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## COGNITIVE SCIENCE & NEUROSCIENCE | NEW PERSPECTIVE

# Defining far transfer via thematic similarity

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**Abstract:** One of the most valuable functions of philosophy within the cognitive sciences and education is to help clarify important concepts, and the transfer of learning—particularly far transfer—is one such concept needing extra clarification. This is for two reasons. First, determining the psychological distance of transfer is a subjective matter depending on how similar the base and target are proposed to be which makes labeling instances of far transfer difficult. Second, current theoretical mechanisms of transfer, based on analogical reasoning structure mapping theories, struggle to explain instances of far transfer because of their commitment to structural similarity. This paper addresses these two issues by proposing an additional level of similarity—called thematic similarity—that people may use when engaging in transfer. Based on the philosophical ideas of Stephen Pepper and Gerald Holton, similarity at the thematic level is distinguished from other previously theorized levels of similarity in that it is prefigurative rather than structural. Furthermore, transfer is defined as near or far depending on the type of similarity that is involved in the transfer process rather than according to the total amount of similarity between the target and base. The paper concludes with a discussion regarding the empirical testability of these ideas.

**Subjects:** Philosophy of Psychology; Learning; Thinking, Reasoning & Problem Solving; Cognitive Science; Educational Psychology

**Keywords:** transfer of learning; far transfer; similarity; analogical reasoning; epistemic beliefs



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### PUBLIC INTEREST STATEMENT

Psychologists and Educators are both interested in a topic called *the transfer of learning*. Essentially, transfer of learning is what happens when the mind makes a connection to a new topic that is different in some way from what is currently being learned or used. Sometimes, transfer is fairly basic, like noticing that a glove is like a shoe for hands, or using a butter knife as a screwdriver. Other times, however, transfer may lead to very distant connections, like using poetry to help invent a new tool or finding similarities between texts about history and science. Psychologists and educators call this trickier type of transfer *far transfer* and it is typically harder to explain how this kind of transfer happens. This paper highlights some of the trickier characteristics of far transfer and then suggests a new way to think about how far transfer might happen in the mind.

## 1. Introduction

Students are very familiar with taking subjects that differ widely one hour after the next. Taking mathematics and science courses side by side with language, history, music, and the arts is a common experience. It therefore seems plausible that what a student learns in one course should have the potential to affect what and how she learns in another course. Using mathematics in the sciences and the skills of writing and reading are two obvious instances where one discipline affects learning in another discipline, but what about less obvious examples? Can the content in a history class affect learning grammar, or can physics influence learning in the humanities? These kinds of connections seem harder to find amongst students, let alone the general population, but they do occur occasionally. Consider three real-life examples observed by the author:

- (1) A middle school earth science teacher is giving a lecture about tornadoes when a student raises her hand and excitedly tries to explain to the teacher and the class how her understanding of tornadoes relates to what she learned in her previous English class about verb formations. The teacher, not really grasping the sincerity of the student, is puzzled about how to respond. Two students on the other side of the classroom, previously unengaged in the lesson, say nearly simultaneously out loud, “What is she talking about?”
- (2) A university art history professor assigns to her undergraduate students weekly “reflections” essays on the relevance of various pieces of baroque artwork. One student turns in an essay explaining how the different styles of two artists, Carravagio and Bernini, made him think more deeply about the strengths and weaknesses of differing management styles he was learning about in a business ethics course.
- (3) A high school economics class is having small group discussions about the 2008 financial crisis and a student starts to explain to his group how the crisis is like the creation of the atom bomb. The teacher, listening in on the conversation, jokingly says, “You mean how the crisis was like an explosion?” The student explains that he was actually thinking more about what he was learning in his history class regarding the formation of the Manhattan Project assigned to create the weapon and the subsequent political problems it created after the war.

The area of research in cognitive science and educational psychology that tries to understand the ability of students to apply what is learned across contexts is called the transfer of learning—often written in short as just “transfer”. One way that transfer of learning has been historically differentiated is via the distance of transfer. That is, distance in transfer denotes the relative degree of similarity between what is being transferred from (often called the base) and what is being transferred to (often called the target). Thus, *near* transfer occurs when there is a high degree of similarity between the target and base and *far* transfer is when there is a minimal amount of similarity between target and base. Unfortunately, using similarity as a method for evaluating psychological phenomena can be subjective (Koedinger, Roll, & Holyoak et al., 2012; Martin & Schwartz, 2013; Medin, Goldstone, & Gentner, 1993) and measuring distance in transfer has inherited the same issues (Barnett & Ceci, 2002; Forsyth, 2012). For example in the first case above, one student saw multiple similarities between grammar and weather patterns whereas the teacher and at least two other students had difficulty seeing any similarity.

There is a lot of available research on transfer in general (cf. Engle, 2012; Lobato, 2006). However, the subset of articles dedicated specifically to far transfer is much smaller (Barnett & Ceci, 2002). This is likely due in part to the fact that far transfer occurs less frequently than near transfer and because it has been difficult to observe in controlled experimental settings (Jaeggi, Buschkuhl, & Shah et al., 2014; Schoenfeld, 1999). This has led some researchers to either downplay students’ capacity to transfer or its usefulness for understanding how people learn (Detterman, 1993; Hammer, Elby, & Scherr, 2005). Other reasons given for why far transfer is often less studied are that the methods used to study transfer have not been adequate enough to measure it (Bransford & Schwartz, 1999; Klahr & Chen, 2011; Lobato, 2006)

or that the concept of transfer has become so unwieldy that researchers talk at cross purposes when discussing their findings and therefore have not been able to make adequate progress toward explaining the more difficult process of far transfer (Barnett & Ceci, 2002; Larsen-Freeman, 2013).

The three anecdotes at the beginning of this paper were chosen not only because they are examples of far transfer but also because they are atypical cases of transfer. Students typically engage in nearer forms of transfer. However, the atypicality of far transfer does not imply its uselessness. In fact, far transfer is interesting especially because it is so atypical in cognition. Instances of far transfer may be able to reveal not only information about how transfer works, but also about other fundamental topics in cognition and education like memory, metacognition, epistemic reasoning, instructional design, conceptual change, assessment, and classroom environments. It is for these reasons that research on how and when far transfer happens needs to remain an important topic in cognitive and educational research.

## **2. Structure-based mechanisms of transfer from the cognitive sciences**

A rich foundation for describing the mechanism behind the transfer of learning in general is the idea of structure mapping (Gentner, 1983; Gentner, Loewenstein, & Thompson, 2003; Wolff & Gentner, 2011) and other “structure” related theories of analogical reasoning (cf., Chi & VanLehn, 2012; Reed, 2012; Vendetti, Wu, & Holyoak, 2014). These theories explain that transfer is based on humans’ ability to evaluate the structural similarities between two or more objects or concepts. Moreover, these researchers have shown that there is a hierarchy of levels of similarity that, if properly identified, can aid in the transfer process. The first and simplest level of similarity is between perceptual surface features called “surface similarity”. For example a surface similarity between a bike and a car is that they both have wheels. The next order of similarity, which Gentner and colleagues call “relations”, are more conceptual and often describe a process or function. For example, a relation between a bike and car is that they are both a means of transportation. In other words, they both “go.” A third and final higher level of similarity, called “higher-order relations”, is when similarity occurs as a relation between relations. Using the bike to car analogy one last time one higher-order relation could be that both bikes and cars use gears to make them go.

A key point in the theories that use structure mapping as a mechanism for transfer has been to show that higher-order relations of similarity can help to monitor, constrain, and even induce lower order relations through a principle called systematicity. Systematicity is defined as the degree of interconnectivity between various levels of relations where higher-order relations constrain lower order relations due to the inherent structure of the problem. Furthermore, different kinds of connections afford different amounts of systematicity. For example, returning once more to the bike and car analogy, the connection that both use gears to make them go has a high level of systematicity because that connection suggests a host of other transportation type connections and invites the person making the analogy to develop further relations of similarity about the gear system. On the other hand, consider the connection that both a car and bike are typically used outside. Although the connection is valid, it affords fewer opportunities for additional relations than a transportation analogy and therefore has a low systematicity. Although the two examples have different overall levels of systematicity, both have a constraining influence on further analogizing. A focus on transportation means the analogizer will look for other transportation-like relations, and a focus on where bikes and cars are used will likely mask some other transportation-like connections.

Individuals prefer analogies with a high degree of systematicity over ones with low amounts of systematicity (Gentner, Anggoro, & Klibanoff, 2011). This means that in analogical reasoning and the transfer of learning, highly structured problems should not only be easier to solve, but they are also sought after when looking for solutions. Additionally, potentially useful, albeit limited, connections that have low levels of systematicity are more likely to be overlooked when analogizing.

### 3. Far transfer: a weakness of structure mapping theories

Educators should be encouraged by structure mapping theories of transfer because it means that analogies in instruction can have a very powerful effect on learning when they are carefully planned, well-structured and attempt to include higher-order relations. Furthermore, transfer problems that have a high level of distance do not have to be harder to solve than near transfer problems provided there are many identifiable relations of similarity. Unfortunately, transfer problems where the structure of the target and base are well understood by the one engaging in transfer are hardly the kinds of problems that need to be better understood. Transfer becomes interesting when there is less structure to rely on and yet transfer still occurs. In the case of the student, it is taking what was barely learned the day before and applying it to the meager amount of instruction they are presently receiving. For the cutting edge researcher, it is taking a highly structured understanding and constantly pushing the boundaries of that structure. Seldom does the industrious student or expert professional have the luxury of transferring between two well-structured problems when it comes to building knowledge. There are certainly cases where the use of systematicity within a highly structured domain is important to learning. For example, students likely engage in this kind of transfer when they revisit previously learned material. Equivalently, professionals use this kind of transfer when making decisions in an established paradigm. However, the kind of transfer that can explain how people improve their current understanding when structural similarity is scarce—the kind of transfer that gets labeled as “far”—seems to require a revision to the structure mapping mechanism.

### 4. Redefining far transfer via thematic similarity

What is the mechanism for transfer when the structure of a problem is perceived to be poor or simply unknown to the problem solver? As a potential answer to this question, this paper proposes two changes to the current structure mapping based theories of transfer. First, a new level of similarity, which I call thematic similarity, is added as a new level of similarity whereby individuals can engage in transfer—especially when structural similarity like surface features, relations and higher-order relations are not optimal. Furthermore, rather than acting as a structural type of similarity, thematic similarity is characterized as a type of “prefigurative” similarity which has been described by scholars like Spiro, Feltovich, and Coulson (1996), White (1973) and Forsyth (2012, 2016)). The second proposed change is that the definition of near and far transfer should be constrained to correspond to the presence of different levels of similarity. As shown in Table 1, the nearest transfer is defined to occur in instances where only surface feature similarity is used for transfer. Further transfer occurs when relational and higher-order relations of similarity are present. Finally, the label of “far transfer” is applied when thematic similarity is present when engaging in transfer. Since most cases of transfer involve using multiple levels of similarity, transfer distance is evaluated only by the highest level of similarity present. By determining transfer distance via the highest type of similarity used rather than the total amount of similarity, researchers should be able to make operationally definitive judgments of transfer distance. Determining distance via levels of similarity should be an improvement over judging distance of transfer based on total amount of similarity present.

Before describing in more detail what is meant by the terms thematic and prefigurative similarity, it is important to note that far transfer via thematic similarity does not dismiss the

Table 1. Four levels of similarity		
<b>Level of similarity</b>	<b>Type of similarity</b>	<b>Distance of transfer</b>
Surface	Structural	Near
Relations		↓
Higher-order relations		Far
Thematic	Prefigurative	

power of transfer via structure mapping. Indeed, structure mapping is a powerful tool for understanding how transfer occurs under many learning situations. The revisions proposed in this paper are simply meant to extend the explanation of how transfer occurs when the power of structure mapping is weakened due to a lack of structure or in cases where structure inhibits transfer. Despite cases where structure can actually hurt positive transfer (e.g., Bassok and Holyoak, 1989; Kaminski & Sloutsky, 2013; Schwartz, Chase, & Bransford, 2012), it is more typical for structural alignment to benefit and strengthen the chances for achieving successful positive transfer. Nevertheless, the focus of this paper is to help explain atypical and distant instances of transfer rather than typical well-structured near transfer.

### 5. What is meant by the term prefigurative

Prefiguration is an idea that is synonymous with terms like world hypotheses, lenses or epistemic beliefs and commitments. Therefore, when thematic similarity is described to be constructed at a prefigurative level, it is meant that similarity is based more on epistemic commitments rather than the specific details of the structure in the problem. Prefigurative similarity differs from structural similarity in that the structure between two situations that have the same prefiguration can be vastly dissimilar.

A good example of how structural and prefigurative similarity differ from each other can be found in a study by Forsyth (2016) in which participants read two structurally different knowledge domains—the French Revolution and quantum mechanics—and then engaged in a free recall task. Embedded in each text were passages containing two types of prefigurations (also described in the study as two types of epistemic beliefs) called mechanism and organicism. Forsyth found in an analysis of the participants' free recall data a significant interaction between participants' prefiguration preferences and the portions of text that were recalled across both texts. More specifically, within each text, participants who preferred a mechanist prefiguration recalled more mechanistic passages and participants who preferred an organicist prefiguration recalled more organicistic passages regardless of structural dissimilarity between the historical scientific text.

The term prefigurative was first used by Hayden White (1973) in his book *Metahistory* to describe how specific epistemic beliefs had the effect of pre-shaping historians' thinking about historical events. For example, White explains that historians in the nineteenth century trying to describe the French revolution often used a "realist" lens to make sense of that time period. All assumptions, conclusions and representations would have been affected by this lens. Therefore, the general form of arguments made by these historians were already constrained to some degree before any historical assertions were put to paper because the arguments were already epistemically prefigured.

Educational Psychologists, Spiro et al. (1996) describe prefiguration "as a constraint occurring at the most fundamental level upon an individual's understanding of what knowledge consists of and how it should be acquired (p. 53)." Prefigurations, or more appropriately, prefigurative schemas, consist of the types of assumptions one makes about a particular body of knowledge. These assumptions both cover and uncover the types of problems that people deem to be relevant as well as the possible solutions to those problems.

Since prefiguration constrains the structure that follows in any domain, it seems plausible that a target and base that possess prefigurative similarity will also possess some amount of useful structural similarity. However, the amount of useful structural similarity cannot always be counted on once different domains are crossed. This is illustrated in Sokal and Bricmont's (1999) book *Fashionable Nonsense* where they point to numerous examples of false assertions made by social scientists based on transfer from quantum mechanics. Furthermore, utilizing the correlated structure in transfer problems do not always lead to correct understanding as is illustrated by Spiro and colleagues' (Spiro, Feltovitch, & Coulson, 1989) study of medical students and doctors who wrongfully diagnosed congestive heart failure despite using an analogy generally accepted by medical professionals, or Bassok and Holyoak's (1989) work with Algebra and Physics students attempting

to solve economics word problems. In short, it is not trivial that similarity judgments can be established via prefiguration instead of structure.

Prefigurative schemas can be quite tacit to most people when they engage in problem solving or transfer, but there should still be methods available to bring these prefigurations to the surface. Surveys focusing on epistemic beliefs, interviews, and thematic analyses of practice (observing students in real situations like a classroom), should all aid in helping a researcher determine what prefigurations are held by someone and to make reasonable judgments about the kinds of prefigurations that are used in subsequent transfer.

## 6. Themes

Themes are considered to be the basic unit of what make up Spiro et al.'s (1996) prefigurative schemas and the present conceptualization of themes borrows much from Holton's (1988) book *Thematic Origins of Scientific Thought*. As a historian and philosopher of science Holton's conceptualization of themes are not often cited in current epistemic beliefs research (cf. Bromme, Pieschl, & Stahl, 2010; Hofer & Pintrich, 1997; Muis, Bendixen, & Haerle, 2006; Strømsø & Bråten, 2008). Nevertheless his conceptualization of themes seems to fit Hofer's (2000) definition of an epistemic belief. That is, themes are "beliefs about knowledge and knowing [that] cut across disciplines and domains" (p. 378).

In his book, Holton describes over 50 themes associated with the practice of science based on historical and philosophical evidence. A portion of them have been listed in Table 2 as examples of the kinds of themes that may be involved in transfer problems. However, it is stressed that most of these themes are not exclusive to the domain of science and neither is Holton's list definitive of all the possible themes that could exist. Holton illustrates this by summarizing how his method of analyzing such themes can be found in many other fields such as biology, sociology, literary criticism, linguistics, psychology and philosophy. Such a wide range of disciplines using themes and thematic analyses is in and of itself an example of far transfer via thematic similarity.

Holton explains that much of what ends up in scientific journals portrays the final product of scientific inquiry and that his work with scientific themes lies within what he calls a "contingent plane" (p. 12) which is made from two dimensions of scientific statements. First, there are empirical "statements of fact" that originate in what is observed. Second are statements of "logical and mathematical propositions" which include all of the analytical tools that are at the disposal of scientists to make sense of what is observed. He states that these two dimensions essentially "boil down" to meter readings and tautologies, respectively. He attributes the success of so many scientific endeavors to the effectiveness of working within this contingent plane because all statements within this plane are capable of being verified or falsified. Despite this success however, he argues that science done at the nascent level involves a third dimension of work composed of "preconceptions that appear to be unavoidable for scientific thought, but are themselves not verifiable or falsifiable" (p. 13). These preconceptions are what he calls themes and the dimension that houses these preconceptions the "the dimension of themata." In defense of this view, Holton surveys the words

**Table 2. A sampling of Holton's (1988) themes**

Randomness	Reductionism
Order	Holism
Symmetry	Constancy
Asymmetry	Discontinuity
Conservation	The Continuum
Entropy	Simplicity
Causality	Complexity
Simultaneity	Mechanism

of many philosophers of science such as Wittgenstein (1961), Braithwaite (1953) and Popper (1959), all of whom point to both the necessity of a thematic dimension in scientific endeavors as well as the general inadequacy of science’s tools to analyze these themes.

Holton’s position on themes as they relate to the field of science is germane to how themes relate to the study of far transfer. First, he explains that themes appear in scientific inquiry in its nascent state. That is, themes become important when the edge of what is known in science is expanded toward new discoveries and this is the kind of environment that can occur in the classroom as well as the laboratory. Although there are certainly differences between “doing science” inside the classroom as a student versus as a professional (cf. Resnick, 1987), student learning in a classroom is still about pushing the edge of what is personally understood and can therefore be said to be in a nascent phase. If this is the case, students in science (and all other subjects for that matter) should still manifest the use of themes as they generalize (i.e., transfer) what they are learning.

### 6.1. Kinds of themes

Holton categorizes in his book two kinds of themes. The first, conceptual themes, are the thematic components of concepts that are otherwise found within the contingent plane of scientific work. He gives force as an example of one such theme that has strong empirical and analytical roots but that also factors into the presuppositions (i.e., prefigurations) that someone might have before they engage in science proper. Methodological themes, on the other hand, are described as “guiding theme[s] in the pursuit of scientific work” (p. 16) and these are the themes that have a much greater hold upon the most fundamental epistemologies of a person. One methodological theme that may have large implications on the ability to engage in far transfer is the theme of the interconnectedness of knowledge. This is the belief that knowledge in one domain or discipline can be used to understand what is learned in a different discipline. If one held the epistemic belief that knowledge from one discipline to the next is insular, there would be far less effort to even search for similarity between two subjects regardless if that similarity was of the structural or prefigurative kind.

Stephen Pepper’s (1942) conception of world hypotheses—also written as world views, epistemic belief systems or, root metaphors (Forsyth, 2016; Koltko-Rivera, 2004; Schraw, 2013; Super & Harkness, 2003)—can be seen as a description of four larger scale methodological themes. He writes extensively about how these four world views can deeply affect a person’s attempts to make sense of knowledge and knowing. Pepper’s four world views—called formism, mechanism, contextualism and organicism—are highly interconnected themes that are resistant to being completely integrated one with another. Each possesses specific strengths and weaknesses in being able to describe how the world works and efforts to shore up the weaknesses only reveal the strengths of other equally legitimate ways of viewing the world (see Table 3). For example, one way that Pepper’s world views vary is according to whether knowledge ought to be reasoned about via analytic or synthetic means. All four world views use both analysis and synthesis when interpreting experience, but two of them—mechanism and formism—use analysis as a primary means of reasoning whereas synthesis maintains a secondary role. The four world views also vary according to whether a person views knowledge as integrative or dispersive—i.e., capable of being placed into one grand structure or resistant to being interpreted beyond the specific experience it

**Table 3. A description of Pepper’s (1942) four world hypotheses**

	<b>Formism</b>	<b>Contextualism</b>	<b>Mechanism</b>	<b>Organism</b>
Principle method of reasoning	Analysis	Synthesis	Analysis	Synthesis
Interpretive tendency		Dispersive		Integrative
Inherent weakness		Precision		Scope

is found in. Each of the four hypotheses also has their own weakness or inadequacies when it comes to describing experience with greater precision (detail) or greater scope (generalizability).

A powerful example of how world views, and therefore themes, can influence what is transferred can be found, once again, in the book *Metahistory* (White, 1973). In this book White describes how the great historians of the nineteenth century could produce such variation in how they approached their topics due in large part to the type of world view that they held. Pepper's (1942) ideas figure prominently in White's analysis. He is able to show how literary styles like comedies, tragedies, satires and romances map on to these different world views. In this way themes are capable of both concealing and revealing potential relations of similarity in transfer situations.

It is likely that most students will have a vague or even non-existent conscious understanding of what their own epistemic beliefs and commitments are, but this does not preclude the possibility that themes originate from such views. For example, Forsyth (2012) presents a case of an undergraduate physics student who unwittingly engages in far transfer using themes that appear to correspond with Pepper's mechanist and organicist world views. Research involving themes will likely need to investigate whether differing world views and other methodological themes can be adequately tracked in students and how much of an effect they have on other types of themes involved in far transfer.

### **7. Empirical support for far transfer via thematic similarity**

As stated above, Forsyth (2012) does provide some preliminary evidence of the use of themes as a means of far transfer, as does Spiro et al. (1996). Furthermore, though it stops short of being an explicit demonstration of transfer, Forsyth (2016) provides empirical evidence that prefigurative similarity can influence recall patterns across texts from disparate knowledge domains. Notwithstanding, greater empirical evidence is needed to evaluate transfer that involves thematic similarity. Evidence for thematic transfer will likely come from researchers who are interested in the confluence of epistemic beliefs and transfer of learning research. However, the number of researchers who currently investigate both epistemic beliefs and transfer of learning simultaneously is small. As an illustration of this lack of research, consider two recent special issues on transfer from *Educational Psychologist* (Chinn, 2012) and *The Journal of the Learning Sciences* (Hmelo-Silver & Kafai, 2012). Despite these two issues revealing a number of novel transfer of learning papers, they are almost completely silent about the role of epistemic beliefs in transfer (with the possible exception of Richland, Stigler, & Holyoak, 2012). Moreover, a review of a special issue on epistemic beliefs in *Metacognition and Learning* (Mason & Bromme, 2010) shows similar paucity of connections toward research on the transfer of learning. If the role of thematic similarity in transfer is going to be better understood, there will need to be greater dialogue between epistemic beliefs researchers and transfer of learning researchers.

Empirical studies aimed at demonstrating thematic transfer must be carefully thought out especially considering that less distant forms of transfer often prove elusive to researchers (Schoenfeld, 1999). One potential method that could be a useful tool for empirically investigating the role of themes in transfer comes from the work of Bransford, Schwartz and colleagues (Bransford & Schwartz, 1999; Schwartz, Bransford, & Sears, 2005; Schwartz & Martin, 2004). In their original paper on the topic (1999); Bransford and Schwartz criticize transfer researchers "sequestered problem solving" assessments of transfer that constrain participants to solve problems using only the information given to them by researchers. They hypothesized that these reductionistic experimental methods are one of the reasons that poor, or at least mixed, results are so often observed in transfer of learning literature. Instead, Bransford and Schwartz suggest that tests of transfer should look to see how a participant seeks out extra information to solve an unknown problem. They call this the preparation for learning (PFL) approach which is based in part on Broudy's (1977) idea that people not only use knowledge in a procedural and conceptual way, but also in a way to gain more knowledge.

Joanne Lobato (2003; Lobato, 2012) is another researcher who has expanded the field's understanding of transfer via her actor-oriented transfer perspective, which should be a useful resource

for designing studies that examine the role of thematic similarity in transfer. In this perspective Lobato defines transfer as “the personal construction of relations of similarity (2003, p. 20).” This means that transfer is counted as occurring whether what the student transfers is correct in the eyes of the expert or not, and as a result, researchers need not analyze only positive instances of transfer. She also advocates that transfer occurs “across, mental, material, social and cultural planes.” Therefore under an actor-oriented approach the researcher has a much wider field of what counts as transfer and what can and should be analyzed. These issues are essential to understanding thematic transfer since the origin of the themes may be better described in cultural, social and historical ways as opposed to purely cognitive explanations. However, far transfer via thematic similarity still remains a cognitive theory on transfer. Although the origin of themes may occur culturally, socially or historically the principal thrust of the theory is to understand how themes affect representations of knowledge.

## 8. Conclusion

In summary, this paper proposes two things. First, it suggests a new level of similarity that people likely use when engaged in the transfer of learning. And second, it defines far transfer as transfer that occurs when thematic similarity is involved in the transfer process. Descriptions of far transfer based exclusively in terms of structural similarity can be problematic because far transfer, traditionally defined, occurs when there is little structural similarity available to transfer with. Furthermore, transfer conditions where structure is well defined and well understood before transfer occurs do not adequately describe instances where far transfer is often thought to occur. In effect, current definitions of far transfer based on structure mapping explain the phenomenon away without providing adequate conceptual tools for analyzing far transfer when it does happen. Analyzing far transfer in terms of thematic similarity as a type of non-structural similarity could address some of the weaknesses that structure mapping theories have in dealing with instances of far transfer.

If the structural similarity between two knowledge domains did not match up, could not matchup, or were not yet known to match up, what else could a person compare as a basis of transfer? The answer would be nothing according to current theories regarding the mechanism of transfer of learning. However, this paper proposes that when structural similarity is unavailable comparisons could still potentially be found in the preconceived ways of thinking about the properties of the domains themselves. Even in cases where the structure of both the target and base are well known, it is possible that the mind still attempts to look for thematic similarity as a means of strengthening the comparison via systematicity. Ultimately, the picture of how transfer occurs seems incomplete without accounting for the role of prefigurative thematic similarity.

Although it was not the focus of this paper, another issue affecting far transfer is the role of individual characteristics. People who are interested in finding a connection between two topics seem much more likely to find that connection compared to someone who is more apathetic about engaging in such a search. The higher likelihood for transfer would not necessarily ensure that the quality of that transfer will be better, however. Interestingly, Forsyth (2012) makes a tenuous case for this in a case study of a physics student who claimed to find links to physics across widely disparate subjects like German, philosophy and the humanities. Researchers who study how dispositions affect like critical thinking and reasoning (e.g., Halpern, 1998; Perkins & Salomon, 2012; Stanovich, 1999) have also made cases for the role of individual differences when considering transfer of learning as a phenomenon. Future work should include looking more closely at the role of individual differences in the use of thematic transfer.

Another topic related to this paper worth exploring in the future is the role that thematic transfer might have in interdisciplinary research (cf., Aboelela et al., 2007; Klein, 1990; Rhoten & Parker, 2004). Interdisciplinarity is a valued paradigm across higher education, within business and in research funding agencies like NSF and NIH. This is because problem solving and creativity can improve significantly when diverse groups with various skillsets and types of expertise are brought together. However, creating a diverse group and framing problems that recognize the need for

interdisciplinary thinking can also be quite difficult tasks. Some of the difficulty may be prefigurative in nature, which suggests an understanding of thematic transfer may have implications for improving interdisciplinary research endeavors.

As a final note, it is possible that some readers will view the idea of thematic transfer as nothing more than a new label for the old mechanism of abstraction (cf. Wagner, 2006), but transfer via abstraction is a bottom up process that compares the structure of a target and base which allows a person to induce a common general schema. Themes are utilized in problem solving not because of the structure of the problem, but rather because of the epistemological assumptions that are held by the individual. Certainly these themes can be challenged and altered as they interact with the details of the target and base, but they are not a byproduct of the problem solving process. Instead they prefigure, or pre-shape, this process in advance of any analysis between the structure of the target and base.

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