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Cognitive Science Approach to Achieve SDGs

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A Short Resume of the Presenter

Muneo Kitajima currently works at the Department of Management and Information Systems Engineering, Nagaoka University of Technology. His recently published book "Memory and Action Selection in Human-Machine Interaction" (2016) proposes a unified theory of action selection and development by integrating PDP, Two Minds, and Layered structure of human action. The theory provides a comprehensive view of how our brain functionally works in our daily life. His current interest is to understand the implications of the theory to development of skill of adaptive problem solving, the important skill for survival.

Sustainable Development Goals (SDGs)

- A blueprint for achieving a better, more sustainable future for all, defined by the United Nations (UN).
  - *Aimed at addressing the global challenges we face, including those related to poverty, inequality, climate change, environmental degradation, peace, and justice.*
- SDGs consist of 17 interconnected goals, and 169 targets under these goals.
  - *Example: "Goal 3: Ensure healthy lives, and promote well-being for all at all ages" is associated with 13 targets, such as "3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination."*

Need for Contributions from Cognitive Science

- Quote from the UN Report, "The Future is Now: Science for Achieving Sustainable Development":

> *During the long period of human evolution, humans have overcome multiple complex challenges, and remained highly adaptive. There is therefore reason to hope that we will also overcome the current challenges to sustainability that are faced on a societal – indeed global – scale. Evolutionary adaptation is most often based on tangible experiences, short-term outcomes and relatively straightforward theories of change. Several aspects of the transformation towards sustainability can be different.*
>
> *…*
>
> *Changing behaviours towards evolutionary adaptation in such a context can therefore be different from other contexts in which humanity has had to deal with society-wide challenges.* ***Individuals will play a pivotal role in driving the necessary transformations. Understanding how people – as consumers and engaged citizens – make choices and decisions in that regard can help to further motivate such action. Cognitive science, psychology, behavioural economics, neurobiology and brain research can provide important insights in that regard. They might indicate, for example, what is going on in our brains when we hear science-based information about sustainability challenges, and consequently make decisions and choices.***

P. Messerli and E. Murniningtyas, Global Sustainable Development Report 2019: The Future is Now – Science for Achieving Sustainable Development, New York, 2019, written by Independent Group of Scientists appointed by the Secretary-General of UN.

Achieving SDGs via Problem Solving Activities

- "Problem solving" is the domain of Cognitive Science (CS) for contribution to the SDGs
  - *Activities involved in achieving any of the SDGs may be considered as problem-solving (PS) activities.*
  - *A lot of knowledge concerning PS has been accumulated in CS.*
- The nature of PS for achieving any of the SDGs
  - *PS activities to achieve any of the SDGs have to be implemented as "real world problem-solving" activities.*
  - *Problem space consists of:*
    - Any of the SDGs,
    - Goals for real world problem-solving (RWGs), and
    - Moves from a state to another.
  - *RWGs eventually converge to the 17 happiness goals defined by Morris.*

Morris, D. (2006). *The nature of happiness*. London: Little Books Ltd.

SDGs and RWGs Reside in the Different Layers of Human Activities

Newell's Time Scale of Human Action

Scale (sec)	Time Units	System	World (Theory)
10^7	months		
10^6	weeks		SOCIAL
10^5	days		BAND
10^4	hours	Task	
10^3	10min	Task	RATIONAL
10^2	minutes	Task	BAND
10^1	10sec	Unit Task	
10^0	1sec	Operations	COGNITIVE
10^{-1}	100ms	Deliberate Act	BAND
10^{-2}	10ms	Neural Circuit	
10^{-3}	1ms	Neuron	BIOLOGICAL
10^{-4}	100μsec	Organelle	BAND

SDGs are located at SOCIAL BAND

RWGs are located at RATIONAL BAND or COGNITIVE BAND

Newell, A. (1990). *Unified Theories of Cognition (The William James Lectures, 1987)*. Cambridge, MA: Harvard University Press.

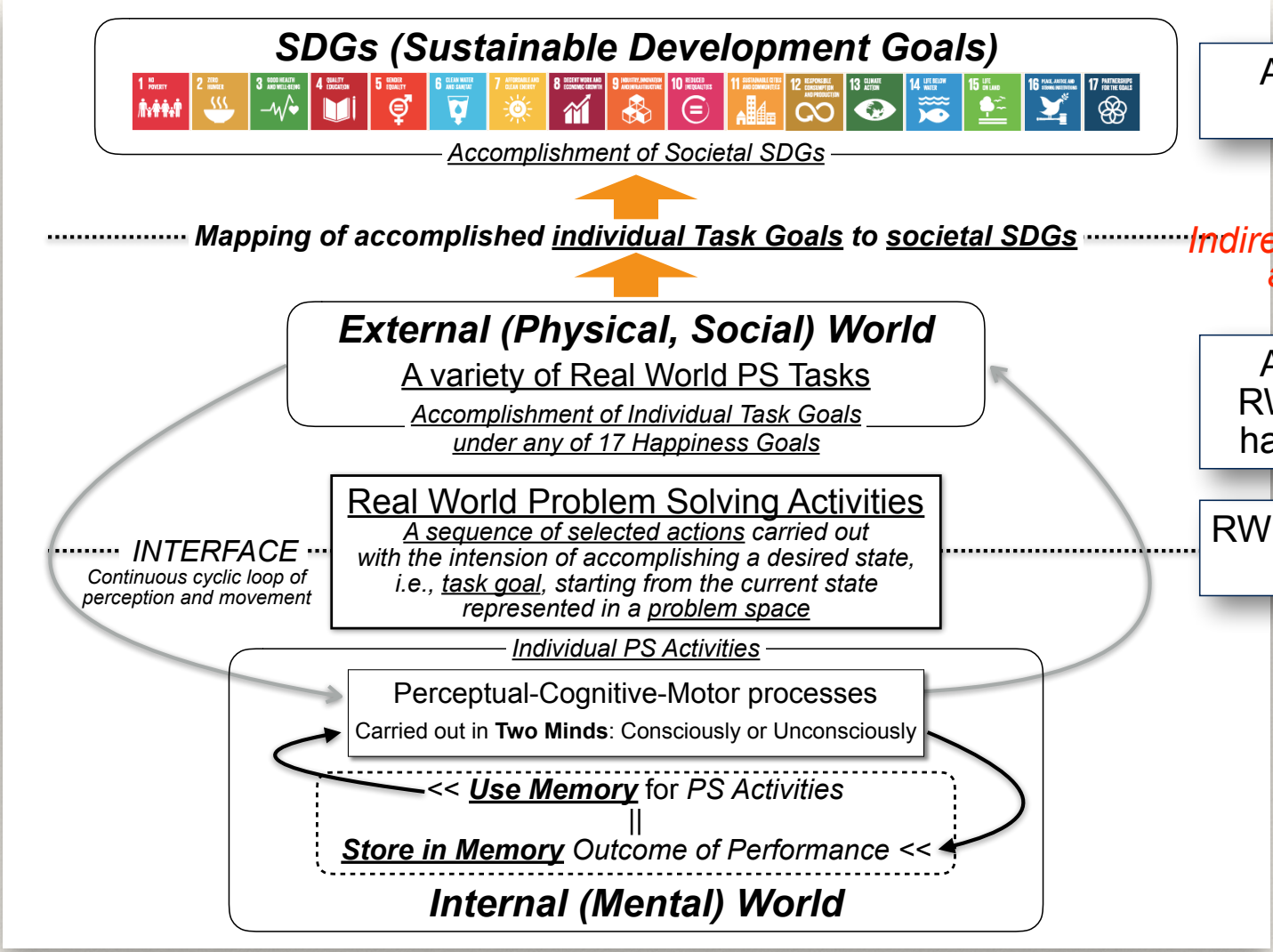
Happiness Goals and Their Relation to Social Layers

	Name of Happiness	Types	Social Layers		
			Individual layer	Community layer	Social system layer
1	Target Happiness	The Achiever	+++	+++	+++
2	Competitive Happiness	The Winner		+++	+++
3	Cooperative Happiness	The Helper		+++	+++
4	Genetic Happiness	The Relative	+++	+++	
5	Sensual Happiness	The Hedonist	+++	+++	
6	Cerebral Happiness	The Intellectual	+++	+++	++
7	Rhythmic Happiness	The Dancer	+++	+++	
8	Painful Happiness	The Masochist	+++		
9	Dangerous Happiness	The Risk-taker	+++	++	+
10	Selective Happiness	The Hysteric	+++	++	
11	Tranquil Happiness	The Mediator	+++		
12	Devout Happiness	The Believer		+++	++
13	Negative Happiness	The Suffer	+++	++	
14	Chemical Happiness	The Drug-taker	+++		
15	Fantasy Happiness	The Day-dreamer	+++		
16	Comic Happiness	The Laugher	+++	+++	
17	Accidental Happiness	The Fortunate	+++	+++	+++

+'s denote the degree of relevance of each goal to each layer.
+++: most relevant, ++: moderately relevant, and +: weakly relevant

Morris, D. (2006). *The nature of happiness*. London: Little Books Ltd.

Achieving SDGs through Individual Real World Problem Solving Activities



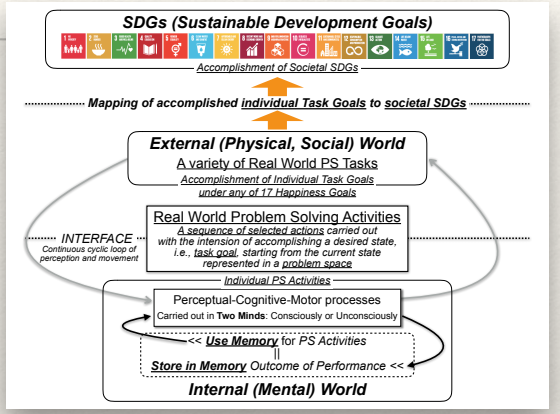
PS Activities with the SDGs and the RWGs

- Connecting the SDGs and the RWGs is difficult because:
  - *Not easy to envisage the situations wherein any of the SDGs can be achieved, and*
  - *Not easy to ascertain the relevance of accomplishing individual-level RWGs to achievement of these societal-level SDGs.*
- This difficulty is the direct consequence of "Newell's time scale of human action" consisting of four non-linearly connected bands
  - *Human action should be structured in terms of the four discrete bands*
    - *Possible* to build predictive models for activities that happen within a single band.
    - But *impossible* to build predictive models that include activities that happen in multiple bands with inter-band interactions.
  - *Non-linear inter-band connections make impossible to construct predictive models for inter-band activities.*
    - Even if a model is deterministic, it will suffer from Sensitive Dependence on Initial Condition (SEDIC), and consequently, become unpredictable.

Example: Individual Level Achievement of the SDGs

- Two Randomized Controlled Trials (RCT) reported in Banerjee et al.(2019)
  - A. Banerjee, A. G. Chandrasekhar, E. Duflo, and M. O. Jackson, "Using Gossips to Spread Information: Theory and Evidence from Two Randomized Controlled Trials," *The Review of Economic Studies*, **86**(6), 2019, pp. 2453–2490.
  - *Received the Nobel Prize in Economics in 2019*
  - *Major results:*
    - Vital information regarding vaccination was spread by using people who were considered gossips as information sources.
    - It eventually led to an increase in the vaccination rate.
  - *Summary:*
    - The RCT method was used for verifying whether gossips really worked toward spreading information.
    - Succeeded in bridging the gap between achievement of any of the SDGs and accomplishment of individual task goals by selecting the appropriate individuals for making this possible.
- Re-interpretation of the activities of Banerjee et al.'s gossips from the viewpoint of problem-solving activities:
  - *The gossips did not necessarily work toward achieving any of the SDGs.*
  - *Their efforts for the fulfillment of their personal goals – belonging to the COGNITIVE BAND – led to the achievement of "Good health and well-being for people (one of the SDGs)" as a by-product.*

Achieving the SDGs by applying CCE



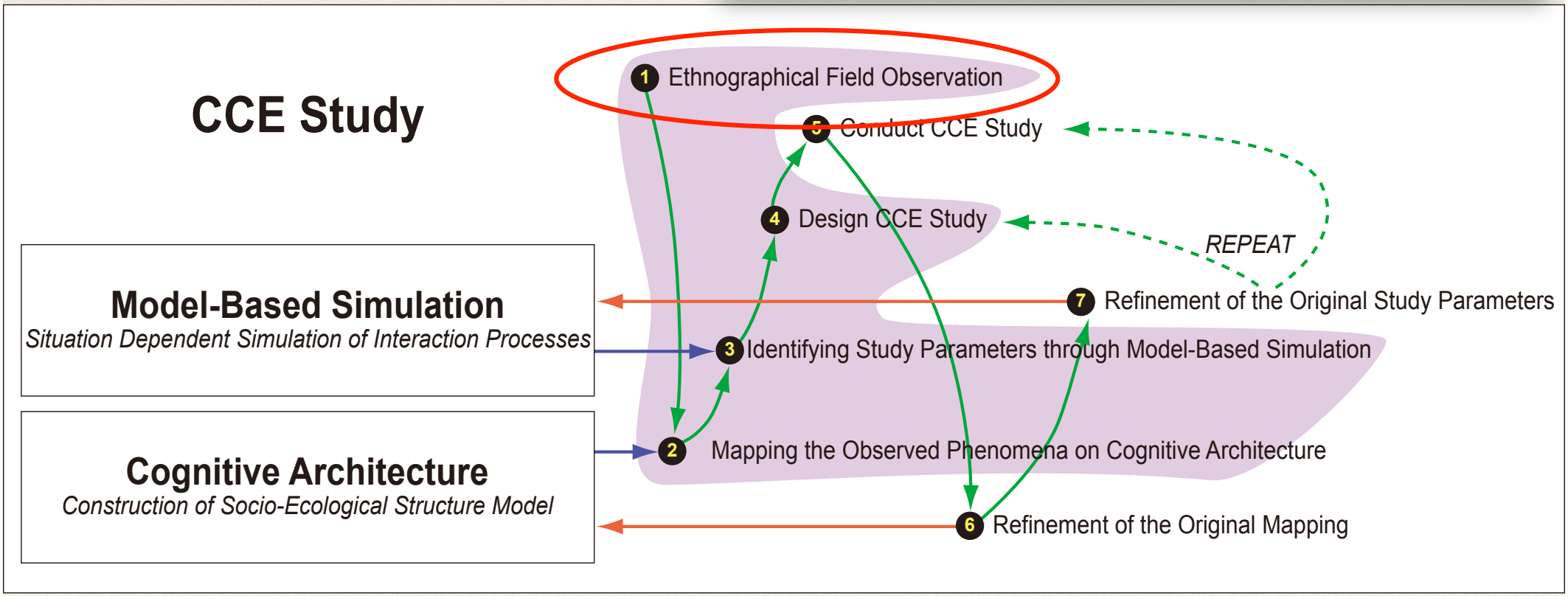
- A CS approach to what Banerjee et al. did by integrating all the portions shown in the figure.
- Cognitive Chrono-Ethnography (CCE) is a research methodology for understanding people's daily action selection processes by combining three concepts, Cognitive, Ethnography, and Chnology:
  - *The fact that "daily behavior is the outcome of a non-linear system" suggests that we need an ethnographical approach. This is because SEDIC (SEnsitive Dependence on Initial Condition) is the primary feature of such a non-linear system.*
  - *The results of cognitive simulation of people's activities by using cognitive architectures (e.g., MHP/RT), that defines the cognitive constraints, provide a basis for selecting "who to observe ethnographically in the real world" focusing on "as-is" and "the process leading to the present" along the time dimension (chronology).*
- Conducting a CCE study:
  - *The purpose is to derive a model in the form "**What such-and-such people would do in such-and-such way in such-and-such circumstance (not an average behavior)**".*

1) *Identify critical parameters for the study field to define the parameter space that captures the the structure and dynamics of the study field.*
2) *Select study participants (elite monitors, i.e., such-and-such people) who correspond to the points in the parameter space.*
   - Monitor selection is conducted by purposive sampling rather than by random sampling, similar to RCT.
3) *Record elite monitors' activities in the study field and analyze the recorded data to derive the model.*

CCE Procedure Adapted to Achievement of the SDGs

1) Ethnographical Field Observation:
Use the basic ethnographical investigation method to clarify the outline of the structure of social ecology that underlies the subject to study.

Additions for the adaptation: The study's focus would be any social ecology that has achieved or is approaching accomplishment of any of the UN defined targets associated with one of the 17 SDGs. The purpose of the CCE is to understand how this goal accomplishment is possible in the social ecology in question. Therefore, the enabling condition for a CCE study is the existence of such a social ecology, i.e., there is an ecologically valid solution for achieving the target under the SDGs.

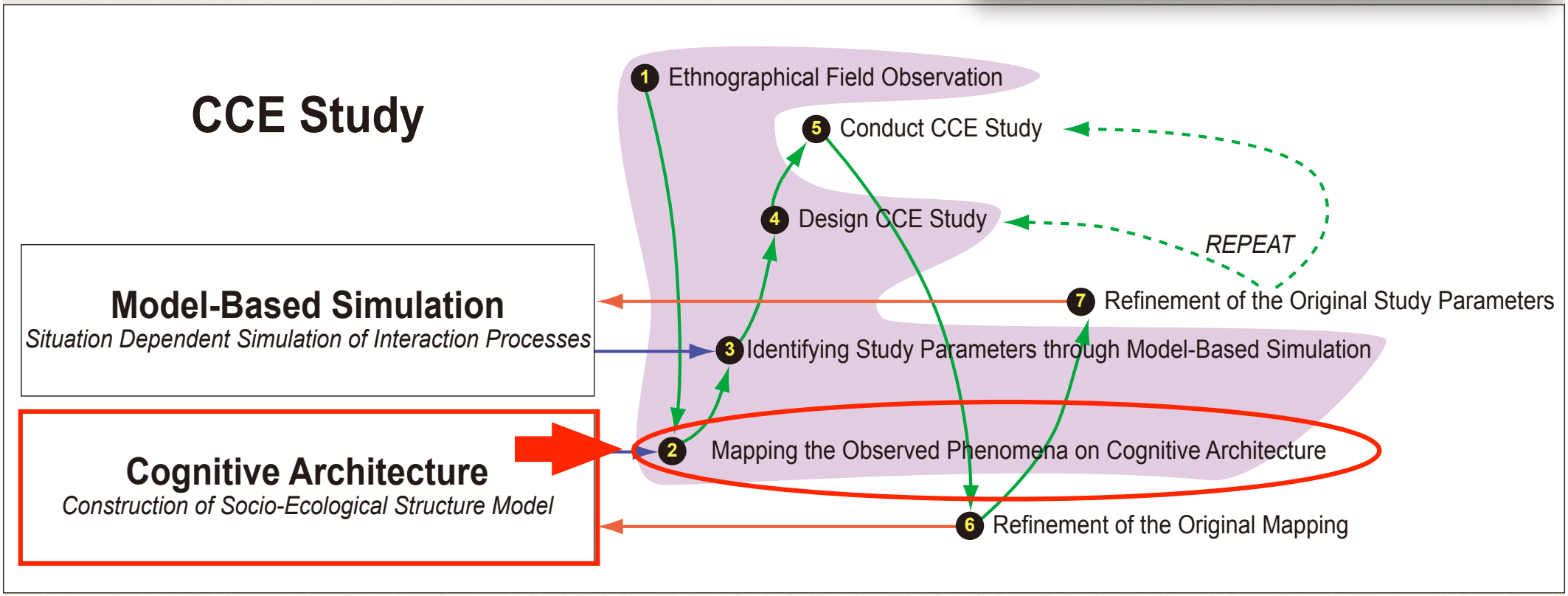


CCE Procedure Adapted to Achievement of the SDGs

2) Mapping the Observed Phenomena on Cognitive Architecture:

With reference to the behavioral characteristics of people which have been made clear so far and MHP/RT, consider what kind of characteristic elements of human behavior are involved in the result in (1).

Additions for the adaptation: The emphasis is on identifying a plausible happiness goal that might be held by the people in question. This step is particularly important, because the happiness goal is normally different from the target of the SDGs, each of which resides in different bands.



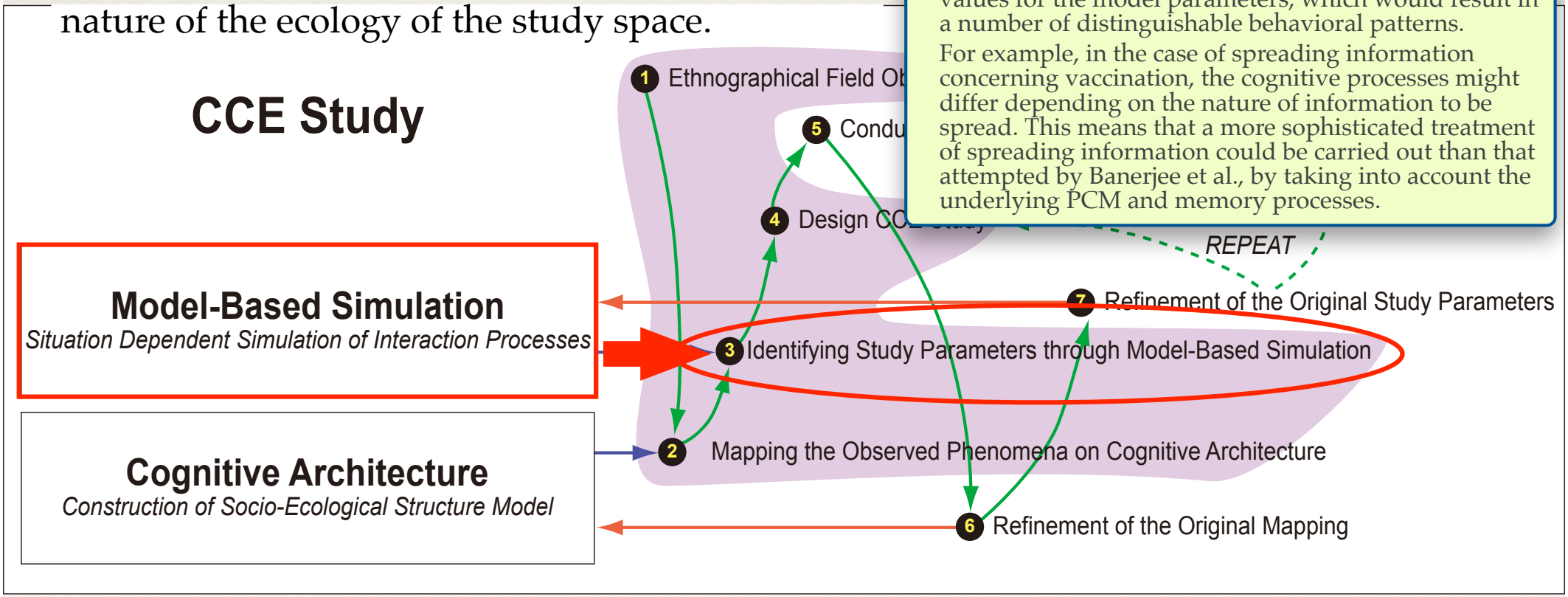
CCE Procedure Adapted to Achievement of the SDGs

3) Identifying Study Parameters through Model-Based Simulation:

Based on the consideration of (1) and (2), construct an initial simple model with the constituent elements of activated memories, i.e., meme, and the characteristic PCM processing to represent the nature of the ecology of the study space.

Additions for the adaptation: The focus would be to identify classes of behaviors that are distinguishable from each other due to different functioning of their PCM and memory processes. Cognitive simulation is achieved by using appropriate cognitive architecture, such as MHP/RT by assigning plausible ranges of values for the model parameters, which would result in a number of distinguishable behavioral patterns.

For example, in the case of spreading information concerning vaccination, the cognitive processes might differ depending on the nature of information to be spread. This means that a more sophisticated treatment of spreading information could be carried out than that attempted by Banerjee et al., by taking into account the underlying PCM and memory processes.

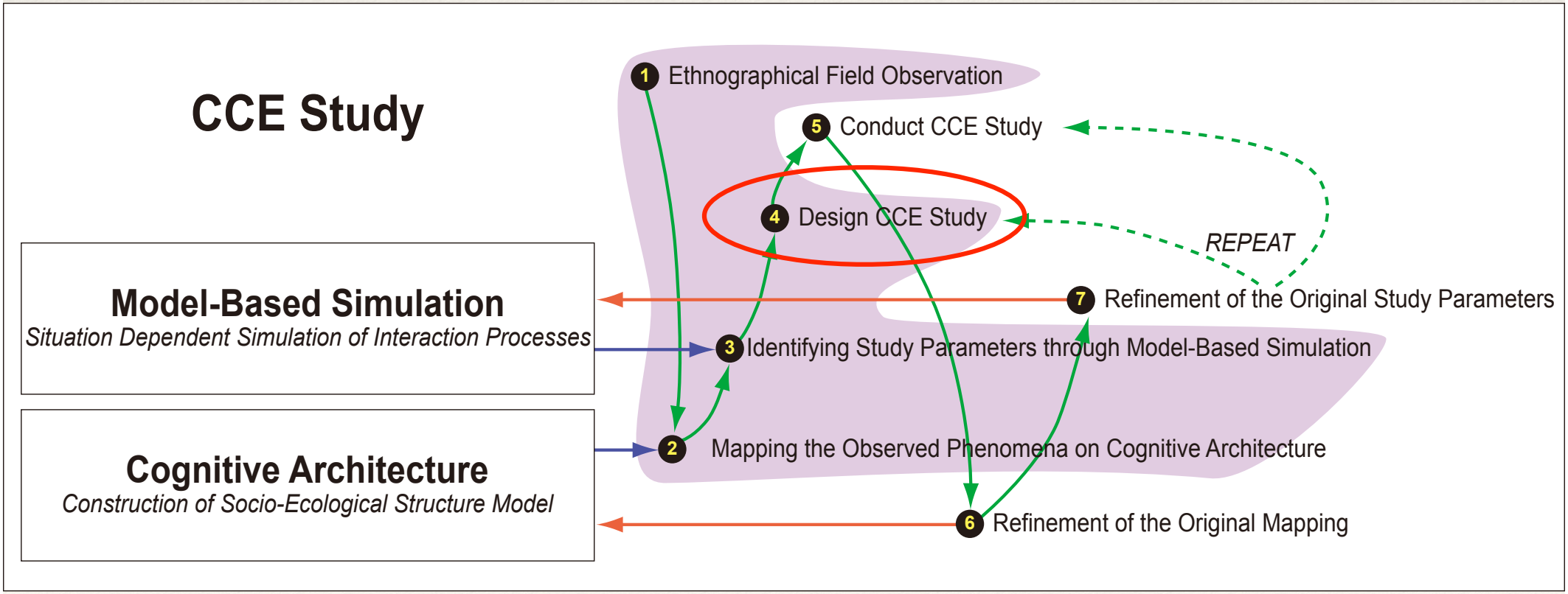


CCE Procedure Adapted to Achievement of the SDGs

Additions for the adaptation: None.

4) Design a CCE Study:

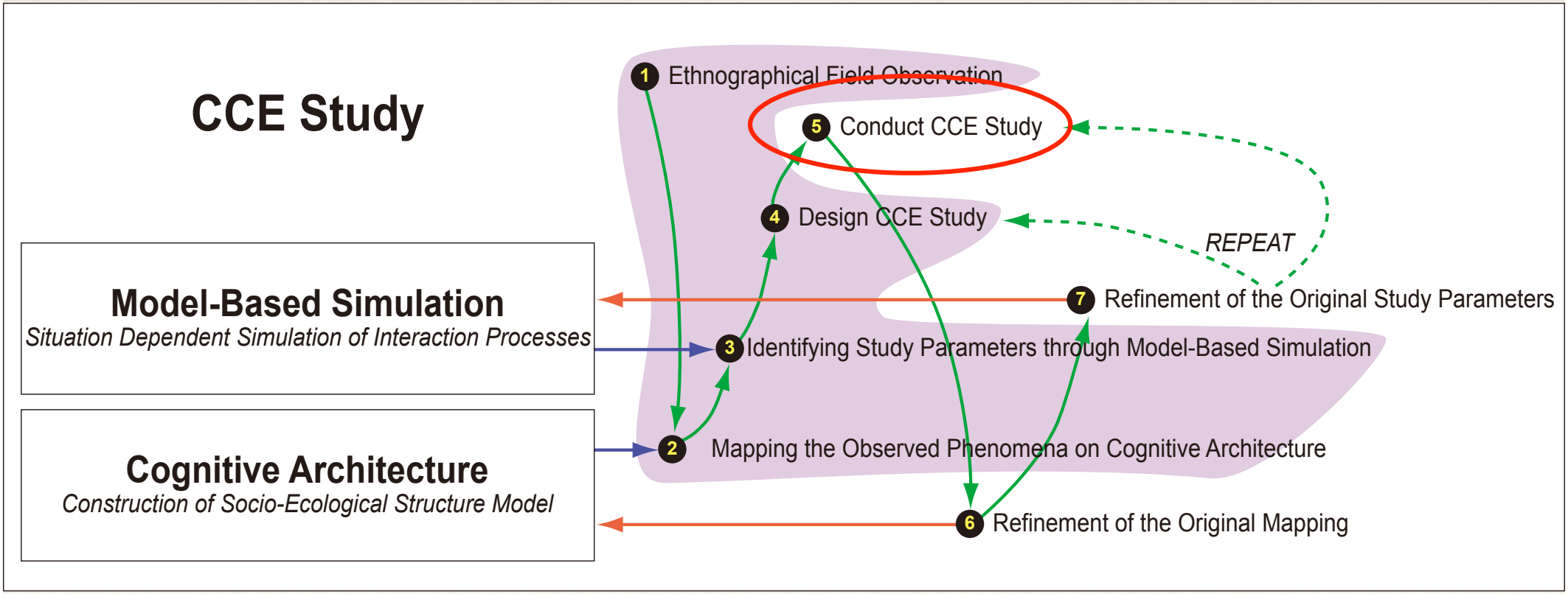
Based on the simple ecological model, identify a set of typical behavioral characteristics from a variety of people making up the group to be studied. Then formulate screening criteria of elite monitors who represent a certain combination of the behavioral characteristics, and define ecological survey methods for them.



CCE Procedure Adapted to Achievement of the SDGs

Additions for the adaptation: None.

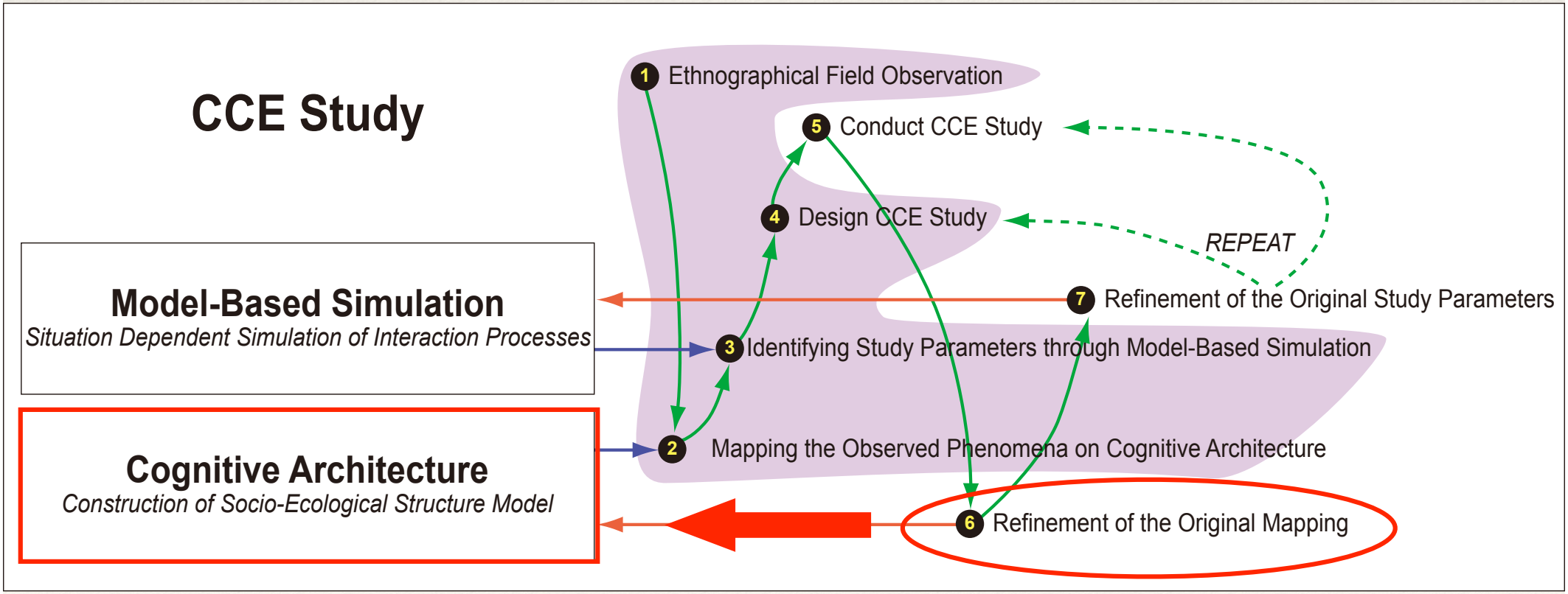
5) Conduct CCE Study:
Select elite monitors and conduct an ethnographical field observation.



CCE Procedure Adapted to Achievement of the SDGs

Additions for the adaptation: None.

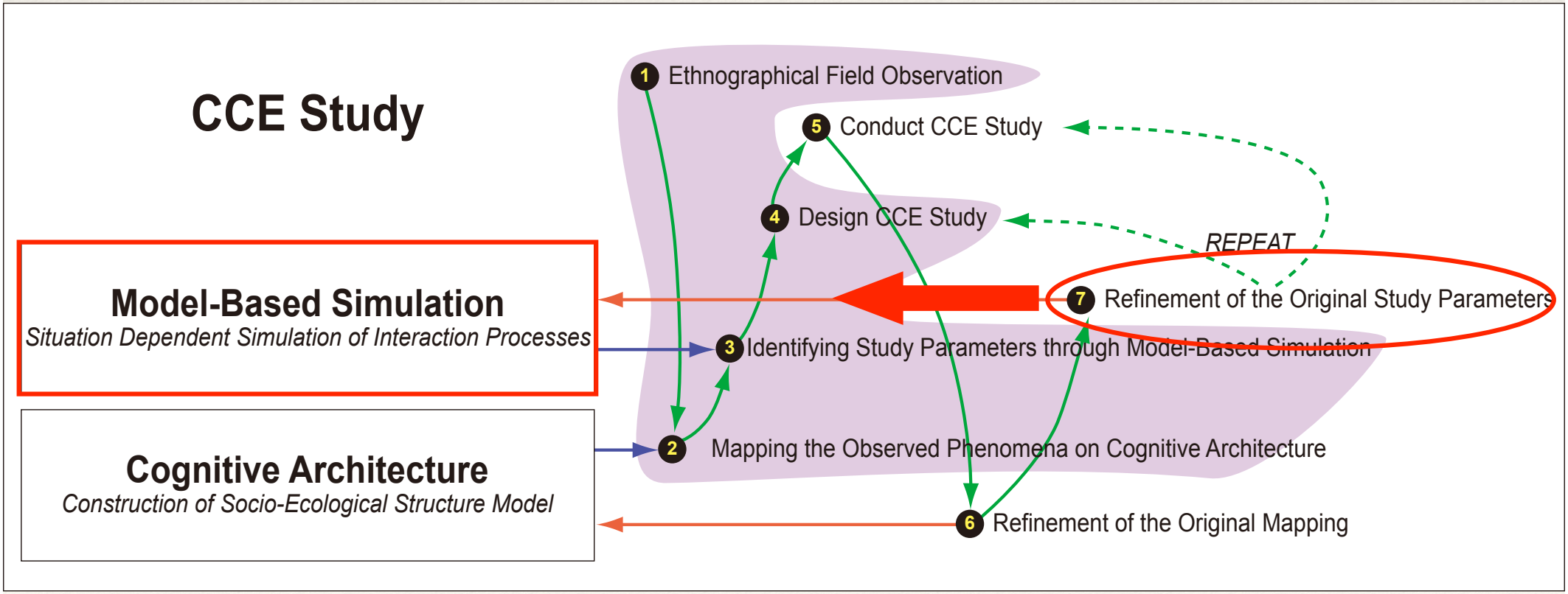
6) Refinement of the Original Mapping:
Check the results of (5) against the results of (2) for appropriateness of the mapping. If inappropriate, back to (2) and redo from there.



CCE Procedure Adapted to Achievement of the SDGs

Additions for the adaptation: None.

7) Refinement of the Original Study Parameters:
If the result of (5) is unsatisfactory, go back to (4) and re-design and conduct a revised CCE study, otherwise go back to (3) to redo the model-based simulation with a set of refined parameters.



On Completion of a CCE Cycle

- A feasible scenario for achievement of any of SDGs is defined:
  - *The CCE study was conducted with the focus of the existing social ecology, that has already contributed to the achievement of any of the SDGs, by observing representative elite monitors.*
  - *The CCE study has associated "the achievement of any of the SDGs" with "the accomplishment of the RWGs" at the individual level.*
  - *The CCE has built the model in the form "What such-and-such people would do in such-and-such way in such-and-such circumstance" for the activities of the elite monitors.*
- Increasing the level of achievement of the SDGs:
  - *By transferring the feasible scenario another social ecology that is similar to the existing one, but has still not achieved the goal.*

Conclusions

- Contribution of cognitive science to the achievement of the SDGs was discussed:
  - *An example was shown that the communication of vaccination information that lead to the achievement of health goals.*
  - *There is room for consideration as to whether the targets set to achieve all SDGs can be advanced in the same way. However, as stated in the UN report, it is impossible to achieve the targets without human involvement.*
  - *In that regard, cognitive science, dealing with human behavior, is destined to make a significant contribution.*
- Important points when applying CS:
  - *The SDGs, that reside at SOCIAL BAND, cannot become the goals that individual persons set for the real world problem solving that happen at RATIONAL and/or COGNITIVE BANDs.*
  - *If there exists a social ecology that has achieved any of the SDGs through people's activities, it must be understood by the problem-solving activities with the RWGs under 17 happiness goals.*
  - *Human activities should not be modeled as a linear system but modeled as a non-linear system.*
  - *CCE is the appropriate study methodology when attempting to apply CS to the achievement of SDGs.*
  - *TCCE studies can define a feasible scenario of people's involvement in achieving any of the SDGs.*
  - *The scenario is transferrable to another social ecology which has NOT achieved the particular SDGs.*

http://oberon.nagaokaut.ac.jp/ktjm/organic-self-consistent-field-theory/index.html

Organic Self-Consistent Field Theory

last update: 26 May, 2018

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Introductory document and materisls for BICA 2014 conference are available from the follwoing links.

- An introductory document.
- BICA2014 Presentation Slide
- BICA2014 Presentation Slide with note
- BICA2014 Paper 15
- BICA2014 Paper 16
- BICA2014 Paper 18

<< Organic Self-Consistent Field Theory >>

Outline Of Organic Self-Consistent Field Theory

Human Beings Living In The Environment

Living organisms, including human beings, act autonomously. The living environment on the Earth is a field constructed through interactions among the living organisms in a variety of ways. The Earth's environment changes continuously in a one-year fundamental cycle. In order to attain stability in the ever-changing environment, which incorporates the Earth and the other living organisms, living organisms have developed their own autonomous control systems. The whole universe of complexly interconnected living organisms thus constructed can be called ***Organic Self-Consistent Field***. Figure A depicts such a field from the viewpoint of the information structure. The autonomous living organisms act by mapping the information structure shown in Fig. A onto their brains in their evolution. The nonlinear dynamic human behavior model with real-time constraints represents an organic self-consistent field as a model. It consists of three fundamental nonlinear constructs that correspond to the information structure of Fig. A.

- **Brain Information Hydrodynamics (BIH):** BIH deals with *information flow* in the brain and its characteristics in the time dimension. Biological activity can be viewed as the results of information flow in the brain and it shows the characteristics of complex systems and dissipative structure. In other words, it is best characterized by *hydrodynamics* at the microscopic phenomenological level and by *thermodynamics* at the macroscopic collective level.

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