Sentire Decision-Making in a Mixed-Motive Game

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Abstract

The complexity of situations makes individuals use emotions to make sense of their environment and interdependent others. In this paper, we build on the idea that physiological reactions give emotional information about the subject and we focus on Electrodermal Activity (EDA), an index of arousal, to inspect *deep* processes of a dyadic interaction in a mixed-motive game. Our interest lies on how conflict episodes unfold, to design intelligent agents that are more socially aware and thus able to express and recognise dyadic forms of conflict. A qualitative analysis of the data allowed us to identify moments where players made choices to cope with ongoing conflict or prospects of it in the future.

Keywords: Conflict; Electrodermal Activity; Skin Conductance Responses ; Agent Modelling;

Introduction

Emotions are inherently informative. They are central to guide people's behaviour, to support the interaction with others and they carry information about how one is feeling, her motives, preferences, motivations and goals. When interacting with others, emotional expressions help the interlocutor to decode one's internal state, feelings, worries and satisfaction. Emotions (or instead the *appraisal* of the environment) are also transmitted through bodily changes, such as action tendencies and physiological responses (Lazarus, 1994).

In the work described in this paper, we build on the idea that physiological reactions give information about the subject and we focus on Electrodermal Activity (EDA). EDA results from the interaction of local electrical processes of the skin with the sympathetic nervous system of an individual (Boucsein, 2012). It can, thus, inform us about a myriad of psychophysiological processes. Our interest lies on how conflict episodes unfold, to design intelligent agents that are more socially aware and thus able to express and recognise dyadic forms of conflict. We believe that investigating *deep*[1] details of the interaction, such as emotional signalling, is critical for designing more natural experiences between agents and humans. In the future, systems that are able to respond to small details of the interaction (social signals) will become more effective and efficient in their design purpose (Vinciarelli et al., 2009). Focusing on EDA, it is a signal that might be potentially useful in helping a therapist to evaluate which strategies have a more beneficial impact in an autistic child (Chaspari et al., 2014). Furthermore, jointly with heart rate, in can also give insights about how immediate emotions can inform bidder's behaviour in an auction game (Astor et al., 2013).

[1]By *deep* data we mean, rich data representative of one's perspectives, emotions and motivations. We believe that these elements establish the context for many dyadic interactions, which are no more than a form of relating.

In this paper, we use EDA as a *tracing methodology* to study how emotional reactions to events in a bargaining game can change the dynamics of the negotiation process. We attempt to establish links with phases of conflict in a bargaining scenario, by analysing patterns of skin conductance responses (SCRs). For this purpose, we analyse the EDA of 22 children (aged 10 to 12 years-old) in a mixed-motive game under incomplete information. We created a real-life setting reduced to a mixed-motive game, in which the child's previous experiences and relation with the interactional partner play a relevant role in the interaction. We have found that, although there was not overt manifestations of conflict in the interactions, we could identify moments of intense anxiety (high number of SCRs), due to extreme initial offers or during more intense negotiation moments, when the parties are forcing the same deals without making concessions. We conclude the paper discussing our achievements, limitations and whether EDA is actually useful in this type of scenario.

Related Work

Electrodermal Activity

Electrodermal Activity (EDA) results from the interaction of local electrical processes of the skin with the sympathetic nervous system of an individual (Boucsein, 2012). It was verified that the skin becomes a better conductor in response to external stimuli (physical and/or emotional) having influence in myriad of psychophysiological processes. Over the years, EDA has been studied in several domains ranging from attention/engagement, information processing and emotion to clinical research (Dawson, Schell, & Filion, 2007). Researchers found that EDA is an adaptive mechanism to mobilise a 'flight-or-fight' reflex, and is related to anticipation, anxiety and distress (Andreassi, 2000). In the overall, is linked to cognitive and emotional processes.

The EDA complex[2] includes both a *tonic level* (SCL [3]) and a *phasic response* (SCR [4]). The former is the tonic level of conductivity of the skin, a slowly habituating measure of arousal. It slowly decreases when the subject is at rest and rapidly increases when a novel stimulus is introduced, and then gradually decreases (Dawson et al., 2007). The latter is

[2]Contemporary research has focused on measuring the skin resistance response which relies on external current for its observation (*exosomatic method*). Its reciprocal – the *skin conductance response* – has been the unit of analysis used widely by researchers. Within other reasons, *skin conductance* is easier to measure and increases with arousal hence, it provides a more intuitive mechanism for data interpretation.

[3]Skin Conductance Level

[4]Skin Conductance Response

a small fraction of the tonic level and a rapid changing component (often referred to as peak in the signal), which is sensitive to stimulus novelty, intensity and significance (Dawson et al., 2007). Stimuli that elicit a SCR are referred to as "event-specific responses", and on the opposite, if a SCR occurs in the absence of an identifiable stimulus, it is called a "non-specific response" (NS-SCR).

EDA and Decision Making

This interest in affect and emotion in judgement and decision making (JDM) research has renewed the interest in skin conductance and its potential to support research on how emotion impacts decisions in general (Figner & Murphy, 2011). For instance, Wout et al. (2006) studied the role of emotion in the Ultimatum Game. They focused on how skin conductance responses varied when the proposer offered a fair or an unfair division. Furthermore, they also assessed if emotional reactions to the type of offer would be the same if the proposer were a human or a computer. They observed a relationship between human unfair offers and higher skin conductance associated to rejection of those offers. In other words, SCR amplitude measured before response was a better predictor of acceptance or rejection than the offer itself, but the same was not verified when the proposer was a computer.

Another example is the work by Krosch et al. (2012), who explored how people make decisions in morally challenging situations, using self-reported and skin conductance measures. Moral decisions lack a clear right or wrong solution and the authors studied which choices minimise post-decisional consequences[5] for the decision maker. In their experiment, subjects participated in a hypothetical choice scenario, with no interaction with a counterpart. Nevertheless, the results suggest that people reflected increased physiological arousal when facing a conflicting choice, which may be related to post-decisional worry.

Constant and rapid decision making was studied by Palomki et al. (2013) in the context of a poker game variant – No Limit Texas Hold'em (NLHE). This scenario provides a rich context where the participant has to make rapid investment decisions, under risk and uncertainty. The authors use anticipatory arousal of various actions as a predictor of what action is likely to be taken by the decision maker. The authors have related the emotional reactivity to expected and experienced outcomes.

As it is possible to infer from the above research directions, skin conductance is a phenomenon that does not reflect a single psychological process, even within JDM research. Nonetheless, is a mechanism that can provide information about otherwise hidden processes that reflect how people make decisions and form judgements (Figner & Murphy, 2011). In our work, we are specially interested in skin conductance as a *process tracing* methodology to track cognitive states or stages during a decision making task. For that reason,and similarly to what have been done before, we focus on skin conductance responses (SCRs) in anticipation and decision making.

[5] Decision difficulty, post-decisional worry, and negative arousal.

EDA in Mixed-Motive Game: *Game of Nines*

In mixed-motive negotiations, conflicts are bound to emerge because participants have opposing preferences, and each attempts to maximise his or her own gains. An experimental setting in which the potential for conflict exists, acts as a model of a social interaction that is object of study. For this study, we used a variation of the "Game of Nines".

The "Game of Nines"

The "Game of Nines" is a mixed-motive bargaining game and it was firstly used by Kelley (Kelley, Beckman, & Fischer, 1967). This bargaining game was selected because it creates a setting where two negotiators face dilemmas concerning their goals and forms of communication. For a full description of this game refer to (Campos et al., 2015).

Briefly, the game is played with ordinary playing cards and involves three parties: the two players and the house/bank (which is not played by anyone). Each player holds eight cards from one (Ace) to eight, available every round. During each bargaining round, the players had to jointly agree on a possible contract. Each contract corresponded to a card that would be played by player A and one that would be played by player B so that their sum would not exceed 9. In each round, a *minimum necessary share* (MNS) is assigned to each player, privately, by the house[6]. This MNS value is only known by the person to whom it was assigned. for a profitable agreement, the negotiator has to bargain for a value above his MNS (e.g., if a player has a MNS equal to 4 and he plays a 6, he will get 2 as a reward), without knowing the extent of the concessions the other can make. If the participants do not reach an agreement in a limited amount of time both get zero. The player who makes the most profit wins a prize at the end.

What is *conflict* in this setting?

In this created setting, the structure of the task determines the degree of interdependence between the dyads. That is, it establishes the fuel for potential conflict at the beginning of each round. The task structure is determined by the MNS values that are discovered by each participant when each opens a new envelope. The rationale behind using fixed MNS values (see Table 1) throughout the game is to create the same situation each time a new round begins (with the exception of round 4). In our view of conflict (see (Campos, Martinho, & Paiva, 2013; Campos et al., 2015)) at least one party must perceive the incompatibility between the two and attribute the interference in achieving the desired goal to the other party.

Method

Twenty-two children (13 girls and 9 boys, age range 10-12) participated in dyadic sessions of the game. All dyads, with

[6] In our experiment the players took a card from an envelop,which was identified with the number of the correspondent round.

Table 1: Minimum necessary share per round

	Round				
	1	**2**	**3**	**4**	**5**
Player 1	2	1	3	4	2
Player 2	2	3	1	4	2

one exception, were same-sex participants. The mixed-sex dyad was excluded from the analysis described in this paper.

Opt-out consent forms were provided to all of the children's parents or guardians and all games were video and audio recorded, as well as, their skin conductance.

Each pair had to play 5 rounds. In each new round, each participant took a MNS (a numbered card) from an envelope. The child was instructed not to show the card during the trial and to never agree to a value below that number. They were told to negotiate as they saw fit. At the end of the round, each participant had to show the other his or her MNS value. The player with more total points in the end wins the game. The points were not converted to money, but the winner chose a prize between two choices.

Procedure

Before the game sessions, the children completed a sociometric questionnaire and were administered a personality test. The former was applied mainly to ensure that children on opposite poles (neglected vs. popular) or children who did not like each other were not paired together, given the sensitive nature of this experiment[7], to avoid undesirable effects on the participants. The paired children were from the same class, hence they knew each other and shared a history.

For the experiment, each dyad was collected from their classrooms and bracelets to measure their electrodermal activity were immediately attached to their wrists. Then, the children were conducted to a room that had been made available for the purpose. The participants were sat face-to-face at the opposite ends of a table that had a card board to assist them throughout the game. After explaining the rule, the participants were "walked through" two rounds of the game to learn its mechanics (The pre-game sessions took, on average, 15 minutes). Next, they were left alone to play the game.

To motivate the participants to do well, we told the players that the person who accumulated more points during the game would win a prize. In the end, both children won prizes, but the winner was able to choose between two options (one item was better than the other).

Equipment and Recordings

Skin conductance was continuously recorded using the Affectiva Q-Sensor, which has been proven to be highly correlated with data from traditional skin conductance monitoring systems (Poh et al., 2010), with a 8Hz sampling rate.

[7]The results from both questionnaires are beyond of the scope of this paper and are not going to be discussed here.

Sensors were placed in the child's non-dominant wrist right after they were collected from their classroom. After that, they had to walk to the experiment room (2 minutes walk, including climbing stairs). Once they got to the room where the experiment took place, there was a 15 minutes (on average[8]) warm-up period, during which the rules were explained and the participants were "walked through" two rounds of the game to learn its mechanics. Next, children were left alone to play the game and the start of the interaction was "marked" by pressing the sensor's button.

Data was collected during Winter, in January and February.

Detection and quantisation of SCRs

Although measuring EDA is relatively easy nowadays, the analysis of stimulus-related activity remains a challenge, mainly in situations where inter-stimulus intervals (ISIs) are short and peaks may overlap. To address this issue Bach and colleagues (Bach, Flandin, Friston, & Dolan, 2010) and Benedek and Kaernbach (Benedek & Kaernbach, 2010) have proposed two different approaches, based on signal deconvolution, which promise a reliable measure of SCRs. Both works resulted in two different tools for the detection of SCRs and nsSCRs (*SCRalyse*[9] and *Ledalab*[10], respectively). All the results we present in this report were obtained using Ledalab, which we found to be easier to use.

Using *Ledalab*, EDA signals were de-noised with a low-pass Butterworth filter of 1sec length. Afterwards the signal was analysed using continuous decomposition analysis (CDA), which decomposes SC data into continuous tonic and phasic activity (Benedek & Kaernbach, 2010). Furthermore, we used a response window of 1 to 3 sec after each marker, with an amplitude threshold of 0.03 μS to determine the SCR. All nsSCRs were extracted with same minimum amplitude.

Data Analysis

Making decisions consists in evaluate possible options and think about eventual future consequences, take an action and then possibly re-evaluate the decision made. Therefore, both experienced and anticipated emotions influence the decision making process, mainly in quite uncertain situations (Barry & Oliver, 1996). Hence, in this analysis we look for variations in SCRs in three stages (Figure 1): *pre-decision* (anticipation of utility), *decision* and *post-decision* (experienced utility). Pre-decision corresponds to the 3s before the event onset, post-decision which refers to the 3s after the established response window for the event/decision itself. We call to these three stages a *decision block*.

The values presented in this analysis were normalised using a logarithmic transformation (SCRamp = log(1 + SCRamp)). Furthermore individuals that showed no electrodermal activity were excluded from analysis (Dawson, Schell, & Courtney, 2011).

[8]This warm-up period was no less than 10 minutes, minimum required to obtain good results from the Q-sensor.

[9]http://scralyze.sourceforge.net/

[10]http://www.ledalab.de/

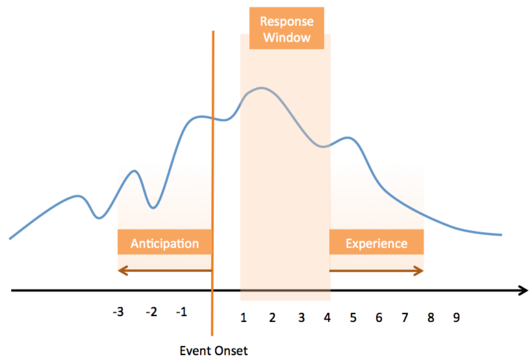

Figure 1: Analysis of the SCRs in three stages: *pre-decision* (anticipation of utility), *decision* and *post-decision* (experienced utility). We call to the set composed by the three stages *decision block*

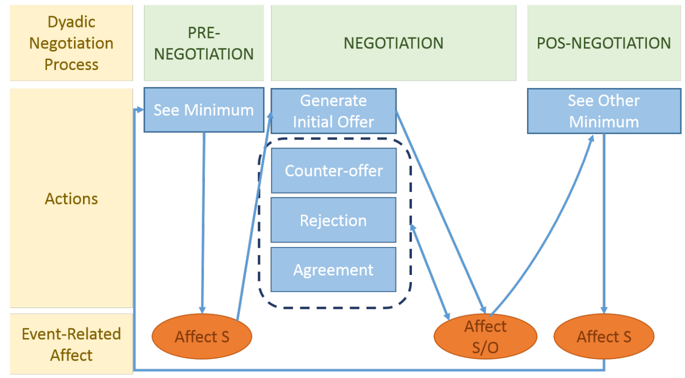

Figure 2: Flow of the interaction in each round of the *Game of Nines* and the affect experienced by the actor of the action (S) and the other (O) due to the game events. The dotted box represents a negotiation cycle.

The analysis of EDA, in particular the skin conductance responses (SCRs), was focused on the actions in the game: *a*) see own minimums; *b*) make an offer; *c*) decline or reject an offer; and *d*) see each other's minimums. Moreover, it is the combination of these actions that may allow us to know more about the emotional dynamics throughout the decisions made within the game. In the next section, we analyse them more closely.

Discussing Results

In our approach, a prototypical negotiation is embedded in the design of the experiment itself. We consider that every round is composed by a *pre-negotiation phase*, a *negotiation* and a *post-negotiation phase* (Figure 2).

In this created setting, children bring their expectations about their partner, their past experiences and the relationship they have built with their partner. These elements, along with the structure of the task, determine the degree of interdependence between them. That is, it establishes the fuel for potential conflict at the beginning of each round. Then, they engage in a negotiation cycle that represents attempts to reconcile conflicting interests and it may be a process marked by intense emotions, which depends on the individual's motivation (Van Kleef & Sinaceur, 2013). Building on the idea that physiological reactions give information about the internal state of the subject, we looked into the EDA of participants, with particular focus on event-related *affect* [11]. A summary of the % of SCRs elicited in each event is in Figure 3.

In ***pre-negotiation***, players see their minimums and formulate their expectations, aspirations and limits, which may vary throughout the interaction. The number of SCRs decrease in *anticipation* of that event, although there is not a significant difference between rounds ($\chi^2(4) = 1.143, p = 0.887$)[12]. This trend may be caused by a decrease in the novelty effect, one of the sources of SCRs (Boucsein, 2012; Dawson et al., 2011). The *experience* of the same event does not vary much over time ($\chi^2(4) = 4.154, p = 0.386$), but we verify a peak in ***Round 4***, which reflects the child's awareness of the few options available for negotiation and might be related to the expectancy of possible negative outcomes (Dawson et al., 2011), We did not find, however, a relationship between the *first offer* and the SCRs elicited by the event *See Minimum* in each round. Independently of the round the *first offers* were high, except in one case:

Case 1 A player demonstrated a feel of guilt in one round after obtaining a very large profit on the previous one. That feel of guilt resulted in cooperative behaviour, that is, she bid low in her first offer (with arousal). This type of behaviour had been identified before by Ketelaar and Tung Au (2003), who experimentally showed that the feeling of guilt fuels cooperative behaviour.

Nevertheless, the increasing number of SCRs exhibited by the *See Minimum* event itself, as the game progresses, may be related to the internal desire of achievement, guided by self-interest only (Barry & Oliver, 1996).

During the ***negotiation phase***, players make offers, counteroffers and generate responses to them. Those actions have effects on the actor of the action (intrapersonal effects), but they certainly have interpersonal effects as well. In Figure 2 we call those effects Affect S/O, i.e. affect experienced by self and by the other. Regarding the affect on the actor of the action (S), the % of SCRs was higher in Rounds 1, 2, and 5 and occurred when players ask for a large slice of the profit. Furthermore, SCRs were elicited over intense moments of the negotiation, that is, slices of the interaction wherein players are making none or very small concessions or even applying

[11]The term affect is used here as a way of describing an affective reactions to a stimulus (event, object or person) without demarcating it as positive or negative (Slovic, Peters, Finucane, & MacGregor, 2005)

[12]Cochran Q test

ROUND	See Min			Bid			Accept/Reject			See Min Other		
	B	D	A	B	D	A	B	D	A	B	D	A
1	40	46.7	13.3	17.6	29.4	0	0	25	7.1	25	56.3	31.3
2	38.5	38.5	7.7	16.7	29.6	3.7	4.3	23.4	4.3	25	37.5	18.8
3	35.7	42.9	28.6	10.8	21.6	8.1	3.1	25	3.1	31.3	50	18.8
4	23.1	23.1	38.5	8.7	18.8	2.9	5.7	24.5	3.8	6.7	46.7	20
5	28.6	50	28.6	12.5	30.4	0	2.6	13.2	2.6	25	41.7	8.3

80-100
50-80
40-50
30-40
20-30
5-20
0-5

Figure 3: Percentage of SCRs elicted by each action by round. **B** - Before/Anticipation; **D** - Event; **A** - After/Experience

avoidance strategies. In ***Round 4*** disputes are over smaller gains that originate some or no profit.

Furthermore, we studied more closely what was a party's reaction to the other's offer since it may be related to the action one takes next. SCRs were elicited in the opponent in two situations: *threat* and *opportunity*. *Threat* corresponds to situations in which the offer generates low or negative profit. The immediate response is to reject in opposition to prompt a counteroffer. *Opportunity* is linked to offers that reflect what the opponent wants to accept, resulting in acceptance of the deal by the opponent. We verify a significant difference in the mean amplitude of the SCRs elicited in the opponent ($F(1) = 4,141, p = 0.046$) when the bid represents a *Threat* ($\overline{amp} = 0.23$) or an *Opportunity*($\overline{amp} = 0.40$)[13].

Accepting and rejecting offers are two moves part of the "*negotiation dance*" and throughout the interaction there are more rejections than acceptances (13 out of 49). Rejection of offers that elicit an SCR are related to high bids made by the proposer that are not the first bid. The next action is usually to replicate the other's offer or wait for the other's proposal. But in particular cases the players used the *give up* card or threatened to use it, this occurred in situations where the opponent did not want to change his offer or was continuously offering bad deals to the player. On the other hand, agreements that elicit a SCR are linked to bad decisions or to concessions that still provide a good profit, but it is not possible to distinguish between the two.

Moving to the ***post-negotiation phase***, this a phase characterised by the revelation of the minimums. The premise is that the behaviour in subsequent rounds will suffer from previous decisions (unfair deals, exploitation or deception). Barry et al. (Barry & Oliver, 1996) alert for situations of asymmetry, wherein a negotiator experiences positive affect and the other negative. Based on previous findings, this may lead to a certain level of "retained hostility" that is exhibited in avoidance or retribution in the following encounters. This state of "retained hostility" was observed twice in our data and are somehow related to the post-negotiation phase:

Case 2 A negotiator simply engaged in avoidance tactics, using irony to make counteroffers. She did not use the card *give up*, but she had threaten to do it a few times.

Case 3 A negotiator A got the worse deal in comparison to his opponent B (in rounds 1,2 and 3), except in Round 4 when B played a card below his minimum. In round 5 they engaged again in negotiation with few concessions, player A used the give up card without saying anything before, just to punish the adversary.

These two cases shift our attention to the levels of affect post-settlement and its consequences, when the cause for failure is attributed to the opponent (Weiner, 1985), although they are not directly visible in EDA data. That is, we are able to identify intense moments of the interaction, but more information is needed to make these inferences.

Conclusions

The use of EDA as an index of emotional arousal in judgement research is a common approach and has gained momentum in more recent years (Figner & Murphy, 2011). Among other reasons it a cheap and easy to use method that promises access to hidden processes and information that may reflect how people make decisions, unobtrusively. Research on EDA and decision-making processes has focused essentially in games that involve a risky decisions (Palomki et al., 2013; Slovic et al., 2005; Bechara & Damasio, 2005) to understand people's moves and to study the physiological signals associated with it. With some exceptions (Krosch et al., 2012), there is not much research exploring other types of decision making nor the dynamic process in more natural settings, as the one presented in this report. To approach such complex experimental design we chose to examine the impact of affect in specific moments of the negotiation process: *pre-negotiation*, *negotiation* and *post-negotiation* phase. From that point onwards we continuously broke down the components in smaller pieces. In the *pre-negotiation*, for instance, we analysed the *see minimum* event, which in turn was analysed around a decision block that includes: *pre-decision* (anticipation of utility), *decision* and *post-decision* (experienced utility). This method allowed us to apply between-subjects analysis of each of the actions in the game.

A limitation of our study is that most of the data obtained come from pairs 5, 6, 8 and 10, exhibiting different type of relationships, a pair of best friends and pairs in which the subjects are indifferent to each other. All those were engaged in longer and more disputed negotiations, resulting in the 3 manifestations of conflict (cases 1, 2, 3). Nevertheless, those were

[13] This data should be taken with a grain of salt though. A spike linked to an opportunity only occurred 7 out of 68 times, although we verified a significant ($p < 0.05$) difference in amplitudes by running ANOVA.

the subjects who kept showing arousal in repeated events suggesting that SCRs are more related to stimulus significance than to stimulus novelty. Furthermore, the decision process was not always fully captured due to the short ISIs between actions, which did not allowed us to have complete *decision blocks*. EDA readings are not useful in such cases (Dawson et al., 2007) and it is debatable if can be used in more natural experimental settings, unless the experimental paradigm is better controlled. Moreover, EDA alone may not help us to automatically make sense of an episode. SCRs only become interpretable by taking into account time and sequence of actions and stimulus conditions, which not makes SCRs alone good predictors of behavioural actions.

All these small details of the interaction, which we call *deep data*, are critical for designing more natural experiences between agents and humans. This study shifted our attention to the role of emotion in the manifestation of conflict and probably the most important finding is the absence of no active behaviours. Dawson et al. (2007) underlines that EDA is linked to the *inhibition* system and thus, involved in processes such as responding to punishment, passive avoidance or to frustrative reward. Hence, it is most responsive when the subject does not take an action. This is an important implication for the design of agent system that deal with conflict: emotions are *retained* and sometimes subjects choose to act upon them and that is visible in cases 2 and 3 described above.

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