Performance of Simple Recurrent Network Indexes Creativity and Predicts Discovery in a Rule Induction Task

Frédéric Vallée-Tourangeau
Department of Psychology
University of Hertfordshire
Hatfield, Hertfordshire
UNITED KINGDOM, AL10 9AB
f.vallee-tourangeau@herts.ac.uk

In the "2:4:6" induction task, participants are told that a rule underlies the generation of number triples of which *2:4:6* is an example. The rule is "any increasing sequence". Subjects are instructed to attempt to discover the rule by producing new triples which the experimenter classifies as conforming or not conforming to the rule. Wason (1960) originally proposed that Popperian falsificationism was the normative hypothesis-testing model against which subjects' behavior should be assessed. This proposal has dictated most of the subsequent research (e.g., Gorman, Stafford, & Gorman, 1987).

This emphasis on *testing* strategies reflects a perspective on discovery that places greater importance on the process by which ideas are justified rather than on the richness of the hypothesis set that underlies the production and interpretation of triples. In an attempt to redress this imbalance Vallée-Tourangeau, Austin, and Rankin (1995) showed that solvers produced a greater variety of positive and negative triples than nonsolvers.

An obvious but important (and neglected) aspect of triple production is that it reflects a sequential process which may exhibit contextual dependencies. Up to now, there has been no analysis of either the local context of the current triple within which a number is generated or the broader context of the preceding set of triples. The proposal outlined in this paper is that successful rule discovery in the *2:4:6* task can be reliably predicted by the extent to which a given number in a sequence departs significantly from its prior context. The challenge, however, is to develop an instrument that is able to measure such departures on the basis of a dynamic charaterization of the prior context. This paper proposes that a simple recurrent connectionist network (Elman, 1990) offers such a tool and reports data that demonstrate that the resulting indices of creativity are among the best predictors of successful rule discovery reported thus far in the literature.

A SRN was used as a statistical exploration tool. The data explored were the triple sequences generated by the participants in Vallée-Tourangeau et al.'s study. These subjects had to produce 15 triples before announcing their guess; they were not asked to formulate a hypothesis at any other moment. The aim of the exploration was to assess whether a SRN could extract regularities in the triples tested that would demarcate solvers from nonsolvers. The input representation encoded features of each number within a triple and its relation to previous numbers along five binary dimensions. Each number was thus translated into a 5-bit input vector and each triple was defined in terms of three consecutive input vectors. The SRN architecture employed consisted of 5 input, 5 output, 2 hidden and 2 context units. The task of the network was to learn to predict the characteristics of the next number within the sequence. The performance of SRNs trained on triples from subjects who announced an incorrect hypothesis was compared to the performance of SRNs trained on triples from correct subjects. According to Vallée-Tourangeau et al., successful subjects show more variable triple production than unsuccessful subjects, and consequently it is expected that the prediction error of a SRN for successful subjects versus unsuccessful subjects will exhibit significant differences

Simulation results showed that the mean output activation values for each number within a triple produced by successful subjects were statistically different from those produced by incorrect subjects. Specifically, the mean output activation values for triples generated by incorrect subjects corresponded more closely to the activation values for the triple given initially, namely *2:4:6*, than the mean values for triples generated by correct subjects. In other words, the profile of the typical triple tested by incorrect subjects resembled the initial triple. In turn, prediction error was statistically greater for triples generated by successful than by unsuccessful subjects. That is the characteristics of the numbers within a triple were more predictable when they were produced by unsuccessful subjects. This suggests that triples produced by successful subjects demonstrated more creativity and were therefore less predictable. Thus, the performance measures of the SRN support the conjecture that discovery in the "2:4:6" task is a function of breaking free from the constraints of the salient features of the initial example. As well they can be interpreted to index the breadth of the exploration of the space of possible triples and successful subjects explored that space more extensively.

References

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