

4 Formal Models of Language (pjb48)

This question concerns a hypothesis space where each language is characterised by three binary parameters:

Parameter name	0	1
S_{right}	subject before verb	subject after verb
O_{right}	objects before verb	objects after verb
S_{drop}	subject is required	subject is optional

- (a) Complete the table of language patterns exhibited by all possible parameter combinations. Denote S-optional with (S). When the order of S and O is ambiguous, place O closest to the verb. The first two rows are given:

S_{right}	O_{right}	S_{drop}	language pattern
0	0	0	SOV
0	0	1	(S)OV

[3 marks]

- (b) A learning algorithm attempts to identify the parameter settings which characterise a *target language*. The algorithm records the *learner state* (the current hypothesised parameter settings). It proceeds by checking the compatibility of an input sentence with the learner state. If they are not compatible, the algorithm flips **one** bit in the learner state. Draw a diagram to represent the possible transitions between learner states. [2 marks]
- (c) The target language is represented by the parameters [011] ($S_{\text{right}} = 0$, $O_{\text{right}} = 1$, $S_{\text{drop}} = 1$). Sentences in a language may contain 0, 1 or 2 objects and therefore sentences in the target language are in one of the following forms:

1. SV 2. SVO 3. SVOO 4. V 5. VO 6. VOO

When presented to the learning algorithm, the probability distribution over sentence forms is uniform. Each bit has an equal probability of being selected for flipping when the input is not compatible. Provide a transition matrix showing transition probabilities between learner states. [4 marks]

- (d) If the algorithm is initialised with state [100], give an equation for the expected number of steps to converge on the target language parameters. [3 marks]
- (e) Given equal probability of any given state being used to initialise the algorithm, write an equation for the overall expected number of steps before convergence on the target language parameters. [2 marks]
- (f) Suggest an alternative learning algorithm within the same learning paradigm and discuss the assumptions of the learning paradigm with respect to human language learning. [6 marks]