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JCD

Model Answer – Neural Computing, Question 3. 2000

(A)
The neural faculties that have been selected for in human brain evolution are those which optimised sexual success; that is how evolution works. These skills focus on: being charming and seductive; outwitting one's rivals; deceiving others; being able to figure out what others are thinking; out-guessing their intentions and contradicting their plans; manipulating others' desires; in short, the whole set of social skills cultivated and achieved by ambitious and upwardly mobile humans.

Superior execution of the above social tasks leads to higher status in a power hierarchy in social primates, and therefore to better mating privileges. When the ratio of brain size to body size is compared among various primate species, it is most highly correlated with the characteristic size of social groups for that species. From smallest to largest, typical examples of social group size are: orangutans (3); baboons (20); and chimpanzees (100). It appears that the need to compute and monitor social factors, keeping track of one's con-specifics and of one's own place among them all, is a primary factor in relative brain size.

If such "social computation" is indeed the major computational load of the human brain, then:

- The traditional goals of AI have not been formulated with a corresponding focus.
- Face processing algorithms, if aimed at simulating human performance with faces, should focus much more on reading social intent and expression than mere identity.
- A crucial step was the evolution of the perspective that other people have minds, too. This (and indeed consciousness itself) would not have been necessary in evolution were it not for the demands of social computation.
- The notion of agency (that others are agents, with their own plans and intentions), and that two agents might need to interact, either in conflict or in cooperation, is perhaps the computational origin of human social psychology.

[8 marks]

These perspectives highlight a divergence between the computational goals that have shaped the brain, and those of machine computation. Thus they may limit the mutual relevance between these two subjects of study.

[2 marks]

....Continued....

(B)

1. There are roughly 10^{11} neurones in the human brain.

2. There are roughly 10^{15} synapses in the human brain, i.e. about 10,000 times more than the total number of stars in our galaxy, and about 10,000 times more than the total number of galaxies in the known universe.

3. Nerve impulse propagation is described as "saltatory" because when propagating down a single axon, it "jumps" between Nodes of Ranvier which are the isolated patches of excitable membrane separated by about 0.1 mm. The axonal membrane between the Nodes of Ranvier is insulated, and contains no excitable patches. The purposes served by this arrangement are (i) greater speed of impulse propagation, and (ii) less energy consumption by the process, since the dissipative transmembrane current flows are limited to discrete patches.

4. The approximate speed of nerve impulse propagation is 100 meters/sec in warm-blooded animals.

5. "White matter" consists of the myelinated axons which are the communications channels between neurones. It is white because of myelin insulation, which prevents current leakage and short-circuits. Each axonal fibre is wrapped around many times by insulating Schwann cells.

6. The three principal ions involved in nerve membrane current flows are sodium (Na^+), potassium (K^+), and cloride (Cl^-) ions. Of these three, Na^+ and K^+ transit through voltage-dependent conductances.

7. The time required to restore ionic equilibrium to the resting state concentrations of these three ion species is about 1 msec. Therefore most neurones cannot generate nerve impulses at frequencies exceeding 1 KHz.

[10 marks in total, for any 5 of the 7]