

Linking population dynamics and high-level cognition: Ambiguity resolution in a neural sentence processing model

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A dynamic interaction in our neural sentence model [1,2] can resolve an example of sentence ambiguity in line with human sentence processing. The ambiguity concerns the difference between Bill knows John (1) and Bill knows John likes fish (2). In (1) John is the theme (object) of knows, but in (2) knows has a complement (John likes fish) with John as subject. In online processing, humans can easily switch from John as theme of knows to John as subject in a complement of knows, which resolves the ambiguity between the roles of John and knows in (1) vs. (2). Figure 1 shows the representation of (1) and (2) in terms of the model [1,2]. Large circles are neural 'syntax assemblies' representing syntactic information, here sentence (S1), noun (N1, N2, N3), verb (V1, V2) and clause (C1). Small circles are subassemblies used for binding syntax assemblies. Connections between the syntax assemblies and subassemblies are gated, which controls the flow of activation in the sentence structure (initiated by external control signals). Binding is also achieved by gating, initiated by the co-activation of the assemblies involved. First, neural 'word assemblies' (not shown) bind to syntax assemblies of their type (e.g., knows to V1, John to N2). The syntax assemblies bind using their subassemblies of the same type. F1 shows how in (1) John can bind to knows as theme. Here, V1 and N2 activate their theme (t) subassemblies (V-t and N-t), because a control network [2] recognizes John as theme of knows and opens the gates to activate V-t and N-t. If no more words follow, this results in the representation of (1). But in (2), V-c and N-n have to bind to the complement clause C1 instead. Figure 2 shows the activation of V-t, N-t, V-c and N-n, implemented as neural populations with Wilson-Cowan dynamics. At 0 ms, knows activates V-t and V-c, anticipating a theme or complement. At 300 ms, N-t and N-n are activated as potential roles of John. Initially V-t and N-t start to bind and win the competition with V-c and N-n. At 600 ms, likes initiates the activation of clause C1 as complement, which starts to bind with N-n and V-c. This results in the competitions V-c with V-t and N-n with N-t. N-n and V-c win the competition, which results in the correct binding in (2) and overrides the binding V-t with N-t that would arise in (1). The dynamical resolution of a sentence ambiguity in line with human processing illustrates the possibility to implement aspects of high-level cognition in neuronal models based on population dynamics.

Figure 1

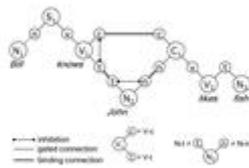
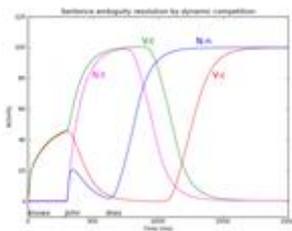


Figure 2



References

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