UNDERSTANDING AND IMPROVING HUMAN DECISIONS AGAINST CLIMATE CHANGE VIA COMPUTER SIMULATION TOOLS

A Thesis submitted

In accordance with the requirements

For the award of the degree of

DOCTOR OF PHILOSOPHY

By

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THESIS CERTIFICATE

This is to certify that the work contained in the thesis entitled "Understanding and improving human decisions against climate change via computer simulation tools" being submitted by Ms. Medha Kumar (Enrolment No: D13015) has been carried out under my supervision. In my opinion, the thesis has reached the standard fulfilling the requirement of regulation of the Ph.D. degree. The results embodied in this thesis have not been submitted elsewhere for the award of any degree or diploma.

June 19, 2020

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DECLARATION BY THE RESEARCH SCHOLAR

I hereby declare that the entire work embodied in this thesis is the result of investigations carried out by me in the ***School of Computing and Electrical Engineering***, Indian Institute of Technology Mandi, under the supervision of ***Dr. Varun Dutt***, and that it has not been submitted elsewhere for any degree or diploma. In keeping with the general practice, due acknowledgments have been made wherever the work described is based on findings of other investigators.

Place: IIT Mandi, Kamand

Date: June 19, 2020

Signature:

Name: Medha Kumar

DECLARATION BY THE RESEARCH ADVISOR

I hereby certify that the entire work in this thesis has been carried out by ***Medha Kumar***, under my supervision in the ***School of Computing and Electrical Engineering***, Indian Institute of Technology Mandi, and that no part of it has been submitted elsewhere for any Degree or Diploma.

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Date: June 19, 2020

ABSTRACT

Prior research shows that certain cognitive misconceptions drive people's wait-and-see preferences for climate change and stock-and-flow simulation tools help in reducing these misconceptions. However, it is not clear whether the reduction in cognitive misconceptions in simulation tools is due to learning of the problem's surface features (units and values) or behavioral features (how inputs and outputs influence curve shapes). Furthermore, it is not clear how people's learning in simulation tools is influenced by the problem's difficulty and the use of simulations as decision aids. Still, less is known about how people make decisions against climate change in the presence or absence of information about investments of opponents (information asymmetries) and how influential theories of reinforcement learning would account for these decisions. The main objective of this thesis is to address these literature gaps via a series of experiments involving the use of simulation tools. In the first experiment, participants performed in a simulation tool, Dynamic Climate Change Simulator (DCCS), and were subsequently transferred to a paper-and-pencil Climate Stabilization (CS) task. Misconceptions reduced significantly in the CS task across problems where the CO_2 concentration behavior was either identical or different between DCCS and CS tasks, showing behavioral learning in simulation tools. In the second experiment, both the surface features and behavioral features of climate problems were varied in DCCS and participants were subsequently transferred to the CS task. Results revealed that climate misconceptions reduced significantly due to both surface and structural learning in DCCS. In the third experiment, participants performed in easy and difficult climate problems in DCCS and were subsequently transferred to the CS task. Difficult problems caused a greater reduction in cognitive misconceptions in CS task compared to easy problems. In the fourth experiment, the potential of DCCS as a decision aid in reducing cognitive misconceptions was tested. Results revealed fewer cognitive misconceptions in the presence of DCCS as a decision aid

compared to in the absence of DCCS. In the fifth experiment, the role of information asymmetries among participants making investment decisions against climate change was investigated. Results revealed that information availability about investments of others causes greater investments against climate change. In the sixth experiment, the role of partial information asymmetries among participants making investment decisions against climate change was investigated. Thus, investment information may be known to only a subset of decision-makers. Results replicated the findings of the fifth experiment and decision-making was similar in conditions where information was partially available and not available. In the seventh experiment, two multi-player reinforcement models, Expectancy-Valence-Learning (EVL) and Prospect-Valence-Learning (PVL) were developed, to understand the cognitive mechanisms driving investment decisions in the presence of information asymmetries. Results revealed that the EVL model performed better when investment information was present among all players and PVL model performed better when investment information was not present or partially present among all players. Furthermore, model parameters showed reliance on recency, reward-seeking, and exploitative behaviors. The implications of using simulation tools for improving people's decision-making against climate change have been highlighted.

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