

12-28-2007

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Michael Ryan Massey

University of Missouri-St. Louis, mrm453@umsl.edu

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Transfer and the Fuzzy-Trace Theory

by

M. Ryan Massey

MA, Education, University of Missouri-St Louis, 2007

BA, Physics and Chemistry, Drury University, 2004

A THESIS

Submitted to the Graduate School of the

UNIVERSITY OF MISSOURI – ST. LOUIS

In Partial Fulfillment of the Requirements for the Degree

MASTER OF ARTS

in

PHILOSOPHY

December, 2007

Advisory Committee

Gualtiero Piccinini, Ph.D.,
Committee Chair

Robert Northcott, Ph.D.

Anna Alexandrova, Ph.D.

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ACKNOWLEDGMENTS

Without the thoughtful insight and direction from Professor Piccinini, this thesis would have instead been a collection of thoughts inside my mind...an exercise in armchair philosophy (psychology).

DEDICATION

To Melissa, with love.

ABSTRACT

Transfer occurs when something is learned under particular circumstances and is applied in a new, somehow different, situation. This paper will argue that fuzzy-trace theory can be used to explain the process of transfer. The advantage of fuzzy-trace theory is found in a dual-process theory of memory. Fuzzy-trace theory explains a broad range of phenomena and has the strength to conquer the elusive problem of transfer.

Trace-cue compatibility theory is a theory of memory retrieval. By combining the trace-cue compatibility theory with fuzzy-trace theory, we get a method for treating both memory storage and memory retrieval. This combination provides a powerful mechanism for understanding the results of classic experiments on transfer.

We can explain transfer in terms of particular forms of memory being cued by an event. In many cases, the cued memory is an analog for the target item. When the target analog has been mapped onto the appropriate memory trace, transfer can occur.

1) Introduction

The main goal of this thesis is to show that fuzzy-trace theory provides a framework for solving the elusive problem of transfer. Transfer occurs when something is learned under particular circumstances and is applied in a new, somehow different, situation. Fuzzy-trace theory is an empirically based psychological theory on human memory and learning. It has been suggested that fuzzy-trace theory can be used to understand transfer.¹ This thesis takes the work done by Wolfe, Reyna, and Brainerd, connects it to other psychological theories, and applies the resulting framework to the problem of transfer. This approach will strengthen the argument that fuzzy-trace theory deserves a place in the mechanism of transfer.

We will combine the trace-cue compatibility theory with fuzzy-trace theory. Trace-cue compatibility theory covers memory retrieval. This combination gives us a method for treating both memory storage and memory retrieval. With help from trace-cue compatibility theory and other research on analogies, fuzzy-trace theory provides a powerful mechanism for understanding the results of classic experiments on transfer.

¹ Wolfe, Christopher R., Valerie F. Reyna, and Charles J. Brainerd. "Fuzzy-Trace Theory: Implications in Teaching and Learning." In Transfer of Learning From a Modern Multidisciplinary Perspective, edited by Jose P. Mestre. Greenwich, CT: Information Age Publishing, 2005.

2) What Is Fuzzy-Trace Theory?

Fuzzy-trace theory is a psychological theory of memory. Specifically, fuzzy-trace theory models the interaction between memory and higher order processes.¹ It makes a number of claims that deviate sharply from traditional models. We will now survey the specific claims made by this theory.

Fuzzy-trace theory claims there are two independently functioning types of memory in the human mind. These are called gist memory and verbatim memory. This position is referred to as dual-process because of the two independent processes for memory. One of the founders of fuzzy-trace theory described memory as being “of two minds - minds that are not well integrated with each other, neither when memories of experience are first stored nor when they are subsequently retrieved.”² Empirical evidence supports the dual-process position and the evidence will reveal itself throughout this document.

Verbatim traces represent the superficial and particular characteristics of an item. Gist traces are representations of logical, linguistic, relational, and meaning-based information.³ Gist memory supports a fuzzy and intuitive form of reasoning. Gist is the basis of pattern recognition. Typically, the formation of generalizations and the ability to recognize similarity require the usage of gist traces. Verbatim memory, on the other

¹ Brainerd, C. J. and V. F. Reyna. “Fuzzy-Trace Theory and False Memory.” Current Directions in Psychological Science 11 (2002), 164.

² Brainerd, C. J. and V. F. Reyna. The Science of False Memory. New York, NY: Oxford University Press (2005), 87.

³ Brainerd and Reyna (2005), 84.

hand, is about details. Verbatim traces are rich in detail and tend to be context-specific. For example, suppose a person sees a computer. Information about the shape, color, and size of the computer would normally be stored in verbatim memory. Information about the general functions of the computer would be stored in gist memory.

One of the most distinctive tenets of this dual-process approach is that both forms of memory are stored in parallel. They are, for the most part, stored simultaneously and processed independently. Gist and verbatim retrieval are dissociated from one another. Verbatim traces are generally used for recall. They store the surface features of a particular item that were directly observed during an event.¹ Gist traces are generally used for reasoning and store interpretations of concepts formed about an event or an item. So while these two types of memory may be stored at the same time, they are typically retrieved separately depending on the task at hand.

Another difference between gist and verbatim traces is their relative stability over time. Verbatim traces are affected by retroactive interference.² Retroactive interference often results in people remembering the details of an event differently than they were at the time the memory was formed (encoded). This results in a faster rate of forgetting. For example, you remember that a person has green eyes. If you subsequently observe several people with blue eyes, the green eye memory could now be stored (incorrectly) as a blue eye memory.

¹ Brainerd and Reyna (2002), 165.

² Brainerd, C. J. and V. F. Reyna. "Memory Independence and Memory Interference in Cognitive Development." *Psychological Review* 100 (1993), 46.

Surface details are typically not maintained in memory for extensive periods of time. Verbatim memory is initially stored more readily because it represents the actual input data of the surface features of an experienced item.¹ Gist memory requires additional processing and is therefore more difficult to store initially.² The advantage to gist lies in being stored as a semantic form of memory.³ Semantic memory refers to meaning content and is maintained for longer periods of time. Thus, there is a trade off between ease of storage and stability of storage. An important consequence of the instability of verbatim memory is that it fades in time.

Gist memory accounts for the strength of human rationality. The word ‘fuzzy’ hints at the detail deficient nature of gist traces. As they age, people use more intuition and less surface detail for problem solving. Children prefer to use quantitative reasoning. Older children and adults prefer a more qualitative method and have a ‘fuzzy-processing preference.’⁴ Fuzzy-processing is a synonym for gist-processing. Despite being more intuitive, adults have greater accuracy in reasoning. Without so many verbatim details filling working memory, adults process information much more efficiently. Difficult solutions to very abstract problems can result from this intuitive processing. Precision

¹ Brainerd, C. J. and L. L. Gordon. “Development of Verbatim and Gist Memory for Numbers.” Developmental Psychology 30 (1994), 166.

² Brainerd and Gordon (1994), 166.

³ Brainerd and Reyna (1993), 46.

⁴ Reyna, V. F. and Susan C. Ellis. “Fuzzy-Trace Theory and Framing Effects in Children’s Risky decision Making.” Psychological Science 5 (1994), 276.

details are needed to solve some problems, but that seems to be the exception. It is the patterns of inputs that are needed for rationality, not their verbatim forms.¹

From here on, we will focus on applications and connections to other theories. Fuzzy-trace theory fits well with other prominent psychological research. The first section connects fuzzy-trace to a theory of memory retrieval. The next section applies fuzzy-trace theory to the problem of transfer. The final section contrasts fuzzy-trace theory with traditional accounts of transfer experiments.

3) Memory Storage And Retrieval

Encoding-retrieval match occurs when a cue is similar to a memory. For example, a piano might remind you of what you know about playing music. The standard encoding-retrieval view would explain this by appealing to the fact that the cue and the memory are very similar.² Although this is a plausible view, it has limitations. The trace-cue compatibility theory places the emphasis elsewhere with better results.

Nairne has argued that memory-cue similarity may correlate with, but does not cause a match. He describes remembering as a discrimination process. The cues in a situation act as criteria for accessing the relevant memory. The primary inhibitory effect is ‘cue overload.’ Cue overload occurs when a cue has been associated with multiple memory traces. When this occurs, the cue is unable to identify the specific trace that is

¹ Brainerd and Gordon, 163.

² Nairne, James S. “The Myth of the Encoding-Retrieval Match.” *Memory* 10 (2002): 389-395.

relevant.¹ A particular cue could be highly similar to a particular memory trace, but if it is associated with many other memories, a match will be difficult. Furthermore, a cue could be dissimilar to a memory but still match if they have been related in some way. Nairne suggests using 'relative match' as opposed to a simple similarity-based match. Relative match is how much a cue uniquely specifies an event.² The cue may or may not be similar to the event that it matches. For example, you see a car and it somehow brings a chimpanzee to mind. This kind of match is certainly possible but it could not be explained based on similarity. The car might uniquely specify the chimp for a reason other than similarity.

Fuzzy-trace theory claims that verbatim and gist memories can be formed in parallel at the same time. The two memory traces will therefore be very similar and a cue could easily match both memories. Yet, verbatim access is favored when retrieval cues match the surface content of a target memory. Gist access is favored when the cue matches the meaning content of a target memory.³ This is where relative match comes in handy. Verbatim representations contain surface content, so they will have the greatest relative match to cues for surface content. Gist representations contain meaning content, so they will have the greatest relative match to cues for meaning content. Being similar to the cue might be related to a particular memory being accessed, but only because having the greatest relative match uniquely specifies the appropriate memory trace.

¹ Nairne (2002), 390.

² Nairne (2002), 392.

³ Brainerd and Reyna (2005), 89.

Nairne conducted an experiment where subjects were provided one unique cue, two unique cues, or one shared and one unique cue for a target.¹ Although adding a second cue increased the similarity between the cue and target, the extra cue actually decreased success rates for recall tasks when it was a shared cue. If the extra cue did not uniquely specify a target, it reduced performance in comparison to a single unique cue. Not surprisingly, subjects given two unique cues performed best on recall tasks. When the similarity between cue and target increases, recall performance tends to also increase. However, the similarity is not causing the improved performance. In some cases, increasing the similarity decreases recall performance. Cues that uniquely specify the correct memory enable correct responses, not the degree of similarity between the cue and trace.²

Trace-cue compatibility is a theory of memory retrieval. Fuzzy-trace is a theory of memory storage and function. Fuzzy-trace research has resulted in some data about cues. These results are supportive of Nairne's account of trace-cue compatibility. When these two theories are combined, we get the backbone of a complete theory of memory storage and retrieval.

It was important to quickly establish the relationship between cues and traces. We will now switch gears to discuss the main topic of this thesis. The paper will now focus on the application of fuzzy-trace theory to the problem of transfer.

¹ Nairne, James S. "The Functionalist Agenda in Memory Research." In Experimental Cognitive Psychology and its Applications, edited by Alice F. Healy. Washington, DC: American Psychological Association (2005), 122.

² Nairne (2005), 122.

4) A Close Look At Transfer

Transfer occurs when a concept or skill is learned in one situation and is then applied to a new, somehow different, situation. If pressed, we could find twenty or so definitions and descriptions of transfer.¹ A successful theory of transfer has been difficult to find but we continue looking because it is an important area of educational psychology. Corporations are interested in training people for work. Schools are interested in teaching students in classrooms. People are expected to take what they learn in seminars or classrooms and apply this knowledge to a variety of situations. Researchers hope to find an underlying mechanism of transfer.

Historically, there have been many takes on transfer. We will look closely at two that stand out. One position claims that transfer is essentially not possible. The other position claims that transfer requires a huge ‘knowledge base.’ After looking at these two possibilities, we will contrast these views with an explanation provided by fuzzy-trace theory. Wolfe, Reyna, and Brainerd have previously applied fuzzy-trace theory to the problem of transfer². We will combine fuzzy-trace theory with the trace-cue compatibility theory. If successful, this approach will give us a better mechanism for understanding transfer. We will use this method for evaluating the traditional theories of transfer.

¹ Haskell, Robert E. Transfer of Learning: Cognition, Instruction, and Reasoning. San Diego, CA: Academic Press (2001), 29-32.

² Wolfe, Reyna, and Brainerd (2005).

4.1) Is Transfer Extremely Limited?

In the introduction to Douglas Detterman's critique of transfer research, he makes a bold claim: "if people seldom transfer skills and if they cannot be taught to transfer, then transfer can have no importance as an explanation of individual differences in everyday behavior."¹ Detterman believes that transfer rarely occurs. His claim goes to the heart of the transfer debate and it should be evaluated. First, seldom transfer is not the same thing as no transfer at all. Secondly, Detterman does not show convincingly that people cannot be taught to transfer. We will call Detterman's position the extremely limited theory (ELT for short) because this theory claims that transfer is extremely limited.

Detterman typically is focused on 'general transfer.' General transfer occurs when a generalized skill or concept is applied across varied situations. This is the strongest form of transfer that researchers take seriously. Historically, there have been numerous studies claiming to demonstrate evidence for general transfer.

Judd showed that subjects could transfer an understanding of refraction to the task of hitting underwater targets. Young boys who were taught the principles of refraction were able to transfer these principles to hitting targets at various depths under water. For a more complete description of this experiment, see section 5.2 of this paper. The

¹ Detterman, Douglas K. "The Case for the Prosecution: Transfer as an Epiphenomenon." In Transfer on Trial: Intelligence, Cognition, and Instruction, edited by Douglas K. Detterman and Robert J. Sternberg. Norwood, NJ: Ablex Publishing Corporation (1993), 4.

important thing here is that the students were told that refraction was applicable to the underwater target task. Detterman dismisses Judd's experiments as demonstrating that subjects can follow instructions.¹ In another case, young children were taught the skill of stacking. They applied this principle to solve several different problems. Detterman sees this as rule induction and not as transfer. However, it isn't clear from his objection that rule induction is unrelated to transfer. Detterman concludes that most transfer studies either explicitly tell the subjects about an analogous solution or use a "trick" to cause them to notice that a solution they already know may apply to the current problem.² ELT's first major conclusion is that people rarely transfer skills or concepts from one situation to another. Therefore, transfer is not a big factor in describing human behavior.

ELT's second major conclusion stems from the claim that transfer is an "epiphenomenon."³ It can be safely assumed that the phenomenon of transfer consists of more basic processes. These underlying processes theoretically represent the direct causal factors in human behavior. In that sense, transfer will not provide any fundamental explanations. The second conclusion avoids the problem of transfer by suggesting we study learning in a more fundamental way. If transfer is merely a byproduct of other processes, Detterman suggests we should focus our attention on these lower level processes.

¹ Detterman, 9.

² Detterman, 13.

³ Detterman, 19.

We could apply this epiphenomenon argument to most of the topics in the field of psychology. This would put us on a continual search for more basic processes. We would eventually discuss neurotransmitters and that conversation would not explain human ability either. For example, Parkinson's disease has been linked to the lack of a specific neurotransmitter (dopamine) in the mid brain.¹ An understanding of the basic processes does not contain all the information about Parkinson's disease. The symptoms of Parkinson's disease are an effect of the deficiency of dopamine in certain processes in the brain. The symptoms are nevertheless important to understand for the sake of diagnosing the condition. The higher order symptoms should be studied along with the fundamental processes.

Returning to transfer, the epiphenomenon argument does not settle the issue at hand. If the process of transfer consists of more basic processes, we can't be certain there are no important details at other levels of description. Furthermore, while it is plausible that psychological theories might contain ever more fundamental explanations leading down to the physics of psychology, we cannot be certain of this. If we are uncertain that psychology can be reduced in this way, we should not expect our psychological theories to reduce. Jerry Fodor has argued we can use science to study the world without appealing to fundamental laws.² By demanding that our theories contain fundamental

¹ Restak, Richard. Brainscapes. New York, NY: Hyperion (1995), 53.

² Fodor, Jerry. "Special Sciences, or The Disunity of Science as a Working Hypothesis." Synthese 28 (1974), 77-115.

explanations, we could exclude the very thing we are trying to explain. So let's return to ELT's claim that transfer is not important in human behavior.

If people can transfer a skill or concept to a new situation by simply instructing them to do so, this supports the view that transfer is teachable and suggests that transfer could be common. By telling subjects that previously learned concepts are applicable to a new situation, they were given a cue to consider certain concepts stored in memory. To understand any new pattern, problem, analogy, metaphor, relation, or inference, we would always expect people to have some sort of cue to recall prior memories. Whether this cue originates in the subject, the experimenter, or the external environment is of little consequence to the process of transfer. The content of the cue is important, not the origin. We should not expect people to spontaneously transfer concepts any more than we should expect them to self-generate cues for the retrieval of memory representations perfectly suited to the task at hand. So let's proceed with the assumption that people might be good at transfer when provided the correct memory cues.

For memory retrieval, experienced items are better retrieval cues for verbatim traces than non-experienced items. Non-experienced items that comprise the meaning content of an experience are better retrieval cues for gist traces.¹ Transfer falls under the second category. The skill of transfer does not involve experiencing the same item we have seen before and remembering something about it. Transfer involves experiencing something new that has an analogous meaning to an event we have experienced before.

¹ Brainerd and Reyna (2002), 165.

When subjects are told to apply a previously learned skill to a new situation, this does not cue the retrieval of verbatim memory. Instructions to apply prior knowledge to a new situation will cue gist memory. Gist memory alone can provide the underlying meaning needed for transfer. Without clear retrieval cues, the subjects could have retrieved unhelpful verbatim traces or have been confused by the dissimilar surface features between the prior and current situations. For example, a stool looks and feels differently than a couch, but they are both used for sitting. A person who has never seen a couch might not know its purpose. If someone tells them to apply what they know about stools to the couch, they might see the underlying analogy. It would be difficult to achieve this based on comparing the surface details of the two seats.

ELT has not made a strong case against transfer. Fuzzy-trace theory has shown some promise for explaining when and why transfer is possible. Before going further with this approach, we will consider the work of Haskell and his view of transfer.

4.2) Does Transfer Require a Huge Knowledge Base?

Robert Haskell claims, “the essential problem in transfer is when and how something is perceived as being the same as or equivalent to something else.”¹ He believes the solution to this problem lies in having a huge knowledge base. Knowledge base is defined by Haskell as the quantity and organization of the knowledge possessed by a person. Knowledge is acquired in many ways such as reading, experience, listening,

¹ Haskell, 26.

observing, and thinking. Haskell claims that a large knowledge base is “the absolute requirement not only for transfer but for thinking and reasoning.”¹ For example, expert chess players don’t have superior brains; they simply know more about chess. Since knowledge is stored in memory, we can assume that Haskell is suggesting that people need a huge number of memories, organized in the right way, to support transfer of skill. From here on, I will refer to this as the HKB argument.

The HKB position further contends a large knowledge base also improves our pattern recognition ability.² To notice a regularity between two situations, people require a large number of organized memories. The more memory we have about various situations, the more likely we are to notice similarities between them.

The next big claim of the HKB argument concerns the storage of memory. The claim is that people with a large knowledge base retrieve memories and transfer knowledge better than people with less knowledge.³ The knowledge base results in superior memory function, not the other way around. Once again, Haskell supports this claim by pointing out that chess experts have no better memory ability than chess novices; they simply know more about chess.

In summary, the HKB argument suggests that a large knowledge base will result in (1) an increased ability to perceive analogies, (2) superior memory encoding and retrieval, and (3) the ability to transfer as a result of (1) and (2).

¹ Haskell, 96.

² Haskell, 108.

³ Haskell, 109.

To evaluate claim (1), we need a theory of analogies. Fortunately, a clear and general explanation of analogies already exists. A relevant analog must be retrieved from memory. This analog must be compared to the target and similarities must be identified. This process is known as ‘mapping.’ The target is mapped onto a familiar analog. This allows analogical inferences to be made about the target and often results in new knowledge.¹

Thus, it is not a large number of memories that is needed, but relevant memories. It is very plausible that a large number of memories will increase the chances that a person will have the relevant memories for a particular analogy. This new claim would need to be empirically tested. Nevertheless, HKB seems compatible with the findings from analogy research.

Claim 2 is not supported by fuzzy-trace theory. This research has shown that precise memories do not correlate with accurate reasoning.² Even if a large knowledge base results in superior encoding, this does not provide a mechanism for transfer. Precise encoding is not needed for gist reasoning and is therefore not needed for transfer. A large knowledge base full of detail rich memories could actually hurt reasoning. Memory-to-reasoning interference occurs when surface features cue verbatim memories in a situation where gist memory is needed. Interference affects children more frequently than adults. When children are provided the background inputs for a reasoning problem, they have a

¹ Gentner, Dedre and Keith J. Holyoak. “Reasoning and Learning by Analogy.” *American Psychologist* 52 (1997), 33.

² Reyna, V. F. and Barbara Kiernan. “Children’s Memory and Metaphorical Interpretation.” *Metaphor and Symbolic Activity* 10 (1995), 314.

tendency to only consider how the inputs bear on solving the problem. This inhibits their abilities when the problem involves transfer because background inputs do not contain inferences. Without further cues, this results in low performance.³ The following paragraph will explain this in more detail.

Transfer is a reasoning task. Research has shown that reasoning ability is largely independent of storing a great deal of memory.² In one experiment, children were told a short story about the number of various animals a farmer owns.³ Remembering the actual numerical values was not correlated with being able to correctly answer reasoning questions. Suppose the children were told “Farmer Brown has 2 pigs, 3 ducks, and 4 chickens.” When later asked if there are more pigs or chickens, the correctness of their response was independent of whether the children could remember how many of each animal there are. The child may have inferred something relational about these background inputs and stored this in gist memory. Thus, reasoning tasks only require a relatively small amount of gist knowledge. Correctly answering reasoning questions does not rely on the encoding of precise verbatim memory.

Accurate reasoning does not require the storage of huge amounts of knowledge. HKB could be reformulated to suggest that people with a large number of gist memories are good at a broad number of reasoning tasks. However, it is not the large amount of

¹ Brainerd and Reyna (1993), 52.

² Reyna, V. F. “How People Make Decisions that Involve Risk: A Dual-Processes Approach.” Current Directions in Psychological Science 13 (2004), 62.

³ Brainerd and Gordon, 171.

knowledge that is needed. Transferring a skill requires a limited number of gist memories well suited for that particular task. The amount of other memories is irrelevant to a particular transfer task and in some cases could hurt transfer by causing interference. HKB would need to show that having a large knowledge base results in having relevant gist memories for transfer and that these effects are not negated by interference. An alternate possibility is that as we age, people acquire a larger knowledge base and more gist memories for reasoning/transfer. Gist memory would be correlated with a large knowledge base, but not be caused by it.

Fuzzy-trace theory suggests that gist memory for reasoning can exist independently of the knowledge base size. Of course, adding these gist traces will increase the knowledge base to some extent. The point here is that a large knowledge base will do nothing for your ability to transfer unless it contains useful gist memory. It is the gist memory that explains transfer, not the large knowledge base.

4.3) Fuzzy-Trace Theory's Take on Transfer

The key to transfer is not getting distracted by simple surface details of the problem. To apply the same lesson across multiple problems, people must compare underlying similarity.¹ This takes place using gist reasoning.

¹ Wolfe, Christopher R., Valerie F. Reyna, and Charles J. Brainerd. "Fuzzy-Trace Theory: Implications in Teaching and Learning." In Transfer of Learning From a Modern Multidisciplinary Perspective, edited by Jose P. Mestre. Greenwich, CT: Information Age Publishing (2005), 59.

Contrary to Detterman's claim, we can teach people to transfer. In order to teach transfer, teachers must emphasize gist reasoning and find ways to cue gist memories under appropriate conditions. Experiments have supported the views of fuzzy-trace theory. For example, consider a study on learning geologic time scales.¹ Participants were split into groups. One group was asked to study geologic time lines using a rote memory strategy. Another group was asked to generate analogies for the time line. This could play out in many different ways. For example, when magma cools it becomes rock. Analogously, when water cools it becomes ice. A student could use this analogy to remember that magma was present on the surface of the Earth before the current state of rock. The analogy group was better at placing the events on a time line. The rote memory group was more accurate in matching an age to a given event. This study provided evidence that rote memory improves verbatim memory and that analogical reasoning improves gist memory. Increases in one did not correlate with increases in the other. Gist and verbatim traces are independent. Subjects that were good at the time line task were typically not good at the recall task and vice versa.

In light of the preceding sections, we may conclude that transfer depends on how well we learn gist and how well it is cued. Gist is needed for transfer because it enables us to see the underlying similarity between contexts in spite of dissimilar surface features.² Surface features can confuse a person or cue unhelpful verbatim

¹ Wolfe, 65.

² Wolfe, 83.

representations. Under these conditions, transfer will not be possible. If, on the other hand, a person has been trained to link surface cues to the appropriate gist memories, transfer will be possible.

The previous section has dealt with contemporary theories used to explain transfer. We will now look at more traditional views.

5) A Fuzzy Take on Two Classic Experiments

Many classic experiments on learning have been analyzed in terms of the abstractness or concreteness of the knowledge. Edward Thorndike claimed that two situations must have concrete identical elements between them for transfer to occur. Charles Judd claimed that people can transfer on the basis of abstract generalizations. In this section, we will look at the traditional understanding of these experiments and try to shed new light with fuzzy-trace theory.

5.1) Rethinking Identical Elements

Edward Thorndike conducted a long series of psychology experiments in the early twentieth century. In one example, subjects were asked to estimate the area of various rectangles. The subjects were taught to do this by using comparison rectangles with given areas. Even with over 1,000 trials of training, errors remained very high. After some increases in skill with rectangles, subjects were unable to transfer this ability to estimate the area of other shapes like circles or triangles. Thorndike found “no

relationship between how well subjects did on one square and how well they did on the next.”¹

Thorndike’s conclusion is simple. Transfer is very difficult to achieve. These experiments supported the conclusion that transfer requires a set of ‘concrete identical elements’ between two situations or events.² Simply put, for someone to learn something in one situation and apply it to a new situation, there must be at least some part or parts of the new situation that exactly replicate the initial conditions. In 1901 terms, when a person is stimulated by an identical concrete element, they respond by applying a learned skill.

There are reasons to look elsewhere for a theory of transfer. These concrete identical elements do not seem to capture all transfer events. For example, learning mathematics and applying it to science. It isn’t clear how Thorndike would explain this. Furthermore, in his rectangle experiment, there were concrete identical elements between the rectangles and subjects still failed to transfer. Thorndike’s results demonstrate something about human learning, but not how people succeed at transfer.

The fuzzy-trace theory tells a different story. Repeating the same training trial over and over is a rote memory strategy. Contemporary evidence suggests rote memorization results in strong verbatim representations. Just as importantly, rote memorization also leads to weaker gist representations.³ Verbatim traces are cued by

¹ Detterman, 6.

² Haskell, 80.

³ Wolfe, 80.

surface content while gist traces are cued by meaning content.¹ As previously noted, analogical reasoning requires gist memory. To transfer a skill, an analog from memory must be mapped to the transfer target.²

Thorndike trained his subjects in a way that developed strong verbatim representations. These representations are great when you are trying to remember very specific information in a context-specific way. However, the training inhibited the subjects from forming gist representations. Rote memory did not allow subjects to form the kind of analogies needed for gist memory. When properly cued, these memories could have helped the subjects notice the analogy between the shapes they learned and the areas they were asked to estimate. Thorndike chose to focus on the concrete features of the learning conditions and the transfer conditions. He noticed that his subjects were not using any abstract reasoning and their only successes occurred by using concrete representations. Fuzzy-trace theory can explain why subjects typically failed to transfer and it makes a prediction.

If the participants were taught analogies relating the two situations and were cued to use those analogies, they would have succeeded. Specifically, if participants were cued to use the rectangle area memories that are also relevant to finding circle areas, they would have been demonstrating transfer. Analogies help people notice when one

¹ Brainerd and Reyna (2005), 89.

² Wolfe, 66.

memory is useful in more than one application. Verbatim traces inhibit this process by obscuring the bigger picture.

5.2) Rethinking Abstract Generalizations

In 1908, Charles Judd provided an experiment, that seriously challenged Thorndike's theory. The results suggest that transfer can occur by way of an underlying abstract general principle.¹ Judd asked young boys to throw darts at underwater targets. He then split them into two groups and they performed indistinguishably during the first trial. Initially, the targets were twelve inches under water. One group was provided additional training. They were told how light is refracted by water and that this information might be useful for hitting targets.² When the depth was changed to four inches and later to eight inches, the refraction group quickly adjusted. By understanding refraction, these boys were able to perform effectively in a new situation.³ The control group learned by practice only. The boys without an understanding of refraction struggled anew each time the depth changed.

Judd concluded that the group with refraction training was able to generalize a principle and apply it to a new situation. Simply put, these boys used an abstract understanding to solve a problem. Framed in this way, the conclusion raises many

¹ Haskell, 36.

² Greeno, James G., Joyce L. Moore, and David R. Smith. "Transfer of Situated Learning." In Transfer on Trial: Intelligence, Cognition, and Instruction, edited by Douglas K. Detterman and Robert J. Sternberg. Norwood, NJ: Ablex Publishing Corporation (1993), 110.

³ Singly, Mark and John Anderson. The Transfer of Cognitive Skill. Cambridge: Harvard University Press (1989), 9.

questions and is controversial. Just as Thorndike compared two situations based on concrete elements, Judd compared two situations on the basis of underlying abstract similarity. Thorndike's view is that if there are enough concrete similarities, transfer of skill can occur. Judd's view is that if there are enough abstract similarities, transfer of skill can occur. This has caused a long-standing and seemingly irresolvable debate. How similar do the situations need to be? Is abstract transfer different than concrete transfer? Do people actually use both types of understandings to solve problems? Is one more important in problem solving? Did Thorndike actually show that transfer is limited? Did Judd actually show that transfer is possible? And so on.

Just as fuzzy-trace theory gave us a clearer picture of Thorndike's research, it can also help us with Judd. For the boys hitting targets under water, it might not have been obvious to them that a lesson on refraction had anything to do with their task. At first glance, light bending in water and darts moving through water to hit a target may seem unrelated. However, the boys were able to apply what they had learned to the problem.

Both groups discovered that hitting targets underwater is challenging. Only the group with an understanding of refraction understood why it is challenging. Based on their training, the boys learned the underlying meaning of the problem and they were encouraged to notice the relationship between refraction and target-hitting problems involving various depths of water. This is an example where "intuitive, fuzzy, gist-based thinking facilitates bridging across contexts that differ in verbatim detail."¹ The boys

¹ Wolfe, 83.

were trained in a way that created gist representations in memory. In order to cue these representations, the boys were told that they would be useful to the problem of hitting under water targets. The boys formed gist representations, they were properly cued, and they used gist reasoning to solve a problem by connecting two seemingly unrelated concepts.

5.3) Concluding Remarks

Fuzzy-trace theory has given us something new to think about. Analyzing the concrete elements did not provide a complete picture of transfer. Judd's abstract generalizations did not provide a mechanism in support of his theory. Fuzzy-trace theory gives us a plausible mechanism that explains the results of these classic transfer experiments

6) General Conclusions

Fuzzy-trace theory explains a broad range of phenomena. It has the strength to conquer the elusive problem of transfer and provides a mechanism for understanding some classic experiments in psychology. Its strength is found in a dual-process theory of memory. Gist and verbatim traces provide a critical element for understanding human rationality. We can understand transfer in terms of gist and verbatim traces being cued by an event. In many cases, the cued memory is an analog for the target item. When the target analog has been mapped onto the appropriate gist or verbatim trace, transfer can occur.

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