



REPRESENTATION MATTERS

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People are remarkable in all sorts of ways. But our attention and short-term memory are really limited resources. Fortunately, there's hope. The representations provided by language, gestures, drawings, and objects help us communicate and reason. And, importantly for design, different representations can facilitate or hinder different thoughts. The insight of today's lecture is that the ways in which we and the world organize and represent ideas can have a drastic impact on our cognitive abilities, for better and for worse. Things can help us think, and you can leverage this as a designer. Let's start with an example from Don Norman and JiaJie Zhang.

The Oranges Puzzle

goal Order the oranges by size: largest-to-smallest, left-to-right

rule 1 Only one orange can be transferred at a time

rule 2 An orange can only be transferred to a plate on which it will be the largest

rule 3 Only the largest orange on a plate can be transferred to another plate

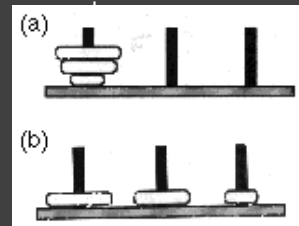
The Bagels Puzzle

goal Order the donuts by size: largest-to-smallest, left-to-right

rule 1 Only one donut can be transferred at a time

rule 2 A donut can only be transferred to a peg on which it will be the largest

rule 3 Only the largest donut on a peg can be transferred to



3

Figure 2.4. Modified Tower of Hanoi puzzles designed by Zhang. Three configurations: rings, oranges and coffee cups. Initial arrangement (a, c, e) and final end state (b, d, f) .

Rule 1: Only one {ring, orange, cup} can be transferred at a time.

Rule 2: A {ring, orange, cup} can only be transferred to a {peg, bowl, plate} on which it will be the largest.

Rule 3: Only the largest {ring, orange, cup} on a {peg, bowl, plate} can be transferred to another {peg, bowl, plate}.

Examining the first puzzle using the rings and pegs, we find that the third rule is redundant for this condition. That is, because the rings are stacked on pegs, the pegs offer physical constraints and force compliance with Rule 3 automatically, assuming the first two rules are followed. So, what happens if we vary the artifacts for the puzzle?

All three puzzles are essentially the same but some are significantly more difficult than others to solve. It was observed that the oranges puzzle took almost 2.5 times as long as the coffee cups puzzle. The oranges puzzle incurred twice as many moves and six times as many errors. These differences are due to the variations in the physical constraints provided in each condition. In the coffee cup condition, Rules 2 and 3 are not necessary since only one cup can fit onto a plate at a given time and the smaller cups cannot be placed on top of larger ones without spilling coffee. These physical constraints and everyday knowledge aid in solving the problem. The oranges puzzle was more difficult because there were no physical constraints to force compliance with the rules.

External representations add power because the physical structures automatically constrain the actions and interpretations, even though all three rules apply to all the puzzles. Someone programming a computer to solve the task would find all three puzzles to be of equal difficulty and would use the same algorithm to solve all of them. This is because the computer would be unable to take advantage of the physical structures. (Norman, p. 89)

Norman further states that "the more information present in the environment, the less information needs to be maintained within the mind (p. 90)." While conducting the study, he claims that many subjects did not realize that the three puzzles were the same problem. The study "serve as powerful demonstrations of how external representations not only aid in memory and computation but can dramatically affect the way a problem is viewed and the ease with which it can be solved. (Norman, p. 90)"

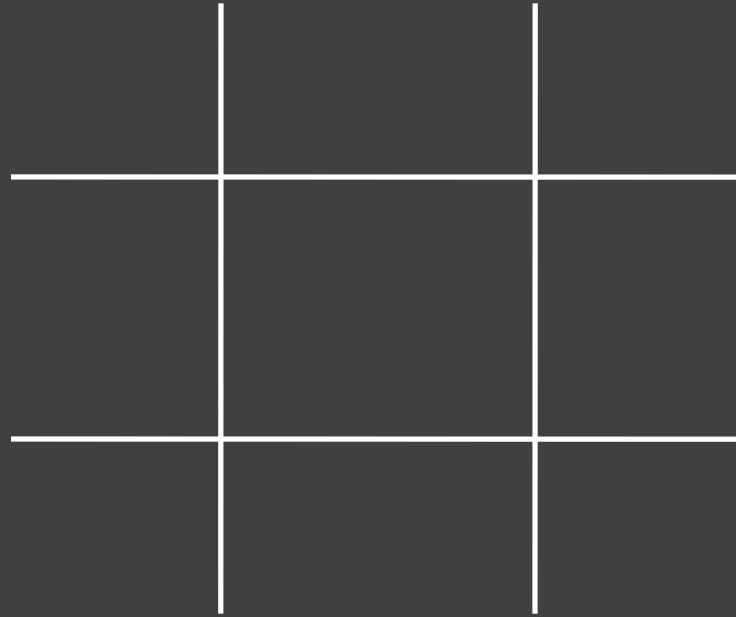
Norman also generalizes these ideas and explains:

The point is that in the real world, the natural laws of physics allow only the appropriate things to happen. There is no need to compute whether you are walking through a wall: You simply can't do it. In the artificial world of computer simulation, much of the computational effort goes into the part that results from the artificiality of the situation. (p. 150)

Let's play a number game!

- Two players
- Think of the numbers 1 to 9
- Players draw alternately, without replacement
- The objective is to make a set of 3 that adds to 15

How 'bout Tic-Tac-Toe?



These Games are Isomorphs

4	9	2
3	5	7
8	1	6

Problem Solving as Representation

“Solving a problem simply means
representing it so as to make the solution
transparent”

—Herbert Simon, *The Sciences of the Artificial*

Working Memory

Getting Things Done

Naturalness Principle

- Experiential cognition is aided when the properties of the **representation** match the properties of the **thing** being represented

Proteus Ingestable Networked Pill



- Sensor and transmitter encapsulates pill
- Stomach acid is part of battery
- Transmits pill
 - > patch
 - > iPhone
 - > Internet

Stanford Academic Calendar 2009-10

An online version of this calendar is available at the University Registrar's web site: http://registrar.stanford.edu/academic_calendar/

AUTUMN QUARTER

AUGUST

- 1 (Sat) Axes opens for course enrollment.
27 (Thu) M.D. students, first day of instruction.

SEPTEMBER

- 11 (Fri, 5:00 p.m.) Course enrollment deadline to receive stipend or refund check on first day of term.
15 (Tue) New undergraduates arrive; Convocation.
21 (Mon) First day of quarter; instruction begins.
21 (Mon, 5:00 p.m.) Preliminary Study List deadline. Students must be "at status"; i.e., students must have a study list with sufficient units to meet requirements for their status, whether full-time, 8-9-10 units (graduate students only), or approved Special Registration Status.
21 (Mon, 5:00 p.m.) Deadline to submit Leave of Absence for full refund. A full refund schedule is available here.
24 (Thu) Conferral of degrees, Summer Quarter.
28 (Mon) Yom Kippur (classes held; some students will be observing Yom Kippur and are not expected to attend classes; some faculty will not be holding classes).

OCTOBER

- 9 (Fri, 5:00 p.m.) Final Study List deadline. Last day to add or drop a class; last day to adjust units on a variable-unit course. Students may withdraw from a course until the Course Withdrawal deadline and a "W" notation will appear on the transcript.

NOVEMBER

- 9 (Mon, 5:00 p.m.) Term withdrawal deadline; last day to submit Leave of Absence to withdraw from the University with a partial refund. A full refund schedule is available here.
13 (Fri, 5:00 p.m.) Change of grading basis deadline.
13 (Fri, 5:00 p.m.) Course withdrawal deadline.
13 (Fri, 5:00 p.m.) Application deadline for Autumn Quarter degree conferral.
23-27 (Mon-Fri) Thanksgiving Recess (no classes).
30-December 6 (Mon-Sun) End-Quarter Period.

DECEMBER

- 4 (Fri) Last day of classes (unless class meets on Sat.)
4 (Fri) Last opportunity to arrange Incomplete in a course, at last class.
4 (Fri, noon) University thesis, D.M.A. final project, or Ph.D. dissertation, last day to submit.
4 (Fri, 5:00 p.m.) Late application deadline for Autumn Quarter degree

SPRING QUARTER

FEBRUARY

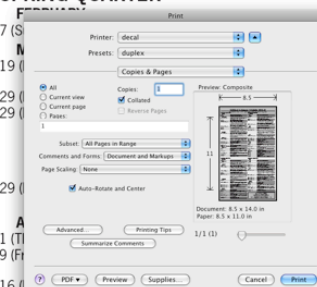
- 7 (Sat) mt.
19 (Mon) receive stipend or refund check on first day of term.
29 (Fri) begins.
29 (Fri) Students must be "at status"; i.e., students must have a study list with sufficient units to meet requirements for their status, whether full-time, 8-9-10 units (graduate students only), or approved Special Registration Status.
29 (Fri) Deadline to submit Leave of Absence for full refund. A full refund schedule is available here.
1 (Thu) Conferral of degrees, Winter Quarter.
9 (Fri) Study List deadline. Last day to add or drop a class; last day to adjust units on a variable-unit course. Students may withdraw from a course until the Course Withdrawal deadline and a "W" notation will appear on the transcript.
16 (Mon) Term withdrawal deadline; last day to submit Leave of Absence to withdraw from the University with a partial refund. A full refund schedule is available here.

MAY

- 12 (Wed, 5:00 p.m.) Change of grading basis deadline.
21 (Fri, 5:00 p.m.) Course withdrawal deadline.
21 (Fri, 5:00 p.m.) End-Quarter Period.
28-June 3 (Fri-Thu) Memorial Day (holiday; no classes).
31 (Mon)

JUNE

- 2 (Wed) Last day of classes.
2 (Wed) Last opportunity to arrange Incomplete in a course, at last class.
2 (Wed, noon) University thesis, D.M.A. final project, or Ph.D. dissertation, last day to submit.
2 (Wed, 5:00 p.m.) Late application deadline for Spring Quarter degree conferral (\$50 fee).
3 (Thu) Day before finals, no classes.
4-9 (Fri-Wed) End-Quarter examinations.
10 (Thu) Grades for graduating students due at noon.
12 (Sat) Session Class Day.



2009-10

http://registrar.stanford.edu/academic_calendar/

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day of quarter; instruction begins.
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