We examine how the complexity of language is influenced by the level of uncertainty (= risk) in the environment (Andras, Roberts and Lazarus 2005), when language is used to communicate cooperative intentions between interacting agents. Since cooperation increases with risk (measured as both environmental adversity and uncertainty) in a number of biological contexts (Andras and Lazarus 2005), and cooperation requires communication between interacting agents, the question arises of whether language complexity might vary adaptively as a function of risk. An example is the evolution of human language in the small cooperative groups of early hunter-gatherers.

We model a world of simple agents that own resources that are used for survival and to produce new resources, environmental risk being expressed as the variance in the reproduction of these resources (Andras, Roberts and Lazarus 2003). Agents produce offspring and the number of offspring depends on the amount of resources owned by the agent. New agents inherit the language of their parent with some random mutations.

Agents communicate with each other about their intention to cooperate by sharing resources. The language contains the following semantic elements: no interest in communicating; start of communication; intend to communicate further; want to engage in sharing; lost interest; share action; not share action. Agents remember previous encounters and if they meet again an agent with whom they have previously cooperated then communication symbols likely to lead to cooperation increase in probability in the current encounter (and vice versa).

As risk increased in the simulations cooperation increased, and cheating and non-cooperation decreased, as found in nature (Andras and Lazarus 2005). Overall, there was no clear relationship between language complexity (i.e. the length of communication sequences between agents) and environmental risk, although communication sequences were shortest in the most risky environments.

The lack of a clear relationship between language complexity and environmental risk may have been because the model language was too simple, varying between only 4 and 6 elements at the outset. For a richer language – which we plan to investigate - we predict that communications will be shorter as risk increases (as the data for our highest risk level suggested) since: (1) there was a positive correlation between cooperation level and risk, and (2) there was a negative correlation between cooperation level and language complexity. Those who cooperated had shorter communication strings than those who cheated or failed to cooperate. This is because if a cooperator meets an agent for whom it has a memory biased towards cooperation then it has a higher probability of producing

positive communication symbols (those encouraging cooperation) and therefore moves with fewer communication steps into an interaction that is likely to be cooperative. Thus cooperative agents, by positive feedback, build an increasingly cooperative relationship with each other. Cooperation thus saves on communication effort.

The results have implications for the design and use of communication systems under conditions of uncertainty, and for the role of environmental uncertainty – for example, in foraging - in shaping the evolution of human communication patterns.

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Keywords

multi-agent systems, communication, language, cooperation, environmental uncertainty