Which Society, Which Software?

Can Baskent

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Can Başkent

INRIA, Nancy
www.canbaskent.net/logic, can@canbaskent.net

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Abstract

In this paper, I discuss social software from the philosophical perspective of non-classical logic, and advocate incorporating non-classical logical tools into social software. In order to achieve this, I raise two questions: "Which Society?" and "Which Software". Similar to logical pluralism, I argue for a pluralistic view of social software.

Key words Social software, logical pluralism, real-world economics.

1 Introduction and Motivation

The term *social software* was coined by Rohit Parikh in his 2002 paper (Parikh, 2002). Social software, even if Parikh himself did not give a precise definition, is the study of constructing and verifying social procedures by using tools in logic and computer science. By definition, it relates closely to the fields of game theory, social choice theory, behavioral economics, and logic. However, to the best of our knowledge since its conception, social software has not been considered from a non-classical logical perspective.

Even if Parikh himself did not explicitly commit himself to the classical logic in the original paper, the *de facto* logic he utilizes in his work is classical. However, if the overall goal is to give a computational and logical explanation for social procedures, there seems to be no reason on insisting on the use of classical logic:

> I want to argue that (...) no doubt we shall never have social procedures which work ideally, we can nonetheless have a theory of social procedures which is analogous to the formal theories for computer algorithms which exist in computer science. I am referring here to a whole group of theories, some of which have come into existence during the early seventies and some are newer.
>
> (Parikh, 2002)

I argue that the above quoted claim, and in general the research program of social software requires the use of formal tools beyond classical logic. The plurality of social procedures and various anomalies (such as lies, jokes and speech acts) in them necessitate a pluralistic approach. Moreover, truth *gaps* and truth *gluts* are an ordinary part logical explanations regarding a wide array of social phenomena. In fact, this is one of the main motivations behind logical pluralism: classical Boolean logic suffers from various restrictions which render it not-so-useful in explaining human behavior and reasoning. In some cases, we can have different notions of logical consequence; in some cases, we may need more truth values; in some cases, we need to reevaluate and redefine the logical connectives. Furthermore, it is not entirely clear how exactly people reason in social situations, and to which logical framework they are usually committed (Kahneman, 2011; Ariely, 2008).

In this work, in terms of logical pluralism and non-classical logics, we mainly focus on paraconsistent logics. I use the term *paraconsistency* for the logical systems in which the rule of explosion fails. In such systems, for some φ, ψ, we have $\varphi, \neg\varphi \nvdash \psi$. In short, paraconsistent systems are the logical frameworks that allow non-trivial inconsistent theories, and help us build inconsistency-tolerant models. I believe this notion is a key in understanding social software.

There are various reasons for that. First of all, contradictions occur in social phenomena. People lie, cheat, make mistakes, and misunderstand each other, they happen to be wrong in their thoughts and actions, and all of these situations require an inconsistency-friendly framework for expressive power. Moreover, various data from behavioral economics indicate that people usually do not reason in the way that the classical logic predicts (Kahneman, 2011; Ariely, 2008; Ariely, 2010). For instance, when people make an error in reasoning that can cause an inconsistency, the very existence of the inconsistency does not collapse the system. People keep reasoning in their inconsistent model in a sound way; and consequently, sometimes they revise their beliefs, sometimes they reason non-monotonically, sometimes they ignore the inconsistency.

Yet, there also exists some other sort of inconsistencies in human reasoning and social procedures. Perhaps, a canonical example for such cases comes from normativity. The problem is how people *should* act under the presence of contradictory obligations. This is a social software issue as well as a problem in legal philosophy. There are various approaches to obligations and normativity, yet very few of them mention the above critical point (Başkent *et al.*, 2012; Priest, 2006).

Priest, for example, describes inconsistent obligations as the "situations where someone is obliged both to do x and not to do x" (Priest, 2006, p. 182). He further elaborates on inconsistent obligations as follows.

> The source of contradictory obligations need not be different contracts, but may be one and the same contract. Of course, in practice it is rare for a contract *per se* to be blatantly inconsistent, but it is not unusual for a contract plus contingent circumstances to give someone inconsistent obligations. Suppose, for example, that I contract

> to do z under condition X, but refrain from doing z under condition Y. We may suppose that X and Y are events not under the control of the parties of the contract, and that there is no reasonable likelihood of X and Y both occurring. Suppose that, despite this, both do occur. Can I then be held in breach for whichever of the actions I do not perform?
>
> (Priest, 2006, p. 183)

The issue, raised by Priest here, has some ontological commitments to the contradictory existence of X and Y, and we will not go into the philosophical discussions about this ontological problem. Regardless, it shows that paraconsistent approach to social situations presents itself as an important perspective.

Another example of a contradictory situation comes from one of Parikh's recent papers. In my opinion, the "Kitty Genovese" case that Parikh et al. discussed illustrates similar concerns.

> [I]n the Kew Gardens section of Queens, New York City, Catherine Genovese began the last walk of her life in the early morning hours of March 13, 1964. As she locked her car door, she took notice of a figure in the darkness walking towards her. She became immediately concerned as soon as the stranger began to follow her.
>
> As she got of the car she saw me and ran, the man told the court later, I ran after her and I had a knife in my hand... I could run much faster than she could, and I jumped on her back and stabbed her several times, the man later told the cops.
>
> Many neighbours saw what was happening, but no one called the police. Mr. Koshkin wanted to call the police but Mrs. Koshkin thought otherwise. I didnt let him, she later said to the press, I told him there must have been 30 calls already.
>
> When the cops finished polling the immediate neighbourhood, they discovered at least 38 people who had heard or observed some part of the fatal assault on Kitty Genovese.
>
> Some 35 minutes passed between Kitty Genovese being attacked and someone calling the police. Why?
>
> (Pacuit *et al.*, 2006)

In this case, the classical logic oriented analysis that the authors suggested is of deontic and epistemic logical in nature. Namely, the witnesses did not call the police, thus did not fulfill their moral duty as they did not possess the full information of the event and their agency in relation to each other. Simply put, witnesses thought that some other witness might have called the police already. This analysis is plausible. Yet, some other analysis can also be given for the Genovese case underlining that people may behave inconsistently in a non-trivial way.

One of the descriptive analysis of the situation calls for a paraconsistent framework. It is assumed that the witnesses are morally obliged to call the police. Yet, they did not. Based on their deontic presuppositions, this is what we have ontologically:

$$\mathsf{WitnessAMurder} \rightarrow \mathbf{Obliged}(\mathsf{CallPolice}), \mathsf{WitnessAMurder} \nvdash \mathsf{CallPolice}$$

If we endorse modus ponens, and assume that obligations relate to the current state (namely, if $\mathbf{Obliged}(\mathsf{CallPolice}) \rightarrow \mathsf{CallPolice}$), then we derive both CallPolice and $\neg$CallPolice which is contradictory and incoherent under classical negation and consequence relation. As widely known, there are various ways to modalize the above formulation by using deontic operators that stand for obligations, yet we will not dwell into deontic logical debates here.

It should be noted that the paradoxical situation in this case is avoidable. As the standard analysis for the Genovese example explicates, if the witnesses knew individually that none of the other witnesses called the police, they could have fulfilled their moral obligation.

Additionally, a simple game theoretical analysis of the situation can be considered. If a witness calls the cops to report the incident, the cost to the witness for the call is less than a dollar and couple minutes which is by far negligible compared to the possible benefit that the call might bring about: saving the life of Kitty Genovese. Simply put, even if a moral agent i assumes that 1000 people saw the incident, and the chances that i will be the one who will report the incident first to the police is %0.1, it is still the rational move to make, since a person's life (nearly universally) is more valuable than the troubles that i needs to go through to report the incident - yielding a much higher expected utility for the call. Therefore, regardless of attaining the full knowledge of the case, I maintain that the witnesses have the obligation *to the best of their knowledge* to report the incident. Perhaps, they would be the 999th person to report it, which is perfectly acceptable, but maybe they would be the first. In either case, game theoretical reasoning dictates that rational agents should make the call. Yet, they did not. Then, the classical analysis suggests that the agents in this case are not rational. Paraconsistent analysis here prevents this over-reaching revision. It can very well be the case that agents could be perfectly rational (and most likely they were), yet still did not make the call. Therefore, adopting a paraconsistent framework also helps us construct a broader framework where we do not need to revise the initial assumptions of the theory just because an inconsistency occurred. In paraconsistent social software, we can very well have perfectly rational agents that can make *mistakes*. This give us a more realistic and broader understanding of social software and social phenomena it sets out to explain.

The Kitty Genovese example and many others from law[1] illustrate the possibility of applying non-classical methods to social software. The central claim

[1]A canonical example from law is *civil disobedience* where agents deliberately break the law and create an inconsistent situation where moral duties and legal duties clash. Yet, still we obtain a *non-trivial* and coherent inconsistent situation.

of this paper is to argue that social software lies within the interesting intersection of logical pluralism and game theory broadly conceived, and it can further benefit from incorporating non-classical logical methods into the theory. Additionally, apart from the descriptive perspective it provides, non-classical logical theories in social software can depict normative theories. In this work, we will not go into the details of this distinction.

In short, in order to analyze a variety of social procedures, we may need to use *logics*, not *a logic*; and social software should be read as a perfect marriage of logical pluralism and game theory. Similar to logical pluralism, we will advocate pluralism within the domain of game theory and social software. After arguing for this point, we will discuss social software as a case of *real-world economics* which is a recent social and economical movement born in Paris against the mathematicalization of economical sciences.

In order to observe more closely how non-classical logic can be incorporated into social software, we will raise two questions: "Which Society?" and "Which Software?". When we address the prior question, we will discuss the moral pluralism, and when we address the latter question, our focus will be logical pluralism.

2 Which Society?

The recent rise of behavioral economics in both popular literature and academic research points out a well-known missing link between formal logic, and social and individual human behavior: people do not reason or behave as normatively as manifested by the classical logic. They sometimes make various deductions that diverge from the classical logic, hinting out the possibility of adopting logical pluralism to address the *logic of society*.

There is a rich literature that discusses various real-life examples that combine various logical issues in game and decision theory (Ariely, 2008; Ariely, 2010; Brafman & Brafman, 2008; Gigerenzer, 2008; Harford, 2009; Kahneman, 2011; Smith, 2010). What is relevant for our purposes here is the immediate observation that classical logic falls short when analyzing individual and social human reasoning and interaction. If a logic claims to be *the* system of correct reasoning, there seems to be a problem here.

More precisely, at a descriptive level, the classical logic is not sufficient to explicate and analyze many interesting social phenomena - but perhaps is sufficient in some others. This, by no means, entails that non-classical logics are normatively the one and only logic that the epistemic and rational agents need to employ - this is exactly the opposite of the perspective of logical pluralism.

Granted, it is not only non-classical logic that may help us understand human behavior within the domain of social software. Decision and game theory, and formal epistemology, are among the formal sciences that attempt at analyzing similar issues. Also, social software has never been a direct target of the criticisms that advocate logical pluralism in game and decision theory. Nevertheless, as long as it relies on classical logic, social software will not be immune

to such criticism. Intuitively, it would not be wrong to claim that social software provides a playground for logical pluralism where it can help explain social procedures.

In order to illustrate our point for the need for non-classical logic in social software, consider a very simple example, the two horsemen, that Parikh also discussed.

Example 2.1. [(Parikh, 2002)] Two horsemen are on a forest path chatting about something. A passerby, the mischief maker, comes along and having plenty of time and a desire for amusement, suggests that they race against each other to a tree a short distance away and he will give a prize of $100. However, there is an interesting twist. He will give the $100 to the owner of the slower horse.

I maintain that the way negation (or game duality) treated in this puzzle is not strong enough to generalize. The idea of switching to the dual role (which is obtained by using the classical negation) is not a universal strategy that can apply to other similar games. In general, players do not deal with negated statements in this fashion. The dual game in this example possesses some simple properties: it is easier to determine, and the negation of *slow* is clear to decide. Yet, such properties do not exist in all games. Can we play checkers in this way? Can we play football as such?

For example, for the games with three players, computing the dual game and permuting the roles for the players are not trivial (Olde Loohuis & Venema, 2010). If we modify the Example 2.1 by allowing a third player, then we can have 2 "dual" games - the permutations of horsemen and horses where nobody rides their own horse. The number of "dual" games increases if we consider even more players and additional intermediate states besides slow / fast.

First and foremost, Example 2.1 shows that the formal analysis of social phenomena has traditionally restricted itself to some well-defined and well-behaved subset of the society. Social software and game theory are not exceptions to this tradition. Their understanding of society is largely utilitarian, and something that mathematical and logical analysis (without really referring to social science at the object level) can directly apply. Yet, this is a controversial assumption - which largely remains unearthed. Recently, some authors in economics and finance communities criticized this approach heavily. For instance, the author of the popular book *ECONned* Yves Smith remarks the following.

> The dominant economic paradigm, neoclassical economics, became ascendant in part because it offered a theory of behavior that could be teased out in elegant formulation. Yet it rests on assumptions that are patently ridiculous: that individuals are rational and utility-maximizing (which has become a slippery notion as to be meaningless), that buyers and sellers have perfect information, that there are no transaction costs, that capital flows freely.
>
> (Smith, 2010)

Similarly, Hartford argues along similar lines.

> Fundamental to von Neumanns approach was the assumption that both players were as clever as von Neumann himself. (...) The second problem is that game theory becomes less useful if your opponent is fallible. If player two is not an expert, player one should play to exploit his mistakes rather than defend against brilliant strategies that will never be found. The worse the opponent, the less useful the theory is.
>
> (Harford, 2009)

Not all of the above criticism applies to social software obviously, yet, the assumptions of von Neumann - Morgenstern utilitarian game theory need to be examined carefully. Even though such a direct game theoretical and ideological influence is difficult to trace in Parikh's works, some utilitarianism based understanding of rationality and semantics is the one that Parikh endorses (Parikh, 1994). He writes that "Roughly speaking, if an agent has a choice among several actions, we would expect that the agent will carry out that (pure) action which the agent thinks will bring the maximal benefit (utility) to the agent" (Parikh, 2002). As widely known, ordinal utilities can be translated to preference orderings at the cost of losing some information, yet, the main problems of von Neumann - Morgenstern framework still remain.

This is the traditional game theoretical understanding. Thus, most of the criticism of (philosophical) utilitarianism easily carries over to game theory and social software. I formulate this criticism as the *deontological criticism*. The deontological criticism suggests that utility based moral analysis does not fully consider the deontological commitments of the moral agents. My suggestion here can be considered as an instance of moral pluralism for social software.

Let us illustrate our point with an example. In his (Parikh, 2002), Parikh mentions the well-known theorem of Gibbard and Satterthwaite that suggests that any social choice function which takes preference orderings of the voters as inputs, and returns a social preference ordering for the society, will be vulnerable to manipulation in the form of strategic voting. Here, Parikh discusses the United States presidential election of 2004 as an example of Gibbard and Satterthwaite theorem, and concludes that "this is murky territory and I shall not venture further into it." (Parikh, 2002).

However, we believe that strategic voting and manipulations in elections constitute a very interesting focal point of social software, and underlines the need for a broader understanding of social software in these "murky territories". Unless it is seen as a pure mathematical procedure, there are various ethical and moral issues at hand here. Moreover, the problem of utilitarian von Neumann - Morgenstern approach makes itself clear in this problem.

If we consider voting as a form of utilitarian calculus, and take strategic voting as a legal and permissible strategy in it (which it is), then we will be puzzled with the results like Gibbard and Satterthwaite or Arrow's Impossibility Theorem or Sen's Impossibility of Pareto Liberal. One of the main reasons for

negative results in the social choice theory is that the theory does not generally take the moral and ethical compass of the society into account[2]. Moreover, such considerations are not even representable in most social choice theories. The reason why people did not vote strategically in the 2004 US elections is not only epistemic, and perhaps epistemic reasons do not even count among the main reasons[3]. One of the real reasons, in my opinion, is that many people (if not most) people consider strategic voting as a *betrayal* to their political conviction for understandable reasons[4]. For people, voting represents commitment and loyalty, and honoring their own opinions, and even if they feel that the party/candidate they support will not win, they do not switch to another one for the aforementioned reasons.

Some disagree with my perspective (Brennan, 2011; Chisholm, 1963). Chisholm discusses those imperatives which are "telling us what we ought to do if we neglect certain of our duties", and argues that the deontic logic (with its deontic modality O) is not sufficient to formalize them (Chisholm, 1963). He argues as follows.

> Ordinarily the rules of a game do not tell us how to proceed with the game after the rules have been violated. In such a case, we may: (1) go back to the point at which the rule was broken, correct the mistake, and resume the game; (2) call off the game; or (3) conclude that since one rule has been broken, others may now be broken, too. But these possibilities are not open to us when we have broken a rule of morality. Instead we are required to consider the familiar duties associated with blame, confession, restoration, reparation, punishment, repentance, and remedial justice, in order to be able to answer the question: 'I have done something I should not have done-so what should I do now?' (Or even: 'I am going to do something I shouldn't do-so what should I do after that?') For most of us need a way of deciding, not only what we ought to do, but also what we ought to do after we fail to do some of the things we ought to do.
>
> (Chisholm, 1963)

This argument is interesting in-itself. For our purposes it is a valid example to justify strategic voting. For this reason, this subject becomes even more interesting for social software, especially once it is supplemented by a logical framework (classical or non-classical) that can formalize contrary-to-duty actions.

Chisholm's argument can be suggested as a counter-argument to our point. Namely, apart from the social and individual aspects of morality, there can be

[2]Other reasons being, no cost of information, no reference to the actual society, etc.

[3]It is generally argued that, in the 2004 US elections, if Greens - which is a very small political party in the US - had voted strategically against Bush, he might not have been reelected.

[4]Brennan mentions Habermas who argued that "strategic voting is disrespectful to other citizens" (Brennan, 2011).

an additional dimension of morality for the actions we were supposed to do, but did not. Nevertheless, notice that Chisholm's point does not invalidate the perspective we presented. The second degree duties (the ones you are supposed to do, after violating your initial duties) still depend on social, political and economical morality and the ethics of the individual. Moreover, the first violation of duties (which come from the very definition of "contrary-to-duty actions") calls for a inconsistency-friendly framework for expressivity. And, under this type inconsistencies (after moral rules have been violated), Chisholm's contrary-to-duty actions follow. Thus, Chisholm formulated how the agents reason under some moral inconsistencies in a sound and non-trivial way. This is nothing but reasoning in a paraconsistent model.

Similarly, if an individual decides to vote strategically, then, the candidate he is going to vote for reflects his "second degree" duty which is also shaped by his individual and social morality. An individual voting for his second best choice to block the worst candidate based on his preferences, is still following his own preferences. In the 2004 US elections, Greens were supposed to vote strategically, because, in a broader perspective, it can be argued that they prefer the Democratic candidate to the Republican one. Therefore, their choice between the Democratic and the Republican candidate reflects their commitment to a broader political agenda as well.

Brennan discusses various forms of strategic voting and concludes that, for him, "there is no objection in principle to strategic voting, so long as strategic voting does not impose too much risk and tends to produce better outcomes than one justifiedly believes otherwise would occur" (Brennan, 2011). Yet, the logical and mathematical complications of strategic voting make it a philosophically interesting subject for social software - broadly construed.

As long as we do not consider other social elements (such as morality, social ethics and human psychology), we will be puzzled by the aforementioned negative results of the theory which only considers misleading and overly simple examples in an isolated theoretical environment, and takes voting barely as a simple mathematical procedure.

On the other hand, discussions on "ethical voters" have been initiated by Harsanyi in late 70s (Harsanyi, 1977). Therefore, it is a rather young field, and incorporating some of the ideas developed in that field to social software might be a wise choice, based on the criticism we raised. Along the similar lines, it can be suggested to discuss a deontological extension of Social Software, which we account for as moral pluralism.

For this purpose of ours, reconsider the Kitty Genovese example which we discussed in Section 1. Besides the epistemic analysis, there is also a strong deontic component in this issue. Namely, it is fair to assume that people are obliged to help others when they do not risk anything substantial, and we can take this principle as our deontological commitment. Regardless of the cost of the phone bill or time spent for it, the witnesses are morally obliged to call the police from a deontological perspective. Moreover, the questions that whether others made a similar call or whether the police would make it on time to the crime scene do not exclude anyone from following their moral obligations. It

may minimize or economize an individual's personal duty if it is shared by the others, yet the individual is still obliged to help, according to the deontological commitment we have formulated above. One can also claim further that the problem is largely due to deontology, rather than epistemology.

Second, one can consider a criminal who plans to blow up a building. A utilitarian social software engineer may conclude that it is acceptable to kill that criminal in order to save the lives of many more. A deontologist social software engineer may have a prior commitment to the sanctity of human life under all conditions for everybody, and based on his convictions he can disagree with the killing of the criminal even if it will, most likely but not certainly, save the lives of others. He will argue that perhaps what we consider a criminal is a movie actor, and what we thought as a crime scene is a movie stage. The deontologist social software engineer may add, the criminal will not succeed in blowing up the building because perhaps the bomb will not detonate. However unlikely they may sound, those minute possibilities indicate that incorporating a deontological component to social software presents interesting research directions.

Similarly, language games, a special favorite of Parikh's, exhibit similar issues. Parikh himself argued that language has a utilitarian element (Parikh, 1994). We choose the nouns (or in general any other language elements) that work. Parikh develops this thought and connects it to vagueness in a very interesting way in the aforementioned work. This explains a significant part of semantics, except perhaps literature and poetry, where ambiguity and vagueness in meaning are intentional and even desirable. Therefore, on some occasions, language games can take another form in art where the utility based analysis of semantics becomes complicated if not impossible.

As another example of a non-utilitarian social phenomena, consider the case of having children. As it is widely known, numerous reasons can be given to bear and have children. Let us consider them in two main categories following Overall: Deontological and Consequentialist (Overall, 2012). Deontological reasons include carrying on the family line and name, duty towards the society and the family whereas the consequentialist ones include the traditional economical benefit (of the children) to the family, and psychological benefits to the parents. Overall goes ahead and argues from a moral perspective that none (and more) of these reasons cannot be ethically justified as a reason to have children. We will not pursue the ethical direction here. Yet, the same issue can be approached from a social software point of view. As we all know, having children has a lot of difficulties as well. They increase the stress level of the parents, and in many societies, it is very expensive to raise them. In short, the quantitative and measurable cost of having children (for instance, increased stress hormones in the blood and diminishing bank accounts) needs to be compared with the qualitative and unmeasurable benefit of having children (happiness and all that), according to the traditional game theoretical approach. Yet, the traditional approach appears to be useless in this direction. Namely, how can we compare the utility value of having a baby with the university tuition that the parents will need to pay for the child. For such examples, where self-sacrifice and deontological commitments play a central role, we need a broader

understanding of social software that goes beyond the traditional consequentialist method of game theory and formal epistemology. It is then a different endeavour to identify the logical model that is required for such situations.

An interesting criticism towards some game theoretical concepts can be found in Graeber (Graeber, 2011). He questions Hobbes's use of "self-interest" to describe human motivation. Graeber writes of "self-interest" as follows.

> Part of the terms appeal was that it derived from bookkeeping. It was mathematical. This made it seem objective, even scientific. Saying we are all really pursuing our own self-interest provides a way to cut past the welter of passions and emotions that seem to govern our daily existence, and to motivate most of what we actually observe people to do (not only out of love and amity, but also envy, spite, devotion, pity, lust, embarrassment, torpor, indignation, and pride) and discover that, despite all this, most really important decisions are based on the rational calculation of material advantage which means that they are fairly predictable as well.

Graeber does not only skeptically argue that the utilitarian social choice based analysis of games in society are missing an important component, but also implies that such calculations, if possible at all, are more complicated than they look. Social software, in this regard, faces a similar problem: is the society that exhibits a wide array of actions and thoughts and emotions organized in a way to reflect the rules and dogmas of classical logic and utilitarian game theory both of which are used in social software?

In short, we believe that society exhibits many interesting cases that call for a broader framework for social software to reflect the different motivations, deontologies and commitments in those interactive social situations.

3 Which Software?

Logical pluralism is a "*pluralism* about logical consequence" asserting that there can be more than one logical consequence relation (Beall & Restall, 2006, their emph.). Namely, logical pluralists endorse the view that from a given set of sentences, it is possible (whenever a formalism can be given) to deduce various conclusions. I maintain that logical pluralism is essential to social software, yet it remains understudied. Let me justify my claim now.

As widely known, in an intuitionistic universe, law of excluded middle does not hold as it can be ontologically possible that there are propositions which are *neither* true nor false. Similarly, in a paraconsistent (or dialetheic) universe, the law of non-contradiction is not valid. Because, it is thought that there are propositions which are *both* true and false. Following the tradition, we will call such systems (and possibly more) as *non-classical*. The important point here is the fact that non-classical logics are motivated not only by logical and mathematical observations, but also by various social, epistemological and ontological phenomena.

For instance, quantum physics provide us with various ontological and epistemological examples with undetermined truth values such as the Pauly Indeterminacy Principle. Similarly, law provides various cases where dialetheism and paraconsistent consequence relations can be put in use, as we have discussed earlier (Priest, 2006). Moreover, there are various other situations where paradoxes appear in social contexts.

Take *Parrondo's Paradox*. Consider the following two games: Game 1 and Game 2. In Game 1, you lose $1 every time you play. In Game 2, if you have left an even number of dollars, you win $3, if you have an odd number of dollars left, you lose $5. Say, you start playing this game with $50. If you play Game 1, you will lose all your money in 50 rounds. If you play Game 2, you will still lose all your money in 50 rounds following the sequence:

$$50 - 53 - 48 - 51 - 46 - 49 - 44 - \dots$$

However, the catch point is, if you play the games in the order of "Game 2 - Game 1 - Game 2 - Game 1 - ....", then you will always win following the sequence:

$$50 - 53 - 52 - 55 - 54 - 57 - \dots$$

The *paradoxical* result here is the fact that by combining two losing strategies, we obtained a winning strategy that is somehow surprising and unintuitive. Non-classical logical elements in this analysis are quite striking.

Yet another major example is *dialectic*. Consider an agent, let us call him Karl the CEO, struggling to make a decision. Assume he has been suggested two opposing points of view: φ and $\neg\varphi$, the thesis and the antithesis respectively. Then, any rational agent would not give up his logical system or decision procedure as there are contradictory statements in the system rendering it inconsistent. In this case, we would expect Karl to reach a conclusion, say ψ, after a dialectical procedure. Thus, we will have for Karl, $\varphi, \neg\varphi \models \psi$ yet $\varphi, \neg\varphi \not\models \neg\psi$. For Karl, the decision φ follows from the given contradictory evidence, whereas the decision (or proposition) $\neg\varphi$ simply does not. Namely, the system did not *explode* or render itself trivial: there is a statement (namely, $\neg\psi$) which did not follow from a contradiction. As this example illustrates, there is an interesting relation between dialectic, dialetheism and paraconsistency, and to do justice to the subject, we refer the reader to the following work (Ficara, 2013; Priest, 1989; Priest, 2006). Expanding the Karl the CEO example to broader domains of social sciences, we can see how social software with its extended (non-classical) logical framework can be helpful in analyzing such interactive situations.

Finally, cases from behavioral economics provide rich examples which show that people do not usually reason in the way that the classical logic predicts (Ariely, 2008; Ariely, 2010; Gigerenzer, 2008; Harford, 2009; Smith, 2010; Stenning & van Lambalgen, 2008). Such examples direct us towards logical pluralism where the logical consequence of what is given can be, to say the least, unexpected and surprising from a classical logical perspective. People do

not end up with trivial theories when they encounter paradoxical situations. They simply work their way through it - usually in a sound and rational way.

3.1 More Examples

Let us now give various specific pointers where non-classical logic can be helpful in explaining social procedures from computational and logical perspectives. We will reconsider some of the examples from Parikh's original paper, and observe how a non-classical take can actually help us get a better picture both descriptively and normatively. Notice that the need for non-classicity will arise especially in the case of anomalies.

Example 3.1 (Carousel Example, (Parikh, 2002))**.** In order to prevent the overcrowded carousels at the airports, Parikh mentions a simple solution. The airport authorities should paint a line a certain distance from the carousel and post signs that say "Do not cross the signs until you see your suitcase".

Let us assume that this solution is implemented. Without doubt, there will still be people who approach the carousel before seeing their luggage.

Intuitionistic approach to this anomaly suggests that there are people who neither know nor do not know that they should approach the carousel. In other words, these are the people *who did not care about the sign*. It does not mean that they disagree with the solution procedure. It also does not mean that they agree with it. They are simply indifferent to this solution concept. Thus, the solution, taken as a proposition, has no truth value in those people's mental models. Anyone who has observed people breaking some simple rules carelessly might agree that this is a very common phenomenon.

Paraconsistent logicians might argue that some people, even if they approve of the solution, would still not wait until they see their luggage. This clearly creates an incoherent if not inconsistent situation within the mental model of the agents. The agent agrees with the solution, and thinks that she should wait. Nevertheless, she simply does not wait. For such situations, which I argue that happens quite often, paraconsistency suggests an inconsistency-tolerant framework for those agents with inconsistent mental models.

Clearly, one can also unify the above approaches, at least formally, in the framework of First-Degree-Entailment (FDE) (Dunn, 1976; Routley & Routley, 1972). We refrained ourselves from using FDE for this formalization as the incompleteness and inconsistency tolerant logics may separately provide a clearer understanding of the phenomenon.

Example 3.2 (The Two Horsemen, (Parikh, 2002))**.** The example of two horsemen (Example 2.1) suggest that sometimes it is wiser to switch to the dual game with dualized strategies. Namely, being the slowest in the original game is more difficult than being the fastest in the dual game where men switch their horses. Strategies can easily be dualized in this case, taking the dual of the game is also trivial.

However, this idea is not strong enough to generalize. It does not, for instance, seem possible to play chess or checkers this way. The hidden preconditions here are as follows:

1. The dual game exists and it is easier to compete in it

2. The players' strategies can be dualized

In order for this procedure to make sense, one can expect that the negation (that is used in the dualization procedure) should not have fixed-points. In the classical Boolean logic, negation does not have fixed-point as for no formula, the formula and its negation have the same truth value. However, in some logics such as Priest's Logic of Paradox, there is a formula (a scheme) that is the fixed-point of negation in that system (Priest, 1979). Paradoxical formulas are the fixed-points in Logic of Paradox since the negation of paradoxical is itself in this system.

In order to illustrate this point, consider the following non-classical variation of the Two Horsemen example, which we call Two Russellian Barbers. Take two Russelian barbers who can only cut the hair of the people who cannot cut their own hair themselves.

Assume that in the case of Russelian barbers, they were asked to compete in a game where the one who gets his hair cut fastest wins. Clearly, if barbers cut each other's hair, they will be slow, and not even cut the hair. At first glance, it seems, then each barber should cut his own hair. If they commit themselves cutting their own hair, then they can compete to be the fastest, it seems. Yet, recall that these barbers are Russelian who only cut the hair of the people who cannot cut their own hair themselves. Thus, the Two Horsemen strategy gets stuck in this case.

The Two Horsemen example also assumes that the players' strategies can easily be dualized. This procedure is almost trivial in the two-person case. However, when multiple players are considered, dualization becomes a selection problem (Olde Loohuis & Venema, 2010). As we mentioned in this paper earlier, consider the same problem with three horsemen, The Three Horsemen Problem. In this case, there are two different ways of permuting the horses where no horsemen rides his own horse. For more agents, the problem reduces to a simple combinatorial problem. From social software point of view, the multi-player version of the Two Horsemen shows that *negation* in games is not a trivial subject, and social software can analyze the social and computational effects of each of negations.

Example 3.3 (King Solomon Example, (Parikh, 2002; van Eijck & Verbrugge, 2009))**.** This example is a very old mythological story about King Solomon and the way he determines the real mother of a baby. He suggests to cut the baby into two and share it between the two women, thinking that the real mother would not allow it, and let the other take the baby. Therefore, the woman who denies the motherhood under the presence of this procedure is indeed the real mother, according to the solution concept of this procedure.

As it is pointed out in (van Eijck & Verbrugge, 2009), the surprise element in Solomon's procedure is essential - this is what prevents the players from playing strategically. Yet, logically, surprises seem to be difficult to formalize. This point begs the question whether surprises are the focal points that require a non-classical analysis.

The surprise element here involves a component that renders the problem and the solution void. Namely, if the mother of the baby is needed to be determined, a hidden assumption requires the puzzle solver to keep the baby alive - otherwise there would be no need to determine the motherhood. Suggesting that the baby will be killed is not actually a surprise at the moment of it being suggested. It is deemed as a surprise *later* when the solution is fully introduced by the King. Therefore, *when* it is suggested it creates incoherence or inconsistency, and requires a logical framework that can tolerate it.

Some further discussion on the King Solomon example can be found in (van Eijck & Verbrugge, 2009). This problem can also be analyzed from the perspective of counterfactual conditionals, yet we shall not dwell into that aspect here - even though it also supports our claim that non-classical analysis can enrich our understanding of social phenomena.

Example 3.4 (Game Semantics as a Language Game)**.** Conceived as a meaning-construing procedure by Hintikka, game semantics provides a very interesting perspective on formal semantics. *Semantic verification game* is played by two players, *falsifier* and *verifier* which we call Abelard and Heloise respectively. The goal of Heloise in the game is to verify the truth of the formula whereas for Abelard it is to falsify it. The rules of the semantic verification game are specified syntactically based on the form of the formula. During the game, the given formula is broken into subformulas step by step by the players. The game terminates when it reaches the propositional literals and when there is no more moves to make. If we end up with a propositional literal which is true in the model in question, then Heloise (or the player who plays as Heloise) wins the game. Otherwise, Abelard wins. We associate conjunction with Abelard, disjunction with Heloise. Namely, when the main connective is a conjunction, it is Abelard's turn to choose, and similarly, disjunction yields a choice for Heloise. The negation operator switches the roles of the players. The major result of this approach states that Heloise has a winning strategy if and only if the given formula is true in the given model. For an overview of the field and its relation to various epistemic and scientific topics, we refer the reader to (Pietarinen, 2003). Moreover, (Pietarinen & Sandu, 2000; Hintikka & Sandu, 1997) provide expositions of game theoretical semantics and its relevance to philosophy.

Not much argument is needed to show the relevance of game semantics to language games which was Parikh's starting point in his article on Social Software (Parikh, 2002). However, a non-classical analysis of game semantics reveals that those games can formalize non-classical behavior. Therefore, using non-classical logics as the formal framework, we can have semantic verification games with additional players, concurrent play, and variable sum games where more than one player can win, or one's loss does not entail the opponent's win.

We refer the reader to the following paper for the formal details of this approach (Başkent, 2013).

Example 3.5 (Law)**.** Real-life paradoxes in social situations are not easy to pin point. However, law provides a unique playground both for paraconsistency and social software. Almost without exceptions, every legal system contains inconsistencies, and one way or the other, they still function. Priest gives various examples of legal dialetheias and inconsistent obligations, and considers the following simple example (Priest, 2006).

> Suppose that there is a certain country which has a constitutional parliamentary system of government. And suppose that its constitution contains the following clauses:
>
> > In a parliamentary election: (1) no person of the female sex shall have the right to vote;
> >
> > (2) all property holders shall have the right to vote.
>
> We may also suppose that it is part of common law that women may not legally possess property. As enlightenment creeps over the country, this part of common law is revised to allow women to hold property. We may suppose that a *de facto* right is eventually recognized as a *de jure* one. Inevitably, sooner or later, a woman, whom we will call Jan, turns up at a polling booth for a parliamentary election claiming the right to vote on the ground that she is a property holder. A test case ensues. Patently, the law is inconsistent. Jan, it would seem, both does and does not have the right to vote in this election.

One should recollect the definition of paraconsistency here. Paraconsistency describes inconsistent formal systems which are not *trivial*. Clearly, law has inconsistencies, yet, it does not render *everything* legal. And in many real-life cases, the point is not genuinely to create a formal system with no inconsistency or incompleteness whatsoever. Yet, the real focus is to make this system work - whatever the word *working system* entails. Also, there is a *procedure* in law even though it is inconsistent. Legal procedures have epistemic and deontic components, and in some cases, perhaps a computational component in terms of time, memory and space restraints. For these reasons, it is of central interest to social software.

Similar examples can be multiplied especially when *dialogues* are considered (Carlson, 1983; Rahman & Carnielli, 2000). Taken as a formal model about a social situation, dialogues contain inconsistencies, and present themselves as genuine examples for paraconsistency. Since communication is an essential part of social interaction, thus social software, formal models of dialogues constitutes an interesting case study which fall within the intersection of social software and paraconsistent reasoning.

The examples we have discussed so far shows that various social procedures call for various different logical and computational paradigms, and we believe this is perfectly normal - and even desirable.

4 Real-World Economics and Social Software

The real-world economics movement (unfortunately named as *Post-autistic economics* initially), which was born in Paris in 2000, heavily criticizes the foundations of neoclassical economics (Fullbrook, 2008; Reardon, 2009). Even if we accept the assumption of *homo economicus* (which is also highly debatable), we will stumble upon many problems when we consider the *markets* as described by the neo-classical economics and game theory (Benicort & Guerrien, 2008). The proponents of real-world economics argue that focusing on equilibrium points which are not even predictive of the future outcomes misses the point. They argue that "in an uncertain world, making sophisticated calculations before making each decision is nonsense", and conclude provocatively with the observation that "to understand the real world, one has to forget microeconomics" (Benicort & Guerrien, 2008).

Similarly, there is an increasing number of works that criticize the heavy mathematical machinery used in economics (ibid). As Milton Friedman put it "... economics has become increasingly an arcane branch of mathematics rather than dealing with real economic problems" (ibid). Solow argues that "economics as taught in America's graduate schools ... bears testimony to a triumph of ideology over science" (ibid). Moreover, Guerrien and Jallais argue that:

> Game theory does not resolve concrete problems or make predictions about player choices. It focuses on the complexity of the decision interactions of persons conscious of being in interaction. As the renowned game theorist Ariel Rubinstein explains,
>
> > game theory is a fascinating and abstract discussion that is closer to philosophy than to the economics pages of the newspaper. It has no direct applications, and if it has any practical utility (which I doubt), then it is in the winding and inscrutable way that our minds absorb ideas and use them when the time comes for real action. And this too must be proved.[5]
>
> (Reardon, 2009, pp. 37-8)

Without much effort, we can find similar approaches, albeit not as radical and explicit, in various other popular books as well (Ariely, 2008; Ariely, 2010; Gigerenzer, 2008; Harford, 2009; Kahneman, 2011). I believe there is some

[5]November 17, 2000 in Israeli daily *Haaretz*. In a similar way, his 2009 (2012, in English) book is called *Economic Fables* to underline the fact that game theorists are tellers of fables.

truth in this criticism towards micro-economics, and this body of criticism easily carries over to game theory and social choice theory. More importantly, for our purposes here, social software and more generally mathematical and logical analysis of social algorithms and social phenomena become a target of the aforementioned criticism as both game theory and social software make similar (perhaps, implicit) assumptions.

The central claim of above approaches of the real-world economics is the fact that neoclassical economics fails to address a broad spectrum of social and economical phenomena as the aforementioned references indicate. Behavioral economics and real-world economics suggest some sound conceptual alternatives within the field, and I believe that logical approaches to these problems should address those concerns - either affirmatively or negatively. I argue, economic pluralism, that is crystallized in the real-world economics, may help illustrate the use of logical pluralism in social software. Furthermore, I claim that logical pluralism can be the key point to address different economical paradigms within logic and game theory, and hence in social software.

One of the central demands of the real-economics movement is to have a pluralistic understanding of economics (Fullbrook, 2008; Reardon, 2009). This provides the field of economics with different theories for different economical phenomena, as opposed to a monist and monolithic methodology that strives to explain and predict all. Simply put, different social situations presuppose different logical reasoning. One cannot impose one single logical structure (i.e. the classical logic) for the social interaction - which by the very definition should be pluralistic. Therefore, plurality in social norms and rules and interactions presuppose a pluralistic view of logic. Real-world economics, in this manner, provides examples and ideas from the same domain that social software attempts to analyze. Let me now argue further along these lines.

An interesting finding and argument of real-world economics perspective is that the economics should not be approached from an individual-centric perspective. In terms of social software theory, this translates into the thesis that agents-based analysis of epistemic, doxastic and deontic situations lack an important component of social interaction: the society itself. Clearly, it can be argued that "the market" itself can play the role of the society, and be expressed as an agent. Nevertheless, this gives rise to the notion of "invisible hand" which can be considered as a problematic point of the theory, and we will not dwell into that here.

Reconsider the "Kitty Genovese" case. A real-economics oriented "real-social software" would approach this example by considering the social dynamics of the community in which the incident took place. For instance, if it was a small town in a closely knit society where the incident took place instead of a New York City neighborhood where social interaction among the neighbors are much looser if not non-existent, the analysis of the case would be much different. The histories of the agents would have much more in common, they would share a larger common language, supposedly they would share a common moral background and moral priors, and the cost of not calling the police would be much higher. In cosmopolitan New York City, the social dynamics are obviously much

different, and "the real-world social software" should reflect this parameter in its analysis of the case.

5 Conclusion

The book *Discourses on Games, Action and Social Software*, which is the product of Amsterdam school of logic, discusses various types of logics and their relations to social software (van Eijck & Verbrugge, 2009). However, their scope is rather narrow, and focuses only on different types of modal logics (dynamic, temporal, epistemic etc.), and they do not discuss non-classicity at all. Similarly, a vast majority of works in game theory, social choice theory and social software take utilitarianism as granted. We argued, in this paper, that such assumptions do not have a well-ground metaphysical basis within the theory of social software, and we gave several examples for such cases.

In this paper, we also tried to avoid the formalism of game theory and social choice theory as much as possible. Our pragmatic goal was to clarify some foundational ideas in social software, and investigate its connection with non-classical logical ideas. The distinctive quality of social software, namely its emphasis on logic and computation, was the main motivation behind this work. If, I argued, logic is so central in social software, then different logical traditions should have a fair chance of representation within its domain since they may have something to say.

On the other hand, perhaps at a more personal level, I am more or less convinced that my thoughts put together in this paper simply complement what Parikh had in mind when he originally suggested the idea of social software. The theory should be comprehensive and powerful, and based on this conviction, the ideas put forward in this work does not suggest otherwise, but provides a broader outlook of social software.

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