MASTERS OF DEDUCTION
Great Puzzles and Their Creators

by Timothy Boester, Ph.D.

I REMEMBER DRAWING MY FIRST MAZE IN KINDERGARTEN. IN ELEMENTARY SCHOOL, I DISCOVERED LOGIC GRID PUZZLES. AS I GREW UP, I LEARNED HOW TO SOLVE MORE AND MORE CHALLENGING PUZZLES. BUT IT WASN'T UNTIL COLLEGE, WHEN I TOOK MY FIRST PHILOSOPHICAL LOGIC CLASS, THAT I REALLY STARTED TO APPRECIATE LOGIC AS A MATHEMATICAL DISCIPLINE.

I started publishing puzzles in *Imagine* in 1993, but I didn't write a logic puzzle for Knossos Games until 1999. I had created many logic puzzles for myself and friends, but before I ventured to publish one of my own, I spent a long time studying different types of logic puzzles and reading about their creators. Here are some of the most important things I learned.

Down the Rabbit Hole

The mathematical discipline of logic has existed since the time of Aristotle, but logic puzzles are a much more recent phenomenon. The first logic puzzles are attributed to Charles Lutwidge Dodgson—more famously known by his pen name, Lewis Carroll.

Carroll's most famous literary works, *Alice's Adventures in Wonderland* and *Through the Looking-Glass, and What Alice Found There*, while considered fun and fanciful adventure stories, are actually a treatise on the state of mathematics in the mid-19th century. At that time, mathematics was undergoing a major upheaval, with the introduction of imaginary numbers, non-Euclidean geometries, and abstract algebra. Being a classical mathematician, Carroll was deeply perturbed by these developments that flew in the face of Euclidean geometry, and his stories implied that the future of the discipline was as wild and disorderly as Wonderland.

Euclid had constructed the field of geometry by creating axioms (statements given as true) and propositions deduced from those axioms. Carroll's affinity for such a system is seen in his extensive study of syllogisms. Categorical syllogisms follow a format of two premises followed by a conclusion:

> All men are mortal.
> Socrates is a man.
> Therefore Socrates is mortal.
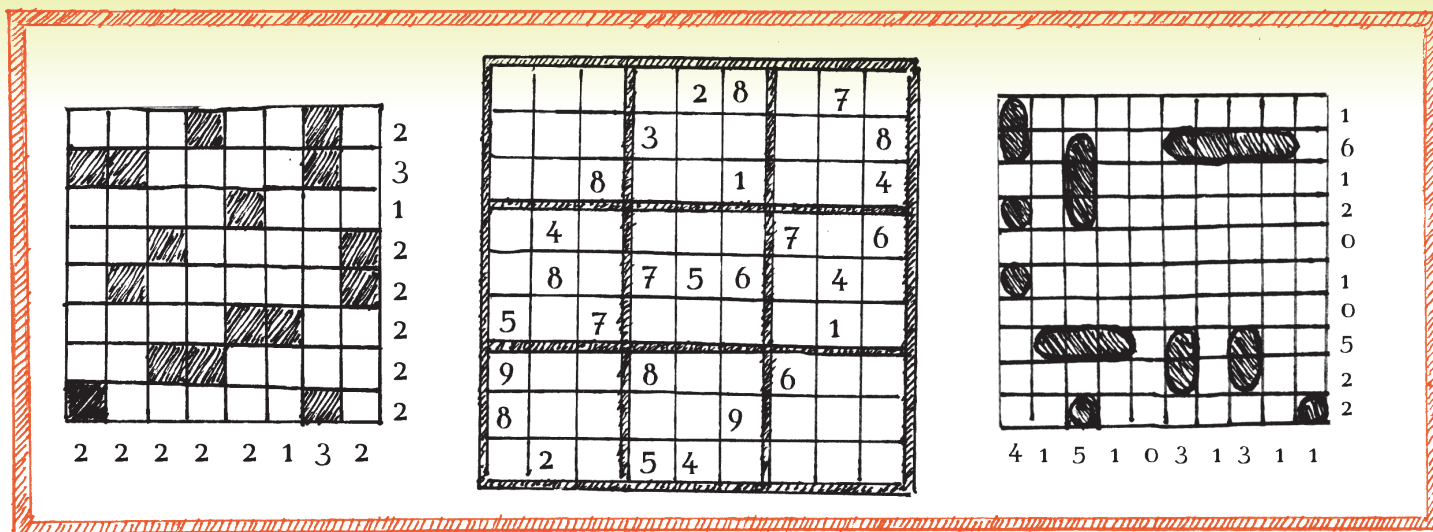
Carroll expanded the basic syllogistic form by introducing extended syllogisms with more than three statements (sometimes *a lot* more than three):

> All humming-birds are richly coloured;
> No large birds live on honey;
> Birds that do not live on honey are dull in colour.
> Therefore, all humming-birds are small.
> —*Symbolic Logic*, by Lewis Carroll

To introduce the logic of syllogisms to children (as a gateway to his beloved field of mathematical logic), he created a graphical system of understanding premises and deducing conclusions that he called the Game of Logic, and published a volume of the same title. To call it a "game" is a bit of a stretch, but Carroll nonetheless generated an extensive collection of syllogisms that brought forth the many forms of logic puzzles we enjoy today.

Studying Carroll's extended syllogisms gave me essential tools for both solving and creating logic puzzles. While none of the logic puzzles I've written for Knossos Games are strictly based on syllogisms, they all use the basic structure of deductive reasoning, and they all depend upon my being able to track the consequences of the clues as I create them. Often, I don't know before I create a puzzle what the solution will be. The solution is generated through trying out clues and combinations of clues, then examining the results. Having an organized, deductive logical system makes that possible.

This Statement is False

Mathematician Raymond Smullyan made major contributions to the field of logic, but he may be best known for his creation of "knights and knaves" puzzles. In these logic puzzles, all knights tell the truth and all knaves lie. Given a set of statements from different people, one can deduce who is telling the truth and who isn't.

> Three suspects in a robbery give the following statements:
>
> Abu: I didn't commit the robbery!
> Ibn: Hasib certainly didn't!
> Hasib: Yes, I did!
>
> Later on, two of them confessed to having lied. Who committed the robbery?*
>
> —adapted from *The Riddle of Scheherazade,* by Raymond Smullyan

Smullyan created numerous variations of these puzzles: true and false signs on rooms, people who lie only at different times of day or on certain days of the week, people who ask only questions whose correct answers are yes and no, and "sane" versus "insane" people (who speak truthfully but switch true and false beliefs). All of these variants (and many more) have different consequences on how you can use the clues or statements to make logical deductions.

I had seen knights and knaves puzzles but was unaware of their history until I wanted to make one of my own. I found Smullyan's work when I decided to write a puzzle based on the questionable honesty of contestants on the reality television show *Survivor*. I already had an idea of adding people who sometimes lie and sometimes tell the truth, because if a person gave multiple clues, you couldn't be sure if the statements would be all true or all false. Of course, Smullyan had previously thought of this.

I also learned that Smullyan is credited with devising the initial version of the so-called "hardest logic puzzle ever," in which you need to determine the appropriate yes or no questions to ask in order to distinguish liars from truth-tellers. Computer and cognitive scientist John McCarthy made the puzzle even

Because the statements by Ibn and Hasib are contradictory, one is lying and one is telling the truth. As there are two liars, Abu must have also lied; thus he committed the robbery.

harder: the truth-tellers and liars respond with yes or no answers in a language you do not understand!

Thinking in Numbers

Not all logic puzzles are word-based, but number-based logic puzzles have become prevalent only recently. Their rise has been helped by the popularity of puzzles in Japan. The Japanese language is made of logographic *kanji*, written characters that represent a word or short phrase. This means that letter-based puzzles, such as crossword puzzles formed with the characters of the Latin alphabet, are basically impossible to construct in Japanese. This led to various forms of logic puzzles based on numbers, the most popular being Sudoku.

Sudoku puzzles, however, did not originate in Japan. The first was titled "Number Place" and published in 1979 in *Dell Pencil Puzzles & Word Games*, an American publication. In 1984, the Japanese company Nikoli began including them in one of their magazines, and called them 数字は独身に限る, (*suji wa dokushin ni kagiru*) which means "the numbers must be single." This was shortened to 数独 (Sudoku), which means "single numbers."

It is difficult and time-consuming to construct a quality Sudoku by hand, so they remained in relative obscurity until Wayne Gould, a retired judge in Hong Kong, created a computer program to generate puzzles. When he eventually convinced *The Times* of London to start printing them in 2004, they were an immediate hit. Several other number-based logic puzzles have also become popular: Ken-Ken, Latin squares with clues consisting of mathematical operations; Nurikabe, grouping cells as diagonally connected islands; and Kakuro, a numerical crossword-style puzzle with sums as clues.

I first saw Sudoku puzzles when they became popular around a decade ago, but my early Knossos Games puzzles were more directly influenced by some of the other number-based logic puzzles that preceded Sudoku's current popularity. For example, my "Rubber Stamp" puzzles were a reinterpretation of Battleship puzzles. Both use a grid with clues around the edges, but instead of placing different length ships, you have a selection of "stamps" whose matrix of shaded squares can be rotated but not inverted.

Studying puzzles by the masters helped me better understand how puzzles work and how they are constructed. If you want to try your hand at creating puzzles, see my book recommendations on this page, and visit my blog for more insights. And be sure to share your puzzles, which is the most rewarding part of the process. ∎

FOR FURTHER EXPLORATION

Books by and about Lewis Carroll

Lewis Carroll in Numberland: His Fantastical Mathematical Logical Life by Robin Wilson (W.W. Norton & Co., 2010).

Symbolic Logic and The Game of Logic, new ed. of 1896 ed., by Lewis Carroll (Dover Publications, 1958).

The Universe in a Handkerchief: Lewis Carroll's Mathematical Recreations, Games, Puzzles, and Word Plays by Martin Gardner (Copernicus, 1998).

Selected Books by Raymond Smullyan

What is the Name of This Book? The Riddle of Dracula and Other Logical Puzzles (Dover Publications, 1978).

The Lady or the Tiger? and Other Logic Puzzles (Random House, 1982).

Satan, Cantor & Infinity: Mind-Boggling Puzzles (Dover Publications, 1992).

The Riddle of Scheherazade and Other Amazing Puzzles (Harcourt, 1997).

King Arthur in Search of His Dog & Other Curious Puzzles (Dover Publications, 2010).

The Gödelian Puzzle Book: Puzzles, Paradoxes & Proofs (Dover Publications, 2013).

Books about Number Puzzles

Before Sudoku: The World of Magic Squares by Seymour S. Block and Santiago A. Tavares (Oxford University Press, 2009).

Japanese Number Puzzles by Anthony Immanuvel (Running Press, 2006).

Taking Sudoku Seriously: The Math Behind the World's Most Popular Pencil Puzzle by Jason Rosenhouse and Laura Taalman (Oxford University Press, 2012).

Teach Yourself Advanced Sudoku and Kakuro by Nick Afka Thomas (McGraw-Hill, 2006).

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