most importantly, the chosen number varies with induced emotion after strategists receive feedback from their interaction partners for the first time.

Bringing this result back to our discussion in the introduction, emotions may indeed be an important component of heuristics used for strategic interaction. In line with Simon's (1967) hypothesis, we interpret our experimental results and view emotions as devices that help to regulate thinking. As we argued above, equilibrium responses are of little value, when strategists need to first learn about their interaction context, and only have few observations at their disposal (Fudenberg and Levine, 1998). Our results suggest that reasoning about others, and the levels of reasoning used in such social interactive processes, varies with induced emotions.

Choosing a level of reasoning is one way to simplify and thus economize on computation in games

(Spiliopoulos and Hertwig, 2020). As emotions serve this purpose, they are likely a component of heuristics used for strategic interaction. Such heuristics are important when strategic interaction contexts are ill-defined (Bettis, 2017), such as when potential new entrants in a home market are unknown; or if relevant technological changes cannot be fully known. For instance, a new firm may surprise an incumbent by entering the latter's market. In such cases, strategists need to adaptively adjust their expectations about others' behavior and learn about the context of interaction during the interaction. We discussed in subsection 2.1 that choosing a level of reasoning is often a mere necessity in such contexts; the "rational" ideal of game theoretical equilibrium is of little value if it is unknown or not computable. In such situations, or if it is unclear whether opponents play along the equilibrium path, strategists need to employ heuristics to respond to interaction partners.

Limiting the level of reasoning is one of several simplification strategies to cope with strategic interaction. The prior literature highlighted that humans simplify, for instance, by only partially representing interaction partners (Menon, 2018; Ehrig, Jost, Katsikopoulos, Gigerenzer, 2019), or by taking shortcuts in game-theoretical computations (Spiliopoulos and Hertwig, 2020). Our results suggest that emotions may serve as a neuro-physiologically 'hard-wired' regulatory device to help simplify.

That strategists need to simplify, in particular, when environments are novel, is of course known. When task environments display a degree of novelty, and the vagueness of goals, opportunity sets, and their linkages make the problem too complex, simplification becomes a practical necessity. Sarasvathy's (2001) effectuation theory of entrepreneurship is a good example. She captures the highly unstructured and fluid environment faced by most entrepreneurs in four simplifying principles: bird-in-hand (working with what you have instead of dreaming about what you don't have), making lemonade from lemons (looking for new opportunities encountered by inevitable errors and unexpected events), crazy quilt (patching together help from new partners and their resources to strike out in new directions), and affordable loss (avoiding losses beyond what is acceptable). Effectuation, like emotions, points to the gains from placing bounds on reasoning to avoid paralysis-by-analysis and to make it possible to act.

Current scholarship starts to address the role of emotions in such simplification (Brusoni, Laureiro-Martínez, Canessa & Zollo 2020), but in the context of decisions that do not involve others. Our results suggest that emotions may be of particular importance for heuristics used in strategic interaction. The special importance of regulation of reasoning by emotions has been emphasized already by Simon (1967), and our preliminary study underlines the importance of further deeper enquiry into this topic. While emotional regulation has long been argued to be a managerial capability to enhance team performance (Reus and Liu, 2004; Barsade, 2002) our results suggest that emotions may also be a central component of heuristics to cope with competition, team members, and strategic environments more broadly. As we argued in 2.1. and in this subsection, this may be relevant for strategic environment uncertainty.

Our results also suggest that forming expectations about others is mediated by organizational designs. To our surprise, our experimental subjects only started to reason iteratively once they were provided with feedback. This is interesting, as it suggests that a theory of mind is only evoked given feedback about the actions of others, at least in aggregate form. This suggests that strategists may learn more effectively about responses to competition if they are in an interactive situation (when they can observe the actual actions of competitors), but they do not think effectively about others in abstract mental simulation. This is relevant for management contexts, as many analytical tools (such as Porter's five forces or, more generally, the value-based strategy framework) assume that strategists think through actions and reactions mentally, before actions of others are observed. This has potential implications for effective organizational design. For instance, strategy departments should be allowed to experiment in actual markets, not just plan a potential new strategy without participating in trial actions.

Zooming out into a broad context, our results are in line with current views on heuristics in strategic contexts (Bingham and Eisenhardt, 2011; Bettis, 2017; Ehrig, Jost, Katsikopoulos, Gigerenzer, 2019). Our findings and argument suggest the possibility that emotions may enable rather than disrupt "rational" responses in strategic environments. We note, however, that we still need to develop a notion of rationality in adaptive, and interactive, strategic contexts. The overall argument of this article implies that the idea of "common knowledge of rationality" in the sense of game theory may not be the most suitable notion of "rationality" in strategic management contexts such as market entry, competitor strategy evaluation, or evaluation of transition speeds towards novel technologies. In Ehrig et al. (2019), the concept of reciprocal bounded rationality is proposed which refers to *"the mutual understanding of potential interaction partners that everyone involved in an interaction under uncertainty is limited in access to information, computation time, and computational abilities".* This condition implies that it is rational to simplify, and in particular, to regulate thinking (Simon, 1967). Our results suggest that emotions may indeed enable such regulation and may thus be a component of reciprocal bounded rationality.

### 5.3. Open Questions and Future Work

Our experimental results only provide a glimpse into the links among rationality, adaptation, emotions, and strategic interaction. One obvious open question is whether our results imply that emotional regulation is a key capability to cope with strategic interaction. Because different levels of reasoning are functional in different contexts (see our example above), emotional regulation may implicitly help to choose a functional level of reasoning. However, whether such regulation enhances strategic performance is not answered by this paper and will have to be addressed in further work.

Moreover, our results leave open how emotions enter heuristics to cope with strategic interaction. A particularly important puzzle is the role of feedback as a mediator for the effect of emotions in forming higher order expectations. We don't know why emotions do not have a significant effect on strategic behavior in the absence of feedback about the actions of others. Is feedback a necessity to evoke a theory of mind, and do emotions then play a role in its formation? Future experiments may shed light on this question.

As we argued earlier, emotions may be of particular value for adaptation processes when interaction situations are relatively novel, that is, when strategists just start to receive feedback about reactions to their actions. In future work, it would thus be useful to explicitly link emotions and Knightian uncertainty in interactive, strategic decision making. How do emotions help to form expectations about others when it is unknown who relevant others may be, or what their likely actions could be? In sum, we hope that this article stimulates further research on the fascinating link between emotions and strategic interaction.

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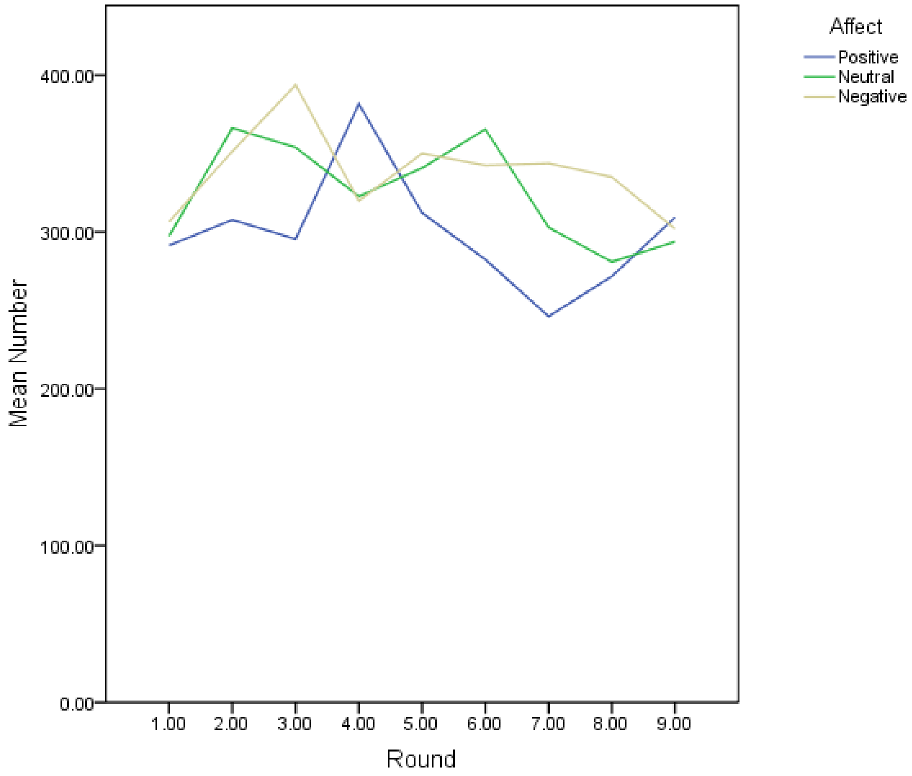
**Table 1: Thinking one step beyond others' level of reasoning**

| Level of Reasoning | My Beliefs about Others | My Action |
|---|---|---|
| 0 | Ignore existence of others | Choose at random from 0-1000 (average ≈ 500) |
| 1 | Others exist, and behave as I do in Level 0 above | Since I think other choose at random from 0-1000, I choose $500n$ |
| 2 | Others exist, and behave as I do in Level 1 above | Since I think others will choose $500n$ on average, I choose $500n^2$ |
| 3 | Others exist, and behave as I do in Level 2 above | Since I think others will choose $500n^2$on average, I choose $500n^3$ |
| .>3 | And so on ... | And so on ... |

Target value is group average times *n*. In our experiment *n* equals 2/3.

**Figure 1: Means and 95% confidence intervals of mean of numbers chosen in 9 no-feedback rounds (Panel A) and 7 feedback rounds (Panel B) across positive, neutral, and negative emotion groups**

Panel A: No-Feedback




Panel B: Feedback

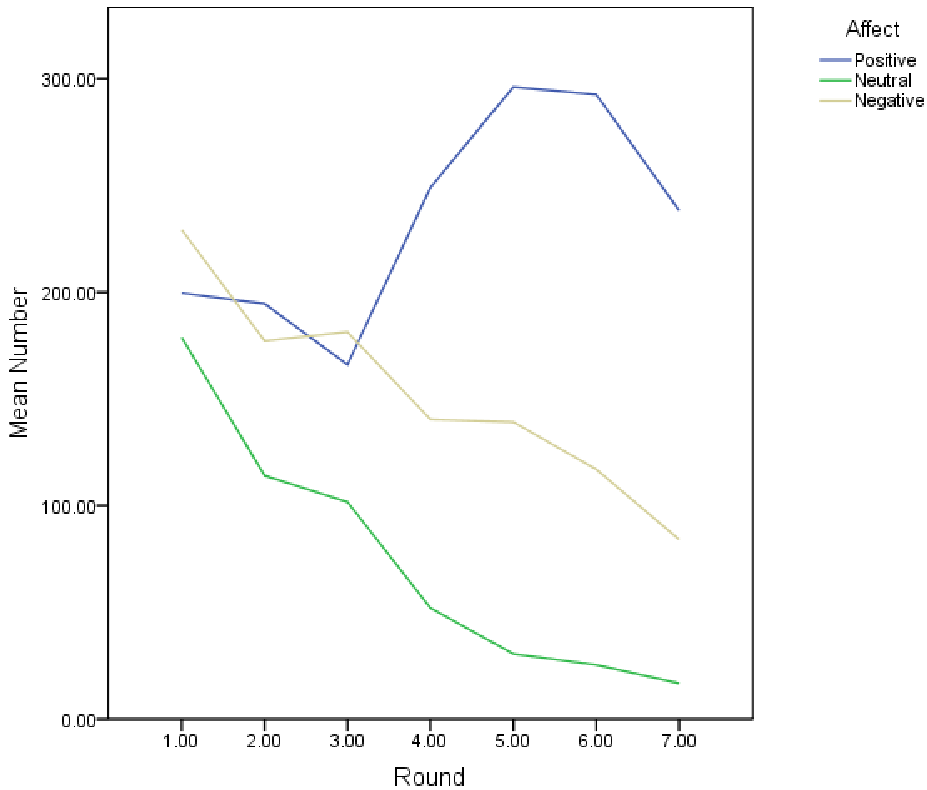


**Figure 2. Comparison of change in numbers chosen from the 9th (last no-feedback) to 10th (1st feedback) round, and comparison of average change across first 9 (no-feedback) rounds, within the positive, neutral and negative emotion groups (average and 95% intervals)**

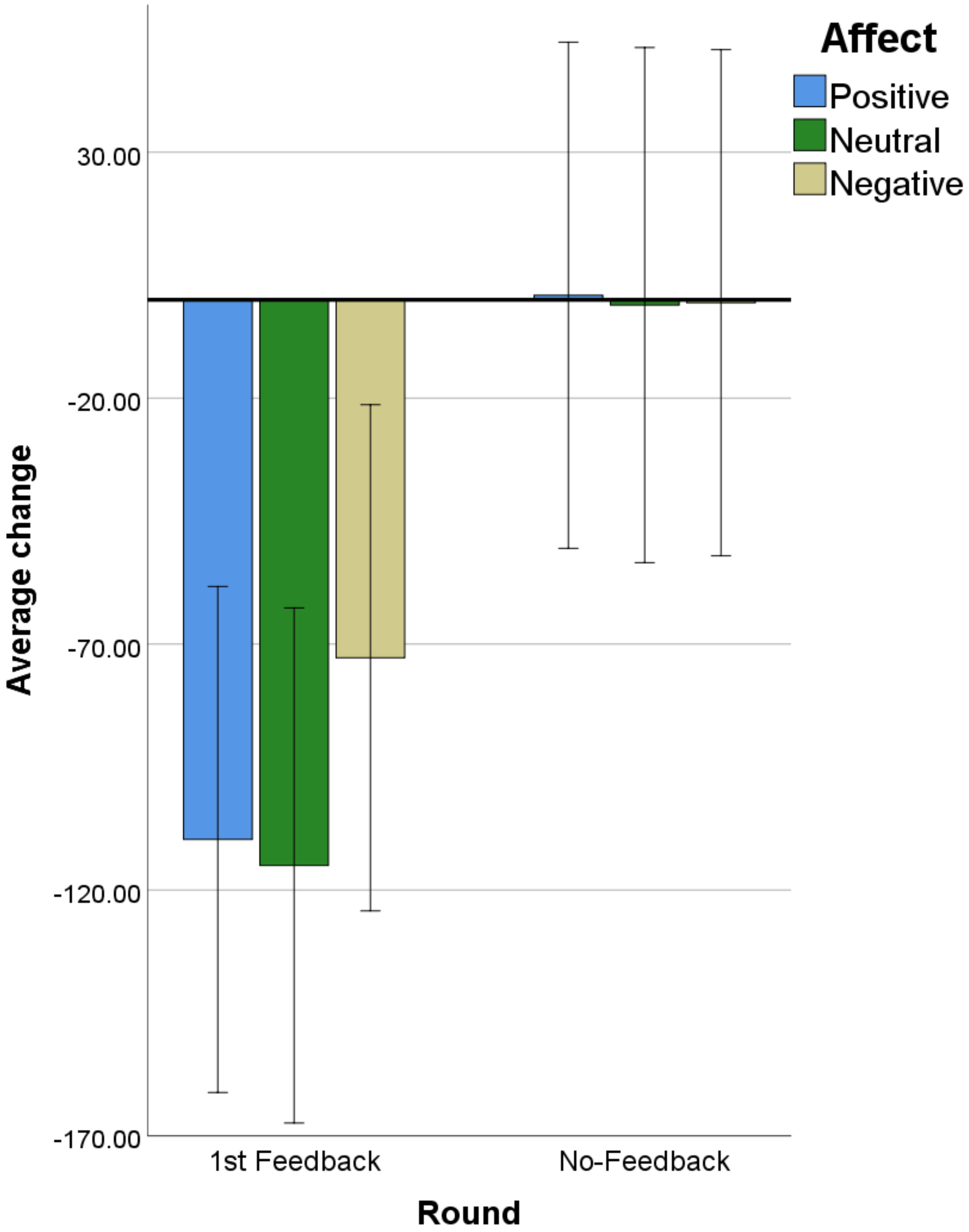
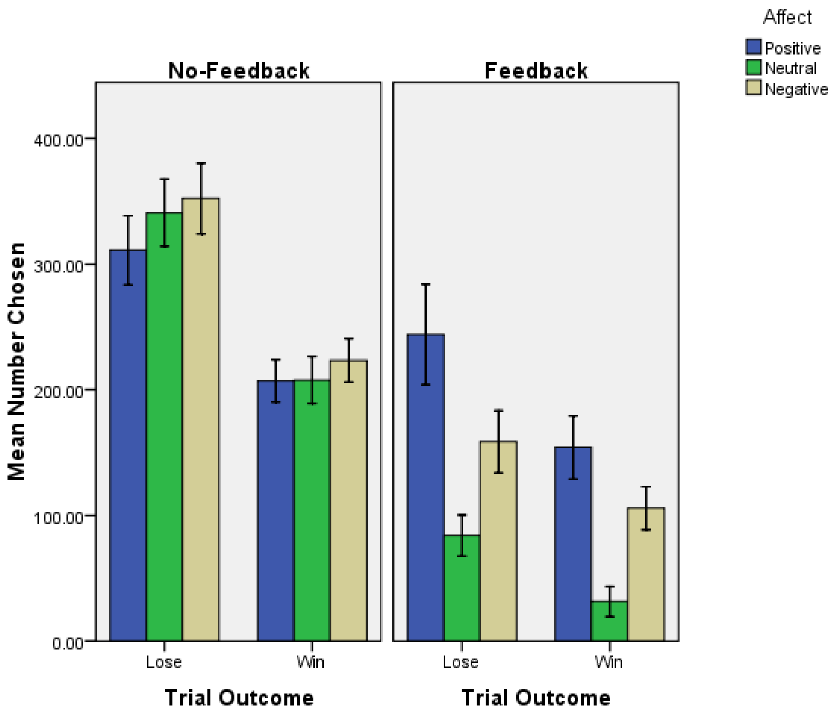


**Figure 3: The mean of the numbers chosen by participants in the trials they won/lost by feedback and affect**



## Appendix I: Script of Procedures and Instructions for Decision-Making Trials

Thank you for coming to this session on decision making. This session will last for about 30 minutes. During this session, you and others in the room will receive instructions, make decisions, and earn cash rewards that depend on what you as well as others do. All of your actions will remain private between you and the administrator. What you do in the session has no bearing on your academic status in the university. You may leave the session at any time, but in that case, you will forfeit any earnings you may have earned until that time. You are not to speak or communicate with anyone other than the administrator during the session. If you have a question, please raise your hand, and the administrator will come to you to address it.

Before we begin, please watch this short video clip

After watching the first video clip:

Please rate, on the scales provided, your current emotional state. You have to tick one of the nine boxes corresponding to the face shown to you. The first scale is the valence scale, where you have to rate your feelings from positive (good) to negative (bad). The second scale is the arousal scale where you rate how energetic, or aroused you feel. Remember that this arousal is independent of the valence scale; you can be highly aroused when feeling either positive or negative. Finally, the third scale is the dominance scale where you rate how big, great or grand you feel.

Remember each rating should reflect how you feel at the moment. This is not a rating of the movie.

Game instructions

You are playing what is known as the 'guessing game' and competing with 9 (or 8) other players. Each of you have to choose a number from 0 to 1000; the person that chooses a number closest to everyone's chosen's numbers' average multiplied by 2/3 wins the round, and receives a small cash reward. For example, if the participants have chosen the numbers 100, 300, 600 and 900, the total will be 1900, the average is 475, and 2/3 of average is approximately 316; this is the target number and the person who chooses closest to 316 wins that round. The winner for the round will be paid Rupees 10. There will be a total of 16 rounds, and each round is expected to last approximately 60 seconds (After the allotted response time is over, the clock indicating the time elapsed turns red, and the experimenter asks the participants to quickly input their choice). You will not know what numbers others have chosen.

Before we begin the game, we will watch another short clip, followed by the same rating task as earlier.

Second video clip

Please refer to the same instructions from the first video clip.

Game No-Feedback

You will be seated in front of a computer. You will have 30 seconds to enter your number. You can press 'OK' to move ahead before 30 seconds are over, but the screen only changes when either everyone has pressed okay or at the end of 30 seconds. There will be 9 such rounds.

Game Feedback

In the next 7 rounds, after you input the number, you will be shown the number you have entered, and the target number (2/3 of average). You can see how far your number was from the target. You can press 'OK' to move ahead, but the screen only changes when either everyone has pressed okay or at the end of 30 seconds.

Post-Experiment

At the end of the game, you have to write down your thought process behind choosing the numbers. Remember in some rounds you were unaware of what others have chosen, and in some rounds you were given the target number. Try and recall the reasons/strategy (or lack of) you used when choosing the numbers.

Please record if you have played, or learned about this game before.

Please write down the number of people in this participant group that you have known for at least a year.

## Appendix II: Additional Analysis of Results

### Manipulation Check

Participants were shown two videos of the chosen emotional valence during each session. Watching the two negative valenced videos yielded high negative valence (M= 5.52, SD= 2.19; M= 7.24, SD= 1.69) and high arousal (M=5.38, SD= 2.12; M= 5.89, SD= 1.99) in participants. The neutral emotion videos elicited moderate negative valence (M= 4.96, SD= 1.52; M= 4.37, SD= 1.49) and moderate arousal (M = 4.36, SD = 1.84; M = 4.11, SD = 1.65). The positive emotion videos elicited low negative valence (M = 4.19, SD = 2.03; M = 4.03, SD = 2.12) and moderate arousal (M = 4.43, SD = 1.67; M = 4.62, SD = 2.08).

A Least Significant Difference (LSD) test for valence revealed that the difference between positive and neutral emotion groups, although in the expected direction, did not reach significance ($p = 0.195$), while the negative emotion group was significantly higher in negative valence compared to both positive and neutral emotion groups with $p < 0.001$ for each. For arousal, the negative valence group was higher in arousal compared to both positive ($p = 0.01$) and neutral emotion groups ($p < .01$), while the positive emotion group did not differ significantly from the neutral group ($p = 0.261$), although the means did lie in the expected direction with the positive group higher than the neutral group.

**Mixed-Model Analysis of the Effect of Emotions on Numbers Chosen**

Since each participant chose multiple numbers in an experimental session, we performed a repeated measured analysis using a mixed model linear regression with participants (level 1) and participant group (level 2) as randomly varying intercepts, emotion as a fixed factor, and numbers chosen by the participants as the outcome variable. We found that group cluster did not account for any significant variance in the model in either the no-feedback (Wald Z = 0.86, p = .39) or the feedback rounds (Wald Z = 0.15, p = .89), and was hence removed from analysis. Our final analysis was a mixed model linear regression with participants as a randomly varying intercept, emotion as a fixed factor as well as a randomly varying slope, a scaled identity covariance matrix, and numbers chosen by the participants as the outcome variable. This model did not reveal a significant effect of emotion on the numbers chosen in the no-feedback rounds, $F(2, 29.11) = 1.13, p = .34$. The Fisher's Least Square Difference post-hoc test also indicated no significant mean differences between the emotion treatment groups. The variance for the residual was 39412 (Standard error of residual = 2055), and variance for the random coefficient was 1586 (Standard error of random intercept = 821). The -2 log likelihood statistic for the model was 10390. Thus, there was no difference in the numbers chosen across the three emotion groups.

The analysis (mixed model linear regression) for the feedback rounds revealed a significant effect of emotion on the chosen numbers, $F(2, 46.93) = 28.52, p < 0.01$, with the marginal estimated mean of the neutral group being the smallest ($p < 0.01$), and positive group being higher than the negative emotion group ($p < 0.01$). Variance of the residual was 33250 (standard error of residual= 1972), and variance of the random coefficient was 566 (standard error of random intercept = 461). The -2loglikelihood statistic for the model was 7965.5.

**Testing for Effects of Gender, Sociality of Context, and Emotion Intensity**

A two-way ANOVA revealed no main effect of gender [$F$ (1, 732) = 1.142, $p$ = 0.29, partial eta squared<0.01] or any interaction between gender and emotion [F (2, 73) = 0.378, p = 0.69, partial eta squared < 0.01] in explaining the numbers chosen in the no-feedback rounds.

Next we used the number of friends in the group as a covariate to see if presence of known social actors increases one's level of reasoning and thereby decreases the numbers chosen. A one-way ANOVA with emotion as a factor and number of friends in the group as a covariate revealed that the number of friends did not affect the numbers chosen, [$F$ (1, 770) = 0.04, $p$ = 0.85, partial eta squared < 0.01].

Using the individual's reported valence intensity as a covariate, we performed a one way ANCOVA with the emotion groups as a factor and found that the individual valence reported did not significantly affect the numbers chosen over and above the emotion groupings, [$F$ (1, 770) = 2.41, $p$ = 0.12, partial eta squared < 0.01]. Further, the same test revealed that individual reported arousal intensity was also not a significant factor, [$F$ (1, 770) = 0.21, $p$ = .65, partial eta squared < 0.01].

In the feedback rounds, just as in the case of no-feedback rounds, we found that gender, number of friends in the group, and the individual valence and arousal ratings did not significantly influence the numbers chosen over and above the affect treatment.

**Table A.** Fixed factors coefficients and their standard errors for the effect of emotion on numbers chosen, with participants as random intercepts.

| | | | 95% Confidence Interval | |
|---|---|---|---|---|
| Parameter | b coefficient | Std. Error | Lower Bound | Upper Bound |
| Intercept | 152.6 | 19.6 | 113.5 | 191.7 |
| Positive Emotion | 81.1 | 27.8 | 25.7 | 136.5 |
| Neutral Emotion | -81.1 | 27.8 | -136.4 | -25.7 |
| Negative Emotion | [set to 0] | 0 | . | . |

**Analysis of Additional Questions**

Strategies reported by the participants fell into the following categories: (a) random response, (b) 2/3 of 1000 (upper limit of choice), (c) 2/3 of 500, (c) 2/3*2/3 of 500, and (d) choosing either 'c' or 'd' after realizing that the iteration is unbounded. In the feedback rounds, the participants also reported choosing (e) a number smaller than the target number, and (f) a number 2/3 or 2/3*2/3 of the target number. The strategies were not analyzed any further since they were results of end-of-the-session recall, and may not accurately reflect the participant's round-by-round strategy, and/or accurately differentiate the feedback from the no-feedback round strategies.

A total of 4 participants (2 in positive, and 2 in neutral) were familiar with the same or a similar game. No participant had played the game before.