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Abstract

By simulating game playing with neural networks, and by using human subjects, it is demonstrated that the interaction between two players in a game of Paper, Rocks and Scissors can give rise to emergent properties that are not inherent in the individual players.

Game theory (VonNeumann & Morgenstern, 1944) describes how rational players should behave in a competitive situation prescribed by rules and with payoffs for certain results. However, to do this it is necessary to make assumptions concerning the cognitive mechanisms available to the players. One assumption that is frequently made is that players have the ability to generate random responses (i.e. to draw responses at random from a predetermined distribution). For example, the game theory solution for Paper, Rocks and Scissors (hence forth PRS) is to play randomly, 1/3 paper, 1/3 rocks, and 1/3.

However, the assumption of random responses is problematic for two reasons. The first is that people are normally quite bad at generating random responses (see Tune, 1964, and Wagenaar, 1972 for reviews), and the second is that when people guess what is coming next in a series they attempt to capitalize on sequential dependencies, regardless if they are present or not (e.g., Anderson, 1960; Estes, 1972; Restle, 1966; Rose & Vitz, 1966; Vitz & Todd, 1967). Given the above research, a more realistic model of PRS play would have players trying to detect each other's sequential dependencies.

To model this, *simple linear models* (Rumelhart, Hinton, and McClelland, 1986) were used. The networks were designed to predict their opponent's next move based on previous trials, and they differed only in how many of their opponent's previous trials they could process. To represent this the networks are be referred to in terms of how many lags back they had access to (i.e. a lag1 network could remember one trial back; a lag2 network, two trials back, etc.). PRS games were then simulated by having the networks play against each other.

The effect of processing more lags was clear, networks that could remember more always won in the long term. However, as would be expected by symmetry, when the networks were evenly matched no advantage emerged. The next step was to find out if human PRS play was consistent with the simulations. To do this, human subjects played PRS against a lag1 network.

The subjects were 13 volunteers from the University of British Columbia and the University of Hong Kong. Each subject played for approximately 20 minutes. The number of trials varied based on each subject's playing speed. All subjects played at least 250 trials (mean number of trials = 441). The mean of subjects' final scores was 16.8, which was significantly higher than zero, indicating that subjects were able to outplay the lag1 network.

PRS is an example of a zero sum, guessing game. From a distributed cognition perspective (e.g. see Hutchins, 1994), such games can be conceptualized as distributed systems composed of coupled sequential dependency detection mechanisms. The results of this study indicate that such systems have emergent properties that benefit players who can process more lags.

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