Spit-Not-So
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Many tasks involve the processing of information from different sources. Some information needed resides in the memory of the person. Other information is in physical things: dials, screens even the position of objects. Physical (and similarly virtual) objects act as memory aids. Is that all they do?

Let's look at a simple example: the two player game of Spit-not-so. Take 9 blank cards and write one of the following words on each: spit, not, so, fat, fop, as, if, in, pan. Place them face up between the two players. Each player takes a card at a time. The aim is to be the first to hold any three cards that contain the same letter. For example, if a player manages to take the cards "spit", "so" and "as", then they win as they hold all cards with the letter 's'. Play the game a few times to get the idea. It can be quite difficult for a novice. Is it familiar? I suspect you have played the game many times before, but with the information represented in a different way so that you do not recognize it. See if you can work out which game I am thinking of and why before you read on. If you need a hint think about arranging the cards in a 3 by 3 square.

When two games can be transformed into one another without changing the underlying rules they are known as isomorphs. The task above of devising an isomorph for the game of Spit-Not-So is a task of designing a new interface to the underlying game: one that allows human cognition and perception to act in a way that makes the game easier.

What is Spit-not-so equivalent to? Noughts and crosses. Arrange the cards in a square with cards containing the same letter in a line (row, column or diagonal) and you have the Noughts and Crosses board. One suitable ordering is:

Not	in	pan
So	spit	as
Fop	if	fat

Notice, for example, how all the 's' cards form a line across the middle. To "take" a card leave your mark (a nought or a cross) on the card. Taking three winning cards is the same as making a line. Whereas spotting when the other player is about to get three winning cards is hard, spotting that they are about to get a line of three is much easier. Noughts and crosses is easier than Spit-not-so and yet the only difference is the way information is represented in physical objects: using grids and positions rather than cards and words. This is known as the representational effect: a situation where the formal structure of a task is the same but its difficulty has changed due to differences in the way information is represented.

The representational effect has been investigated in a series of experiments based around puzzles. For example, Zhang and Norman (1994) devised a series of variations for the Tower of Hanoi puzzle to empirically investigate how the split of information between memory and physical objects alter a problem's difficulty. Tower of Hanoi is the puzzle where monks move disks of differing sizes between 3 poles to the end of eternity. Disks can only be moved one at a time, and a larger one cannot be placed on top of a smaller one. They must all be moved from the first pole where they are stacked in order of size to the end pole. In Zhang and Norman's variations, rules of the game (such as "large disks cannot go on top of smaller ones") were either left to the user to remember or enforced by physical constraints. For example, in one variation the disks were replaced by cups of coffee: smaller ones could not physically be placed on top of larger ones without spilling coffee. The number of rules of the puzzle externalized in this way was varied in different versions. They found that the more rules that were externalized the simpler the puzzle. They also found that representing information by spatial (position) properties of objects rather than visual properties (such as colour) made problems easier.

Physical objects do not just act as memory aids. They allow information to be directly perceived without any explicit interpretation being applied. They physically afford or prohibit behaviours and they change the very nature of the task for the user. Noughts and Crosses is not just easier because the square provides memory cues, it is easier because the cognitive processes involved in spotting winning sets has been changed, for example to ones involving direct perception based on location. Take the representational effect into account when designing interfaces and you can actively simplify a task.

Further reading:

1. J Zhang and D. A. Norman (1994) "Representations in distributed cognitive tasks", *Cognitive Science* 18, 87-122.
2. M. Gardner (1978) "Jam, Hot and Other Games", Chapter 16 of Mathematical Carnival, Pelican.