Reasoning Strategies

The current interest in reasoning strategies is based on some general conclusions implicated by research to date:

- People discover new methods and principles as a result of their successes. Failure prevents such discovery.
- Creativity is hindered if the basics of a task have not been mastered.
- Undirected “learning by discovery” is a poor educational strategy when foisted on the less able.
- But giving people external aids to assist their performance simultaneously inhibits discoveries.

How do people make inferences?

When researchers attempt to answer this question, the hypotheses entertained by them depend crucially on their assumptions about the nature of higher cognitive processes.

Traditionally, it has been assumed that there exists a monolithic *fundamental reasoning mechanism*, a device called into play whenever triggered by appropriate material.

The task of the researcher is therefore simply to identify its cognitive processes and specify them via a universal reasoning theory.

Unfortunately, this is complicated by the fact that people are **adept at applying varied methods**, even for solving simple deduction problems.

It is, therefore, necessary to determine whether the observed processes are genuinely fundamental, or have overlaid and obscured those that are more basic.

The study of individual differences in cognition and, in particular, in strategy usage, is not new.

Until recently, studies have tended to be isolated, and there has been little attempt to integrate the findings across domains.

One consequence of this is that there are still disagreements to be resolved, even for such basics as the definition of the word strategy.

People possess a range of strategies.

The existence of individual differences in people's reasoning strategies cannot be denied, and their study is again gaining importance in its own right.

It seems scarcely possible that we could ever claim to have a full understanding of human cognition without taking them into account.

The definition of the word strategy.

In general, there are two categories of definition for the word “strategy”.

Broad definitions assert that any self-contained set of goal-directed procedures constitutes a strategy, as long as these are optional, so that their utilisation by any given person is not guaranteed.

A strategy is any procedure that is non-obligatory and goal directed.

Strategy is a set of cognitive processes which have been shown to be used for solving certain types of deductive reasoning tasks, but for which there is not sufficient evidence to assert that these processes themselves constitute all or part of the fundamental reasoning mechanism (optional processes cannot be asserted to be fundamental in the domain of deduction).

Narrow definitions of the word *strategy* additionally assert that only self-contained sets of procedures that are *not* fundamental processes can be said to be strategies.

Generally, a conscious element to their selection and/or execution is also specified, closely linking this category to the literature on metacognition.

Other optional extras may also be added to the definition. For example, the principle that a strategy should require more effort to implement than a nonstrategy.

A strategy is

- an effortful, deliberately implemented, goal directed process that is potentially available to consciousness.

- a thought processes that are elaborated in time, systematic, goal-directed, and under explicit conscious control.

What are the consequences of these alternative definitional categories?

At first sight, they appear simply to invoke subtle differences in the use of language. Hence, a researcher using a broad definition might investigate *which* strategies are used in particular circumstances, but, with a narrow definition, might investigate *whether* strategies are used in particular circumstances.

Narrow definitions have many difficulties without conferring any particular benefits. They carry the implicit assumption that it is easy to distinguish between fundamental and non-fundamental processes, and this may well not be the case in some domains.

A broad definition is minimally specifying a strategy as any set of self-contained cognitive processes that can be dispensed with in favour of alternatives.

Any narrowing of the definition runs the risk of detracting from what we consider be the major issue: How, and why do people differ?

However, the use of broad definitions has also been criticised, both for going against common-sense notions, and for their redundancy, and so it is necessary to question whether these are serious problems. Taking the commonsense issue first, dictionary definitions of “strategy” tend to emphasise planning rather than procedure (in line with its military origins)

Even with a broad definition, there are still important differences between “strategy” and “procedure/process”.

The broad definition still entails that a strategic set of procedures is optional and that it is self-contained.

Furthermore, use of the term in this way emphasises a position of neutrality, at the very least, concerning whether fundamental processes exist, and their exact nature.

Types of Reasoning Strategy

In order to simplify matters, it will be helpful first to outline a taxonomy.

The basis for this taxonomy is that strategies differ in

- how information is represented and manipulated,
- how widely they may be applied,
- how accurate they are likely to be under ideal conditions (that is, ignoring constraints such as working memory requirements).

The first two types of strategy are both generally applicable:

They have been proposed for a wide range of reasoning tasks, and will give an accurate answer if executed correctly.

T**hey are domain-free:**

The processes operate identically on represented information irrespective of content and context.

Their versatility goes hand in hand with a tendency for inefficiency: They can be demanding and error-prone to execute in many situations.

For spatial strategies, information is represented in arrays akin to mental diagrams, such that the configural information on the representation corresponds to the state of the affairs in the world.

Relationships between objects can be inferred from their relative positions on the representation.

For verbal strategies, information is represented in the form of verbal or abstract propositions, and the application of various content/context-free syntactic rules enables new conclusions to be drawn from the represented information.

For example, it is often proposed that, given the knowledge if A is true, then B will happen, and given that A is true, a modus ponens rule will automatically activate, producing the conclusion that B has happened.

Of more interest to the current discussion are two categories of narrowly applicable strategy which can potentially reduce task demands, but which are usually not universally adopted, and are hence associated with individual differences in strategy usage.

For some reasoning tasks, sometimes only if items are appropriately formatted, certain people utilise task-specific short-cut strategies which can both reduce effort and result in massive gains in performance.

For example, consider the following categorical syllogism:
Some of the artists are not beekeepers.
Some of the chefs are beekeepers.
Therefore, some of the chefs are not artists.
TRUE or FALSE.

However difficult this problem may appear, it is trivially easy if the *two-somes* rule is applied:

If the quantifier *some* appears in each of the first two premises, a syllogism never has a valid conclusion.

As another example, consider the following compass-point directions task problem:

Where would a person end up, relative to the starting point, after taking one step north, one step east, one step north, one step east, one step south, one step west and one step west and one step west?

The modal strategy is to attempt to trace the path, mentally if no external means of representation are available (a spatial strategy).

A generally faster, more accurate and less stressful approach is to use cancellation: Opposite directions cancel, and those that remain constitute the correct answer.

The action of task-specific short-cut strategies may often resemble simple rules, and it is important to emphasise that they are conceptually distinct from verbal strategies.

These rules are only narrowly applicable, are not innate features of cognition and may be learned rapidly.

If a task-specific short-cut is applied beyond its range of applicability, then, technically, it becomes a coping strategy.

For example, consider adding redundant premises to a categorical syllogism:

Some of the artists are not beekeepers.
Some of the beekeepers are not artists.
All of the beekeepers are chefs.
All of the chefs are beekeepers.
Therefore, some of the chefs are not artists.
TRUE or FALSE.

Applying the two-*somes* rule (or the similar two-negatives rule) here is inappropriate; the given answer is correct.

Alternatively, in the right circumstances, coping strategies will give correct answers. It is easy to devise sets of compass-point directions task trials in which the "last-two" strategy always gives the correct answer.

The distinction will be useful for us:

1. people who devise task-specific short cuts are likely to differ in their ability from people who devise coping strategies;

2. people who adopt coping strategies may prevent themselves from discovering task-specific short-cuts.

Why do some people use verbal and others use spatial strategies to make inferences?

Why do only some people use generally applicable strategies, while others use narrowly applicable strategies?

INDIVIDUAL DIFFERENCES IN THE USE OF REASONING STRATEGIES

The phrase, “strategy development”, subsumes several different, potentially separable phenomena.

To begin with, we need to identify mechanisms of *strategy selection*: how do people choose between different options, and how does experience with the use of a strategy affect the likelihood that it will be used in the future?

However, an understanding of this by itself is not enough:

People can only select between strategies which are available to them.

A full account of strategy availability will almost certainly entail an understanding of *strategy discovery*: how do people identify new methods?

In some circumstances, strategy availability may depend upon the correct execution of an evaluation procedure in order to determine whether a newly discovered strategy is valid.

If this is not carried out with precision, the outcome could be an incorrect rejection of a task-specific short cut, so that a strategy is present in the repertoire, but nonetheless is not available.

Alternatively, evaluation errors could result in a person's applying a coping strategy in the mistaken belief that it is highly accurate. In the past, most research has focused on the different aspects of strategy development in isolation from each other, with strategy selection receiving the most attention.

Strategy Selection

The main point of difference for theories of strategy selection concerns the extent to which these processes are sensitive to experience, current task demands and performance.

At one extreme are cognitive style accounts. Choice of strategy is determined by an individual tendency, or preference, to representand/or process information in a particular way.

With the visualiser-verbaliser distinction, some people will have a tendency to form spatial representations of information, while others will tend to form verbal representations

Verbal and spatial strategies did not differ particularly in their effectiveness, and people with high spatial ability tended to use the spatial strategy while people with low spatial ability tended to use the verbal strategy.

Stylistic accounts of strategy selection have widespread intuitive appeal. The phrase “stylistic preference” has connotations of both choice and some degree of flexibility.

One apparent demonstration of cognitive styles in action is where people use a suboptimal strategy which is apparently in line with their style. When people persist with a particular learning strategy even though a task has been structured in order to make it particularly difficult to apply.

If people genuinely have a choice of strategies in such circumstances, their selections have effectively sabotaged their performance.

Alternatively, if a suboptimal strategy is used because no others are available, this lack of choice indicates that no strategy selection procedure has taken place at all, let alone one that is stylistically based.

Where this occurs, we need to understand why people differ in their strategy repertoires. Even where people do appear to show stylistic preferences, these can usually be subsumed under other explanations.

For example, **where strategy usage is directly linked to levels of ability** (as when people with high spatial ability reason spatially while people with low spatial ability reason verbally) **this can simply be seen as an adaptive choice based upon a cost-benefit analysis.**

To understand the **thinking strategy**, you need to perceive them as **models of thinking.**

Why model?

Reason number one: models are everywhere.

Reason number two: the reason models make us clearer, better thinkers. The reason why is that they sort of weed out the logical inconsistencies.

Reason number three: to use and understand data.

Models take that data, right, and sort of structure it into information, and then turn that information into knowledge. And so, without models, all we've just got is a whole bunch of numbers out there. With models, we actually get information and knowledge and eventually maybe even some wisdom.

Reason number four:

to decide, strategize, and design. So, when you've make a decision, whether it's, you know, it's helpful to build or structure that information in a way to make better decisions. Models just make it better at making choices, better at taking actions.

In explicit models, assumptions are laid out in detail, so we can study exactly what they entail.

On these assumptions, this sort of thing happens. When you alter the assumptions that is what happens.

By writing explicit models, you let others replicate your results. Models can be the focal points of teams involving experts from many disciplines.

Another advantage of explicit models is the feasibility of sensitivity analysis.

One can sweep a huge range of parameters over a vast range of possible scenarios to identify the most salient uncertainties, regions of robustness, and important thresholds.

Can You Predict?

Prediction might be a goal, and it might well be feasible, particularly if one admits statistical prediction in which stationary distributions (of wealth or epidemic sizes, for instance) are the regularities of interest.

Sixteen Reasons Other Than Prediction to Build Models

System analysis and decision making

1. Explain (very distinct from predict)
2. Guide data collection
3. Illuminate core dynamics
4. Suggest dynamical analogies
5. Discover new questions
6. Promote a scientific habit of mind
7. Bound (bracket) outcomes to plausible ranges
8. Illuminate core uncertainties.
9. Offer crisis options in near-real time

System analysis and decision making

10. Demonstrate tradeoffs / suggest efficiencies
11. Challenge the robustness of prevailing theory through perturbations
12. Expose prevailing wisdom as incompatible with available data
13. Train practitioners
14. Discipline the policy dialogue
15. Educate the general public
16. Reveal the apparently simple (complex) to be complex (simple)

Explanation Does Not Imply Prediction!

Each time a strategy is used to solve a problem, the experience yields information regarding the strategy, the problem and their interaction.

This information is preserved in a database on each strategy's speed and accuracy for solving problems in general, problems with particular features, and specific problems

Hence, the selection of a strategy is based upon the strength with which it can be associated with success with a particular problem in relation to its competitors.

This model is able to account for why new strategies - whether discovered or taught - are often generalised slowly, even when superior to their competitors.

With little experience, there can be little associated success, so that a well-practised, reasonably successful strategy may, in the short term, be preferred to a little-practised strategy that could boost success.

Strategy Availability

It is difficult to gain a full understanding of strategy selection without knowing the likely strategies that a person will choose between on commencement of a task, and how new strategies may be added while performing it. “Strategy availability” encompasses several different aspects. A person’s strategy repertoire is the sum total of the strategies currently possessed, suitable for applying to the current task. These may be added to with experience at a task as a result of strategy discovery and evaluation. However, not all strategies in the repertoire may be available.

If a person considers a strategy to be inappropriate for a given task, not because it is too difficult to apply, but because it is believed that it will generate incorrect answers for an unacceptably high proportion of trials, then that strategy will not be available for use unless further events cause a modification of this belief.