Solution strategies for 4x4 sudoku puzzles

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Sudoku is a popular number puzzle that many people solve for fun in their leisure time. To solve a sudoku, numbers have to be placed into a partly filled grid, such that each row, column and box (marked by bold lines) contains exactly one instance of each number. Solving a sudoku requires deductive reasoning strategies of various complexity, depending on the difficulty of the puzzle. In our experiment 10 participants (5 female, mean age 23.6, std: 2.65) filled out small 4 by 4 sudokus on a computer. They could freely choose the order in which they filled the empty cells (7-9 empty cells per puzzle, average: 8.65). While solving the puzzles the subjects were asked to "think aloud" and pronounce all the thoughts they had during the experiment. Each participant solved 20 sudoku puzzles, presented in a randomized order.

Based on the think aloud data, we formulated two different classes of reasoning strategies that participants employed. One based on narrowing down the number of candidate values for a cell, the other based on narrowing down the possible locations to put a number. Each strategy class can be further differentiated into the type and number of units (i.e. columns, rows, boxes) used.

We can automatically determine for each move which deductive strategy could have been used to derive it. But often several sets of constraints are available to deduce the number for a location. The think aloud protocols help to disambiguate these cases.

The data clearly show that individuals have strong preferences for some strategies over others, but not all in the same preference order. This paints a more complex picture than the analyses done by [1] or [2] who assume an objective difficulty ordering of various strategies.

References

[1] N. Y. L. Lee, G. P. Goodwin, and P. N. Johnson-Laird. The psychological puzzle of Sudoku. *Thinking & Reasoning*, 14(4):342–364, November 2008.

[2] R. Wang, J. Xiang, H. Zhou, Y. Qin, and N. Zhong. Simulating human heuristic problem solving: A study by combining ACT-R and fMRI brain image. In N. Zhong, K. Li, S. Lu, and L. Chen, editors, *Brain Informatics*, pages 64–73. Springer, 2009.