

An Investigation Into Adaptive Shifting in Knowledge Transfer



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Abstract

Participants were trained on three knowledge types -- exemplars, tactics, and constraints -- and then thought aloud while solving a series of transfer problems. Results show that participants shift between mechanisms of analogy, knowledge compilation, and constraint violation depending on their prior knowledge and the characteristics of the transfer tasks.

Introduction

A central goal of cognitive science is to develop a general theory of transfer to explain how people use and apply their prior knowledge to solve new problems. Previous work has taken a 'divide and conquer' approach to attaining this goal, resulting in the development of several specialized theories of transfer including analogy, knowledge compilation, and constraint violation (see below). Although this research has contributed to our understanding of particular kinds of transfer, it does not address how these transfer processes interact with and relate to one another. The purpose of the current work is to synthesize across three local theories of transfer in an effort to construct a more complete theory that incorporates each mechanism in principled ways.

Mechanisms

Analogy (Gentner, Holyoak, & Kokinov, 2001)

- Process: retrieval, alignment, mapping, and inference.
- Declarative and procedural transfer of **exemplar** knowledge.
 - Transfer to structurally similar problems or situations.
 - Memory access driven by surface feature match.
 - If procedures transfer, solution will be fast.

Knowledge Compilation (Anderson, 1983)

- Process: the deliberate, step-by-step interpretation of a declarative statement. Translates declarative knowledge into procedures and actions that can be used to solve problems.
- Declarative transfer of facts, instructions, or **tactics**.
 - Can be used over a variety of tasks but costly time because the knowledge must be proceduralized.

Constraint Violation (Ohlsson, 1996)

- Process: generate-evaluate-revise transfer cycle in which a learner uses prior knowledge of the domain **constraints** to evaluate and correct her or his task performance.
- Declarative transfer of constraint knowledge.
 - Can be used over a variety of tasks but costly times-errors and is an indirect route to solution.

General Hypotheses

- 1) Multiple mechanisms of knowledge transfer exist.
- 2) The transfer mechanism used depends on a) one's prior knowledge and b) the characteristics of the task environment.

Previous Work: Nokes (2004) found that the mechanism triggered depended on the learner's prior knowledge and the processing demands of the transfer task. However, this between-subjects design did not address how these mechanisms might interact.

Question: are people capable of *adaptive shifting* between *transfer mechanisms* depending on their prior knowledge and the characteristics of the transfer problem?

Adaptive Shifting Hypothesis

- 1) A person will use analogy if the transfer task has surface and deep structure similarity to one's prior exemplar knowledge.
- 2) If the transfer task does not trigger analogical retrieval (i.e., if it has different surface features), a person will then use knowledge compilation of tactics to solve the problem.
- 3) If the transfer task triggers neither exemplar knowledge nor tactics application (i.e., if no surface similarity exists and the tactics are not relevant) people are expected to use constraint violation to solve the problem.

Laboratory Training Study

Purpose: to test the Adaptive Shifting Hypothesis.

Domain: Sequence Extrapolation Problems (Thurstone & Thurstone, 1941).

Procedure:

Acquisition Phase

- Within-subjects design (training, $n = 38$).
- Trained on exemplars, tactics, and constraints (counter-balanced).

Application Phase

- Solved three sequence problems (see below).
- Thought-aloud while problem solving.
- Comparison to no-training control group ($n = 10$).

Training Materials

Exemplar Section

- Solved 4 exemplars problem isomorphs.
- Each problem had similar surface and same deep structure.
- Example 1: L M Z M L Y M N X . . .
- Example 2: E F S F E R F G Q . . .

Tactics Section

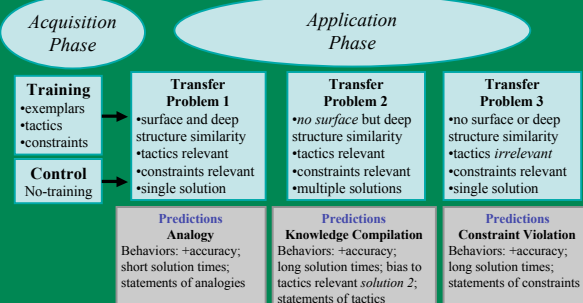
- Read tactics tutorial (learned about pattern relations).
 - E.g., forward, backward, mirror-flip repeat.
- Memorized 5 tactics.
 - Tactic 1: "Look for mirror flips or periods to help break up the pattern into it's parts."
 - Tactic 2: "Letters far apart in the alphabet may signal a mirror-flip alphabet relation."

Constraints Section

- Read constraints tutorial; memorized 4 constraints.
- Constraint 1: "All completed letter strings MUST be divisible into six groups of letters."
- Constraint 2: "The number of letters in each similar group MUST be the same."

Test Materials

Test Problem	Solution(s)	Presentation Format
1: RSFSRESTDTS...	TUBUTA	RSFSRESTDTS... ? □ □ □ □ □ □
2: BCPXYOCDN...	YZMDELZAK (1) WXMDELVWK (2)	
3: BACBEDHG...	LKQP	Finished



Results

Accuracy & Solution Times

Condition	Transfer 1			Transfer 2			Transfer 3		
	M	SE		M	SE		M	SE	
Accuracy									
Training	.86*	(.05)		.85	(.03)		.22*	(.06)	
No-training	.63	(.10)		.84	(.06)		0		
Solution times									
Training	121*	(15)		221	(19)		299	(26)	
No-training	223	(53)		204	(34)		312	(33)	

Percent of Subjects to Use each Solution Type

Condition	Solution Type			
	Solution 1	Solution 2	Other	Unclassified
Training ($n = 36$)	19%	53%	17%	11%
No-Training ($n = 10$)	40%	0%	40%	20%

Verbal Protocol Evidence

Training Problem	Transfer Strategy Number of Subjects Classified		
	Analogy	Tactics	Constraint
Transfer 1	4*	15	7
Transfer 2	1	21*	13
Transfer 3	0	14	17*

Conclusion

The results from this experiment provide converging evidence for the hypothesis that *people shift between multiple mechanisms of transfer depending on their prior knowledge and characteristics of the transfer tasks*. This work takes the first steps towards elucidating how these mechanisms interact, and in determining the conditions under which each mechanism is triggered.

References

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