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研究課題名（和文）Individuals with Bounded Cognitive Abilities and Social Game

研究課題名（英文）Individuals with Bounded Cognitive Abilities and Social Game

研究代表者
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交付決定額（研究期間全体）：（直接経費）　　2,400,000円

研究成果の概要（和文）：1.図論的構造と安定性。影響力を示す有向図を導入し、純粋戦略のナッシュ均衡の存在性を特徴付けました。2.推論構造。辞書式認識構造を定義し、不完全情報で様々な推論構造を特徴付けました。3.協力形成。コアの配分を実現する過程を導入し、公平性と動的安定性の間の本質的な矛盾を示しました。4.協調ゲームの認識基盤。知識の観点からコアを特徴付けまして、既存結果の背後にある矛盾を提示しました：参加者を増やすと、協調ゲームで無限の認識能力が必要になる一方で、競争市場は知識が変わりません。5.ゲームの時間順。展開型から同時行動を許す型に導くアルゴリズムを定義し、それは動的な推論に情報とプレイの順序を保持します。

研究成果の学術的意義や社会的意義
Only hierarchies guarantee stability. Incomplete information equals to distrusting others' rationality. Coalition forming cannot be both stable and fair. Institutes arise from limit rationality and evolution. They revealed a gap between reality and theories, an alarm for sciences and policymaking.

研究成果の概要（英文）：1. Graphical structure and stable behavior. I introduced a directed graphical structure which indicates who influence who and characterized the existence of pure-strategy Nash equilibrium. 2. Reasoning structures. I defined the lexicographic epistemic model and characterized permissibility, admissibility, and proper rationalizability in incomplete information. 3. Coalition formation. A notion called monotonic core allocation path was introduced. Its reveals an essential conflict between fairness and dynamic stableness. 4. Cooperative games' epistemic foundation. I characterized the core in terms of knowledge. It unfolded an inconsistency behind classical results: increasing replicas leaves knowledge in a competitive market intact while requires unbounded epistemic ability in a cooperative game. 5. Chronological order of a game. I reduced extensive forms to the ones with simultaneous moves. It preserves the information and the order of plays, which is vital in dynamic reasoning.

研究分野：game theory

キーワード：game theory　epistemic game theory　algorithmic game theory　proof theory　coalition formation　cooperative game theory　extensive form

１．研究開始当初の背景

Individual decision-making process in social contexts is a central theme in social science. Especially, when each individual has only bounded cognitive abilities, that is, limited ability of perception, memory, judgment, and reasoning, how he makes decisions, how his decision-making processes are affected by the society, and how some social behavior patterns (e.g., customs, norms) emerge from those decisions. I am deeply attracted to those problems. In my three years as a Ph.D. student at Waseda University, I had tried to approach them by game theory. I once studied the process of iterated elimination of dominated strategies as an abstraction process, intending to sperate the viewpoint of an outsider (researcher) and an insider (a player). Noting the bounded cognitive abilities of individuals and their influences on decision-making, I felt satisfied and was hoping to study the issue more generally with attacking various dimensions of “bounded cognitive ability”, like from the aspects of computation, epistemic structure, reasoning processes, and decision-makers’ interaction with social institutes. That is the background when I started the research.

２．研究の目的

(1) How do bounded cognitive abilities influence decision-making in social contexts? To be specific, (a) how it influences an individual’s beliefs, and (b) How it influences an individual’s logical inferences? I intended to study special cases to see how it works.
(2) Also, a decision maker updates his knowledge and beliefs through observations and interpersonal communication. How to formulate such a learning-and-updating process, and what if an individual has only bounded cognitive ability? Theory of learning studied them but does not focused on individual’s initiative learning. Can we find a new way?
(3) Finally, how an individual’s decision-making processes are affected by the society, and how social behavior patterns emerge from such processes? Can we develop a simple model which also preserves essential factors of this mutual-influencing-and-forming system?

３．研究の方法

(1) For personal inference process, I plan to pursue two sub-questions: (a) How does bounded cognitive ability influence individual’s beliefs? (b) How does it influence individual’s logical inferences?
(1.a) Bounded cognitive ability prevents an individual from faithful and detailed perception of the objective. Here, I study an individual’s ignorance of details like probability or time. In other words, I would like to see how strict requirements on perceptions of even small details would change people’s behavior.

(1.b) In interactive situations, decision-making involves interpersonal inferences, i.e., one need to think of others' thinking, and others' thinking of him, etc. Such "one thinks the other thinks one thinks..." is called the hierarchy of interpersonal inferences. I would like to see how the structures of the hierarchies alter people's reasoning toward others as well as their anticipation of the future.
(3) Based on (2), I will work on the interaction between individual decisions and society. We may divide games into different categories, like "random" style games, where a player tries to randomize his behavior and guess others' patterns, and the other is Battle of the pattern-forming ones, where a player tries to signal his behavior pattern and pursue cooperation/coordination with others. I want to study signal-exchanges in the see how patterns appear from it.

4．研究成果

1. Graphical structure of society and its relationship with stable behavior. I introduced a directed graphical structure of a game, called influence structure, which indicates who influence who through a unilateral change of behavior. In terms of it, I characterized the existence of pure-strategy Nash equilibrium of games.
2. Reasoning structures under different information systems and their equivalences. I defined the lexicographic epistemic model for a game with incomplete information and characterized permissibility, admissibility, and proper rationalizability, which are originally defined within the complete information framework, in incomplete information. I also discussed the pattern of mixed strategies and their Kolmogorov complexity in the context of various decision circumstances.
3. Coalition formation process. A notion called monotonic core allocation path (MCAP) for assignment games was introduced. Its properties reveal an essential conflict between fairness and dynamic stableness.
4. Epistemic foundation for cooperative games. I characterized the core of a cooperative game in terms of players' knowledge. Based on it, I discussed the epistemic inconsistency behind Debreu-Scarf Theorem, that is, the increase of the number of replicas has invariant requirement on each participant's knowledge from the aspect of competitive markets, while requires unbounded epistemic ability of players from the perspective of cooperative games.
5. Chronological order of a game. I introduced an operation called compactification to reduce an extensive form to a compact one which allows simultaneous moves. This operation preserves information as well as the unambiguous order of plays in a game, which is proved to be vital in dynamic reasoning processes.

In summary, my research studied how this boundedness influences behavior through social structures, epistemic hierarchy, reasoning processes, and information in dynamic circumstances. The results are insightful, sometimes even surprising. Stable and unambiguous outcomes are guaranteed only by a hierarchical structure. Incomplete information has the same effect on decision-making as the distrust of others' rationality does. In a dynamic coalition formation, stability and fairness

cannot be fulfilled simultaneously. Finally, many social institutes, like market prices, may arise from interactions of bounded rationality and the evolutionary process. They revealed a significant gap between the real world and the classical theory, which is a sound alarm for strategic thinking and policymaking.

５．主な発表論文等

〔雑誌論文〕　計2件（うち査読付論文　2件／うち国際共著　0件／うちオープンアクセス　0件）

１．著者名 Takaaki Abe, Shuige Liu	４．巻 53
２．論文標題 Monotonic core allocation paths for assignment games	５．発行年 2019年
３．雑誌名 Social Choice and Welfare	６．最初と最後の頁 557-573
掲載論文のDOI（デジタルオブジェクト識別子） 10.1007/s00355-019-01197-3	査読の有無 有
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〔学会発表〕　計4件（うち招待講演　0件／うち国際学会　4件）

１．発表者名 Shuige Liu
２．発表標題 Knowledge and Acceptance of Core Payoffs: An Epistemic Foundation for Cooperative Game Theory
３．学会等名 The 13th Conference on Logic and the Foundations of Game and Decision Theory（国際学会）
４．発表年 2018年

１．発表者名 Shuige Liu
２．発表標題 Influence structure, Nash equilibrium, and Potential Games
３．学会等名 the 13th European Meeting in Game Theory (SING 13)（国際学会）
４．発表年 2017年

１．発表者名 Shuige Liu
２．発表標題 Randomness, Predictability, and Complexity in Repeated Interations
３．学会等名 the 28th Stony Brook International Conference on Game Theory（国際学会）
４．発表年 2017年

１．発表者名 Shuige Liu
２．発表標題 Randomness, Predictability, and Complexity in Repeated Interations
３．学会等名 East Asian Game Theory Conference 2017（国際学会）
４．発表年 2017年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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６．研究組織

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