

# Neural Network of “Legal Thinking & Decision-Making” with TD Subjects in fMRI & Epileptic Patients under ECoG

Trial with “Public Goods Game” as Experimental Design: Emergence of Legal Norm?

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## I. Working Hypothesis: Definition of “Law”

“(a) Written & unwritten set of collective norms; if an agent violates them he/she should be sanctioned, typically by a (b) third-party punishment with consistency.” (modified from Wada 2010)

## II. Background: Evolution of Law is Understudied!

Both (a) norms and (b) third-party punishment have been studied extensively in the recent years, e.g.:

- (a) norms: Tomasello et al. 2008, 2013; Schlinghoff & Moore 2017;
  - (b) third-party punishment (TPP): of humans & neural network: Buckholz et al. 2008, 2012, 2015 (*Neuron*); Treadway et al. 2014; Bellucci et al. 2016; Ginther et al. 2016; of non-humans: positive by von Rohr et al. 2012, negative by Riedl... Tomasello 2012 (both on chimpanzees in captivity).
- But, as a synthetic theory of (a) norms and (b) third-party punishment, little has been explored on (evolution of) human and possibly non-human law.

## III. What are (a) Norms & (b) Third-Party Punishment ? :

**a) Norms:** A widely accepted definition among legal scholars in the world: “A non stated set of guidelines which specify normal behaviour in a social context. **Social control and order are prevalent** due to the **pressure exerted on an individual** to conform to the **social norm, one which is expected from all members of a community from each other.**” (The Law Dictionary: Featuring Black’s Law Dictionary [Free Online Legal Dictionary 2nd Ed.]

**b) Third-party Punishment (TPP)** (rich literature!) e.g. : Jordan et al. (*Nature*) 2016 “Third-party punishment as a costly signal of **trustworthiness**”: “Third-party punishment (TPP), in which **unaffected observers punish selfishness, promotes cooperation by deterring defection.**”

## IV. Non-invasive & Invasive “Neurolaw” Experiments

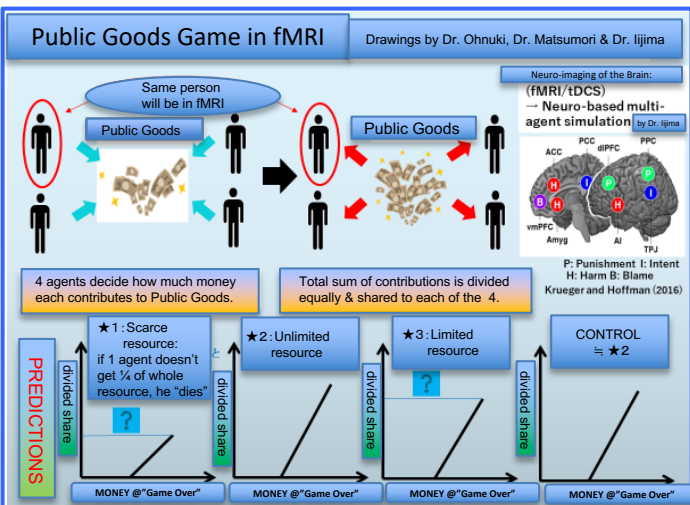
New Experimental Design Common for TD & Patients:

“Public Goods Game” (3 conditions) ⇐ Hints from “Legal Anthropology”: **Roberta 1979**:

- ★1: “Scarce Resource”: cf. Inuits’ housing, food or clothes.
- ★2: “Unlimited Resource”: Does “Tragedy of Commons”(\*) happen ?
- ★3: “Limited Resource”: Does Tragedy of Commons happen?

(\*) Nobel Prize Laureate for Economics, Elinor Ostrom’s Game Theory ⇐ Free-riding by the powerful.

Does a) Norm emerge, under which of these 3 conditions?



## Rule of the Game & 3 Conditions [1st Experiment]

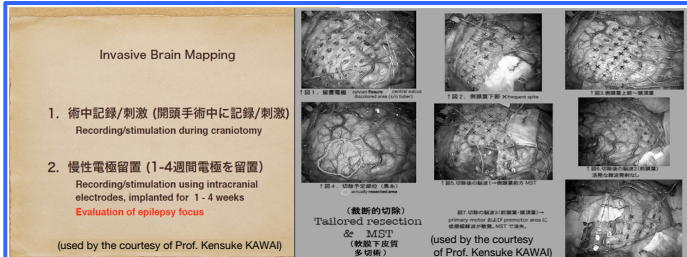
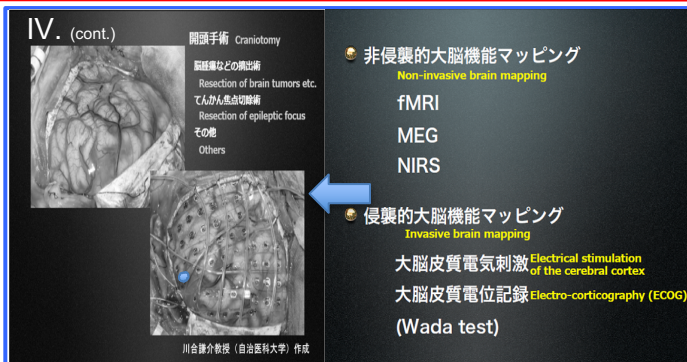
Based on Van Hoorn et al. 2016, 4 participants, including only 1 in fMRI,

play “Public Goods Game”.

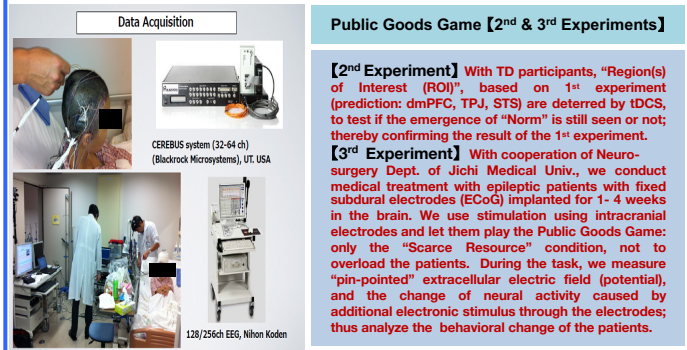
- Yen 500 is given to each at first. Each decides his “contribution” to Public Goods.
- The experimenter sums up the contributions & divide the total into equal share for each.
- For each participant to “survive” at the end of the Game, he must have at least Yen 1,000. If not, that participant should return all his money at hand and “dies”.

- ★1: “Scarce Resource”: Total resource is Yen 4,000; if the total are divided, “game over”.
- ★2: “Unlimited Resource”: Total resource is unlimited. (CONTROL conditions is the same.)
- ★3: “Limited Resource”: Total resource is Yen 8,000.

We test if the “Norm” emerges so that each shall have at least have Yen 1,000 at the end of the game & if so, what ROI is/are activated. [PREDICTION] (based on Van Hoorn et al. 2016) ROI will be dmPFC, TPJ & STS; and the scale of significant difference: ★1 > ★3 > ★2.



We experiment for new findings of “Neurolaw” by invasive treatment for patients of epilepsy by ECoG as participants



## V. Evolution of Law: How to proceed & VI. Tentative Conclusion

V.-1: Do non-human animals have “law”, with (a) norms & (b) TPP? Chimpanzees?

(a) norms: tough on-going debate! Positive: von Rohr et al. 2015, de Waal (2016 Lecture) → Negative: Schlinghoff & Moore 2017

(b) TPP: another debate! Positive: von Rohr et al. 2012 → Negative: Riedl...Tomasello 2012

→ As of today, the existence of law in non-human (primates) group is unknown. However, “Absence of evidence is NOT evidence of absence!” Future research shall prove the absence or existence of (a) norms & (b) TPP, and combined, antecedent of law among non-humans (primates; non-primates) – “worker policing” of ants, honey bees as norm & TPP).

V.-2: Work in Progress (1): Computer Simulation (CS) – Dr. Marco Campenni & Wada are setting a model to simulate out the whole process of evolution of law. (Dr. Campenni already conducted CS on evolution of norms. See Conte...Campenni [eds.], *Minding Norms*, 2013.)

V.-3: Work in Progress (2): Linkage of evolutions of language & law – Dr. K. Iijima, Wada et al. are to clarify how language helped the evolution of law, & if it was an absolute necessity.

VI. Conclusion: Most certainly, law has enhanced human social complexity. However, much remains to be studied on “evolution of law”.

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