

**New Frontiers in Analogy Research
Proceedings of the Second International
Conference on Analogy
2009
Kokinov, Holyoak, Gentner**

The following notes are arranged as per the conference proceedings.

Analogy and Moral Decision Making

Morteza Dehghani, Dedre Gentner, Ken Forbus, Hamed Ekhtiari and Sonya Sachdeva

“The results of our experiments suggest that analogical mapping from core cultural narratives can influence moral reasoning about current moral dilemmas. Supporting the hypothesis that analogical processing occurs during moral decision making, ...”

“Our results suggest that a core differentiating factor in moral reasoning between cultures may be familiarity with different collections of cultural narratives. Even if the foundations and the logic of morality were universally present, the different cultural stories would cause differences in the judgment of morality between cultures.”

Thresholds for Plausible Analogical Arguments

Paul Bartha

“..... analogical arguments, ... , are often employed to show that their conclusions are prima facie plausible, or serious possibilities. Prima facie plausibility is not a matter of degree; rather, it implies the existence of a threshold below which analogical arguments provide no justification for their conclusions. structure-mapping theories cannot easily accommodate the notion of prima facie plausibility.”

Computational Metaphor Identification: A Method for Identifying Conceptual Metaphors in Written Text

Eric Baumer, Bill Tomlinson and Lindsey E. Richland

“This paper described computational metaphor identification (CMI), a technique for identifying potential conceptual metaphors in written text. Unlike other computational models of analogical thinking, CMI does not use encoded representations of knowledge structures, but rather identifies potential mappings based on cross-corpus linguistic correspondences. ... Lakoff argues that “issues [about metaphor] are not

matters for definitions; they are empirical questions” (1993, p. 202). computational metaphor identification has the potential to help fill [the] gap [between theory and robust empirical results]”

Relational Priming of Analogical Reasoning.

Benjamin Bendig and Keith Holyoak

“... processing an instantiation of a congruent specific relation (e.g., black OPPOSITE white) yields reliable facilitation of verbal analogical reasoning relative to an in-congruent prime. ... In contrast, presentation of the same instances with a generic relation (e.g., black GOES WITH white) did not yield facilitation. [Another] experiment ... found facilitation across a variety of prime types, including the relation word only (e.g., OPPOSITE).”

An Interactive Test to Study the Relevance of Analogical Reasoning and Concept Separability in Category Learning

Cesare Bianchi and Fintan Costello

Previous studies have shown that Analogical Reasoning is used to learn categories with similarities between them, but has not addressed the question of whether similarities or separability are preferred in categorization.

“... preliminary results suggest that analogical reasoning has a stronger effect than the separability of concepts: when there are similarities between one or more categories, instead of create confusion and make the task more difficult, they are exploited to more easily learn the other categories. The heuristic used in this case could be described as: “if something has already worked, let's try to use it again”, and this would give a renewed importance to analogies even in a field (category learning) in which has been always suggested that similarities between categories are detrimental to learning.

Analogical Transfer of Emotions

Svetoslav Bliznashki and Boicho Kokinov

“... analogy produces emotional transfer when the stimuli involved are a-priori emotionally valenced. ... the analogy-produced assimilation effect was stronger than the contrast effect found in the Association Condition in all analyses which

implicates that the role analogy making plays in emotional experience is substantial ...”

Meaningful learning and Analogizing, Some Cases in Learning Physics

Sandra Bruno

“... meaningful understanding includes crucial cognitive activities: the assimilation of meaning to one's set of operative invariants characterizing the subject's own representation of the world, and the actualisation of one's knowledge in a large set of situations. In other words, cognitive modelling cannot only rely on a formal network of domain knowledge. And learning is a more complex phenomenon than the processes of making links between signifiers and identifying regularities of the world. “

Constraints on Analogical Reasoning: Working Memory Capacity or Executive Control?

Adam Chuderski and Anna Chuderska

“... analogical reasoning is related to EC but they show that enlarging the WM load is not necessarily related to scores in the analogy test.”

Analogical Reasoning via Imagery: The Role of Transformations and Simulations

John Clement

“... rather than a single process for mapping elements in a discrete symbolic representation, a number of additional processes for evaluating an analogy relation have been identified, namely: bridging analogies, conserving transformations, dual simulations to detect dynamic similarity, and overlay simulations. Roughly, dual simulations work by allowing the subject to detect a perceptual motor similarity between base and target. Overlay simulations are a special type of dual simulation in which the image of one case is aligned over the other case to make comparisons more precise. Conserving transformations work by allowing the subject to detect the causal, perceptual motor irrelevance to a targeted relationship, of making a transformation that changes the target to the base or vice versa. An intermediate bridging case is a higher order strategy that can facilitate making one of the above processes easier to perform.”

Inference Processes in Causal Analogies.

Julie Colhoun and Dedre Gentner

“... Structure-mapping Theory sufficiently explains the analogical inferences drawn from these causal analogies, and that, contrary to L&H's claims, the effect inference can indeed be evaluated by a post-analogical causal reasoning process. Models of analogical processing need not—and should not—subsume causal inferencing processes. “

Individual Differences in Relation Learning in Capuchins: Evidence for Hypothesis Testing

Fintan Costello and Valentina Truppa

“Learning based on hypothesis testing and falsification requires the explicit formulation and representation of rules which are both unambiguous and abstract. Associative learning, by contrast, does not require any specific ability to form or manipulate abstract and unambiguous representations ... “

Non-occurrence of a reward with a stimulus where reward is expected has a strong effect on learning based on hypothesis testing (causes rejection of current hypothesis) and a weak effect on associative learning (association falls by a small amount.).

“... individual capuchins with the best learning performance ... reliably respond[ed] in a way which is consistent with explicit hypothesis testing. “

“... learners do not need language to form hypotheses, however; instead, what they need is a representational system of sufficient complexity to encode the rules to be learned.”

A Two-Process Account of Analogical Category Learning

Fintan Costello and Cesare Bianchi

“...[a] mechanism based on the priming and activation of the substructures which make up representations can also explain analogical learning, with no comparison taking place. ... We ... propose a two-process account of analogical learning, in which substructure priming dominates in early and mid-stage learning but structure-mapping dominates in late-stage learning. the priming mechanism for analogical learning [is] related to implicit

associative learning, while structural alignment is linked to learning via explicit hypothesis testing.”

Anxiety Restricts the Analogical Search in an Analogy Generation Task

Veselina Feldman and Boicho Kokinov

“... individuals in a state of high anxiety tend to be more rigid and focus on a more restricted domain of interest and do not have the power to search broadly LTM for remote analogies in various directions, they rather stick with the first domain found but they are still able to produce consistent structural and systematic analogical mappings and produce convincing and detailed analogies.”

Deriving Narrative Morphologies via Analogical Story Merging

Mark Finlayson

“It has long been suspected that stories drawn from the same cultural setting share important narrative structure. One example of such structure, . morphology ... describes the set of plot elements and their allowed sequences. ... I demonstrate a technique called Analogical Story Merging that derives a morphology given a set of stories. It incorporates [SME and] ... Bayesian Model Merging for inducing a grammar from a corpus of positive examples. [The technique was applied to] a set of summaries of Shakespearean plays. “

Analogical Alignments in Algebraic Modeling

Kristie Fisher and Miriam Bassok

Correct application of mathematical knowledge to real-life problems requires the construction of mathematical models that correspond to problem situations.

“...[students who] engaged in algebraic modelling (i.e., those who performed the task correctly) took significantly longer to read misaligned than to read aligned relational statements. ... By contrast, participants who used direct translation instead of modelling (i.e., those who made reversal errors) were not in such a relational mindset. They did not show any sensitivity to the analogical correspondence between the semantic relations in the relational statements and the

mathematical structure of the equation they constructed ...”

The research involved alignment between addition and division.

Aligned: There are 3 times as many roses as vases
Misaligned: There are 5 times as many cups as mugs

Learning Naive Physics Models by Analogical Generalization

Scott Friedman, Jason Taylor and Ken Forbus

“We describe a simulation that uses analogical generalization to learn naïve models of pushing and blocking from experience.... We show that the models it learns are compatible with naïve models found in the literature, and analyze the effects of presentation order. “

Analogical Estimation of Quantitative Magnitudes

Jonathan Gagne and Jim Davies

Visuo ... models visual reasoning [by taking] a description of a scene in words and produc[ing] estimates of the quantitative magnitudes of the qualitative input”

“Our main claims are as follows:

- reasoners store quantitative perceptions as membership distributions across a logarithmic set of fuzzy numbers.
- these perceptions can be labeled with linguistic phrases.
- when visualizing, reasoners will retrieve an appropriate prototype from memory, and determine the crisp output based on defuzzification of that prototype.
- when retrieval is impossible, reasoners transfer meaning of these descriptors and relations from semantically related concepts in the prototype case base.”

A Distributed Basis for Analogical Mapping

Ross Gayler and Simon Levy

“We present a novel connectionist mechanism for finding graph isomorphisms that relies on distributed, high-dimensional representations of structure and mappings. Consequently, it does not suffer from the problems of the number of units scaling combinatorially with the number of concepts

or requiring dynamic network re-wiring. “

Vector Symbolic Architecture (VSA):

- is a class of connectionist models that use high-dimensional vectors (typically around 10,000 dimensions) of low-precision numbers to encode structured information as distributed representations.
- employ a multiplication-like operator (to associate or bind vectors), an addition-like operator (to superimpose vectors), and a permutation-like operator (to protect vectors from the other operations).
- Can represent the vertices of a graph by random hyper-dimensional vectors, edges by products of the vectors representing the vertices, and mappings by products of the mapped entities.

Graph isomorphisms (mappings) are identified by:

1. representing the target and (all possible) bases as two high-dimensional vectors
2. multiplying target with base to obtain all possible mappings x
3. iteratively submitting x_t to 1) a multiplication by the original x , 2) an intersection with x_{t-1} , 3) a clean-up operation and 4) and re-normalisation. This procedure propagates evidence from each vertex mapping to consistent vertex mappings

The novel aspect of the work lies in the vector intersection algorithm over VSA.

Less than 100 iterations are typically required for 10,000 dimensional vectors to settle.

Using Structural Alignment to Facilitate Learning

Dedre Gentner, Susan Levine, Sonica Dhillon and Ashley Poltermann

“... we asked whether a brief analogical training experience could help children learn a key principle of stable construction—namely, the idea of using a diagonal brace to stabilize a ... model skyscraper ... Even a single brief analogical comparison can confer insight, and add to evidence that structural alignability processes underlie analogical comparison.”

“the principles of structure-mapping can be used effectively in a naturalistic environment to promote children’s learning of an important spatial concept.”

Analogy Making in the TRIPLE Model

Maurice Grinberg and Vladimir Haltakov

TRIPLE is a hybrid model of cognition comprising:

- A Long Term Memory (LTM) implemented as a semantic network of concepts following the DUAL/AMBR model with isA and sub-class-Of relationships with spreading activation.
- The Reasoning Engine (RE) coordinates the event driven activities of the model and transfers analogical evaluation and learning.
- The Similarity Assessment Engine (SAE) spreads activation in LTM and communicates confidence events to RE.
- The Emotion Engine (EE) makes a subjective appraisal of events and adjusts the volume of Working Memory and processing speed.

Unintentional and Unconscious Analogies Between Superficially Dissimilar but Relationally Similar Simple Structures

Penka Hristova

The results from Hristova (2009) were replicated “and extend them from spontaneous analogical mapping to spontaneous analogical transfer. People not only start unintentionally and unconsciously to build analogies between subsequent pairs (which results in slower RT for analogical conditions) but even start to transfer knowledge between analogical pairs (which results in the interaction between congruence and analogy). All this happens even though analogies are not beneficial for the color naming task at hand. Moreover, ... the differential transfer effect [appears to] originate from structural rather than surface similarity between analogous word pairs.”

People in Negative Mood May See Relations Where People in Positive Mood May Not

Penka Hristova

“participants in positive mood based their similarity judgments on attributes, while participants in negative mood – on relations.”

From Analogy to Explanation: Relaxing the 1:1 Mapping Constraint... Very Carefully

John Hummel and David Landy

“The model is based on [the LISA] model of

analogy.

“... modeling explanation necessitates going beyond modeling analogy in at least two important respects: First, explanation, much more than analogy, depends on causal relations. We model the representation of causal relations using units representing groups of propositions (and other groups). [and] explanation, unlike analogy, often requires the reasoner to integrate information from diverse sources in LTM, which in turn requires the reasoner to violate the 1:1 mapping constraint. We resolve this difficulty by serializing the process of incorporating facts from different sources in LTM.”

Explanation and Structure–Mapping in Theory-Based Categorization

Jason Jameson and Dedre Gentner

“most research on theory-based categorization has focused on causal categories”

“We claim that categorization decisions depend on the explanatory principle common to category members, and further that structural alignment processes underlie co-categorization judgements.”

The experiments tested: “the prediction that theory-based categories, in a co-categorization task, will be formed around the best shared explanation between category members ... [despite]. ... “little to no influence from shared surface properties”

Learning Probabilistic Relational Categories

Wookyoung Jung and John Hummel

“people are capable of learning categories with a family resemblance structure, in which every member of the category shares some features with every other member, but no single feature is shared by all category members”

“the vast majority of models of category learning and categorization assume that we represent categories and exemplars as lists of features and assign exemplars to categories by comparing their features [but] this a limitation inasmuch as many natural concepts and categories are based, not exclusively on features, but also on relations, including both relations between the features of an exemplar”

“people find relational categories with a probabilistic structure disproportionately difficult to learn relative

to featural categories with a probabilistic structure or relational categories with a deterministic structure.”

“Our results showed that recasting category learning as “who’s winning” substantially improved participants’ ability to learn relational categories with a probabilistic structure.”

“relational category learning may entail some form of intersection discovery.”

Persistent Mappings in Cross-Domain Analogical Learning of Physics Domains

Matthew Klenk and Ken Forbus

“Cross-domain analogies are a powerful method for learning new domains. This paper extends the Domain Transfer via Analogy (DTA) method with the idea of persistent mappings, correspondences between domains that are incrementally built up as a system gains experience with a new domain.”

“DTA assumes a known base domain consisting of equation schemas, control knowledge and problem/worked solution pairs. Given a problem that it cannot solve plus a worked solution in a new domain, it learns about the new domain using the following four steps ...

1. learn the domain mapping,
2. initialize the target domain theory,
3. extend the target domain further via analogy,
4. verify the new knowledge.

Adding persistent mappings changes this process by recording the domain mapping as part of what has been learned, so that when the next new problem in the target domain arrives, it uses those mappings as a starting point.”

Analogy-Making Automatically Produces False Memories for Both Mapped Situations

Boicho Kokinov, Veselina Feldman and Georgi Petkov

Human memory inaccuracy is typically attributed to the either the influence of general schematic knowledge that is used in constructing the episodes or to the blending of two episodes.

“The AMBR model ... is trying to unify these two mechanisms by replacing them with a single mechanism, based on analogy-making.” AMBR introduces memory distortions in both the encoding

phase and the recall process which are both analogical processes. The AMBR model runs continuously and automatically makes analogies no matter what the task.

“The results [of experiments with humans] clearly confirm the main hypothesis that people make significantly more false recognitions of changed figures if the implant in the figure corresponds to a relation in the analogous figure than if it corresponds to a relation in a non analogous figure presented at the same screen.” These results are replicated in the AMBR model.

Is Analogical Mapping Embodied?

Boicho Kokinov, Veselina Feldman and Ivan Vankov

“The experiment demonstrated that inducing eye-movements along a specific orientation affects the performance of analogical mapping. The result renders support for the hypothesis that analogical mapping could be at least partly embodied in physical actions such as eye-movements.”

“... the horizontally moving dot impedes to a greater extent the spatially misaligned analogical mappings than the aligned ones, supporting the hypothesis that in these cases people do simulate spatial re-arrangement.”

How Analogy Could Force Re-representation of the Target and Inhibition of an Alternative Interpretation

Boicho Kokinov, Ivan Vankov and Svetoslav Bliznashki

“... people may see consciously only the dominant interpretation, but unconsciously they may have built partially the alternative interpretation which will remain inhibited by the competing dominant one, i.e. the prediction is that there might be cases of inhibition of something the subjects would claim they have not seen. This prediction is supported in a pilot psychological experiment.”

“... we obtained evidence that people do perceive unconsciously the “CAT”, i.e. even though they say they have not seen anything else than a face in the figure, we have firm data showing that they

have built not only partial representation of the inscription (e.g. some letters), but they have built a meaningful representation of the word “CAT” which turned out to be negatively primed (longer RT).”

“... analogy-making interacts with perception during this process of representation building.”

“... the more systematic the analogy is the stronger the pressure it exerts on the various alternatives”

Variation Among Individuals in How Structure Affects Similarity

David Landy and Eric Taylor

“A general disconnect exists between most models of structure-based similarity and the empirical literature they attempt to capture. Models of structure processing often purport to explain behavior at the level of the individual, but most studies have analyzed structure sensitivity at the level of mean aggregates across individuals.”

“... individuals’ similarity judgments varied systematically as a function of the weight accorded to (a) the number of competing MOPs, or MOPs with the same feature value as a separate MIP, (b) the number of MIPs, and (c) the number of objects with at least one feature match.”

MOP = Match Out of Place

MIP = Match In Place.

Explanatory Reasoning For Inductive Confidence

David Landy and John Hummel

“... we model categorical induction as a process of causal reasoning, by which knowledge gleaned from possible explanations of the premises is used to form conclusions about the category.”

“ERIC uses a probabilistic logic to encode the intuitions that knowledge-driven explanations are generated in support of property inductions, and that novel explanations are generated via analogical adaptation from nearby cases. We demonstrated that, using these intuitions, ERIC is capable of capturing many known phenomena in property inductions, including the specific role of knowledge about property distributions (e.g., predator-prey relations versus taxonomic distance relations). Compared to other analogical inference systems, ERIC is distinctive in eschewing complex analogies between large schematic structures. Instead, ERIC builds explanations

through many, smaller analogies between analogs often consisting of just two or three propositions. While ERIC's complete lack of large-scale structure surely reflects a simplification, postulating analogical extension as an implementation of symbolic inference suggests that many, if not most, analogies are of just this sort."

Integrating Analogical Inference with Bayesian Causal Models

Hee Seung Lee, Keith Holyoak and Hongjing Lu

"We present an integration of analogical transfer with Bayesian causal models, focusing on distinctions between causes versus effects, generative versus preventive causes, and causal predictions versus attributions."

"The central assumption of the framework is that analogical reasoning can be used to transfer causal structure and strength from the source to the target. Critically, the "cause" relation in a Bayes net operates not simply as a static structural element, as does a relation coded in predicate-calculus-style notation, but as an active vehicle for transmission of causal power, encoded as vectors of strength distributions. It follows that analogical transfer of causal knowledge to the target begins with the acquisition of a causal model of the source. The model thus explains the observation that a poorly-understood source will not support strong analogical conclusions"

Using Analogy to Model Integration During Multimodal Knowledge Capture

Kate Lockwood and Kenneth Forbus

"This paper describes a cognitive model of multimodal knowledge capture that uses analogy to model the cognitive process of integrating information from text and diagram representations."

"... Mayer's (2001) theory of multimedia understanding suggests that a human learner must cognitively engage with the material during the process of integrating the information from the different modalities and that it is this cognitive engagement which leads to better and deeper understanding of the material."

"The MMKCap multimodal knowledge capture model consists of several systems. The CogSketch sketch understanding system is used to input the diagrams into the system. EANLU natural language understanding is used to

parse the text portion of the input. SME is the model of analogy and similarity that forms the basis for our model."

Modeling Perceptual Similarity as Analogy Resolves the Paradox of Difference Detection

Andrew Lovett, Eyal Sagi, Dedre Gentner and Kenneth Forbus

"... alignable differences are naturally salient. Therefore, when pairs are easily aligned (as with similar pairs), their differences "leap out". [however this] seems at odds with a large body of work on the same-difference task showing that people are faster to notice that stimuli are different for dissimilar pairs than for similar pairs"

SME can provide an explanation for this apparent paradox by noting that "naming a specific difference between stimuli requires a full global mapping, and therefore depends on the alignability of the stimuli. However, some comparison tasks can be accomplished without the full process. Specifically, if two items are highly dissimilar, recognizing that they are different can often be done in the first (local matches) stage of processing."

A Continuum Approach to Promoting Creativity: Generating Novel Metaphorical Expressions Through Varying Conceptual Metaphors

Ricardo Minervino, Andres Lopez Pell, Nicolás Oberholzer and Máximo Trench

The continuum approach is "aimed at stimulating creativity based on the idea of introducing adjustments to well established previous ideas."

The heuristics used to train participants in the experimental group have been described by Lakoff and Johnson's theory of conceptual metaphor (CM). They consist of deriving new metaphorical expressions (MEs) by performing variations on conventional CMs."

The experimental results "were more creative than those generated by other [control] means. It was also found that the explicit use of these heuristics produced more creative [outcomes] than their implicit use."

Analogies vs. Contrasts: A Comparison of Their Learning Benefits

Norma Ming

“An ongoing challenge for educators is helping their students recognize connections between related information while also appreciating distinctions between only seemingly related information.”

“...contrasting comparisons improved discrimination between problem types, while analogical comparisons improved generalization to new contexts and surface features. Further, contrasting comparisons produced the greatest benefit for participants who began the training with overly general knowledge, an over-reliance on surface features instead of deep structure, or with no success in identifying the correct analysis method at pretest. Analogical comparisons were most helpful for the smaller number of participants who only recognized problems with both deep and surface similarities to the initial study example. The error patterns underscore the value of assessing students’ abilities prior to selecting an instructional intervention, insofar as what helps one student may hurt another.

Perceptual Vs Conceptual Similarities and Creation of New Features in Visual Metaphors

Amitash Ojha and Bipin Indurkha

“In the similarity task, participants primarily reported existing perceptual similarities between the two images, and it seems that conceptual similarities were considered only when similarity at a perceptual level could not be found. On the other hand, in the metaphor task existing perceptual similarities seem to help in relating the two images conceptually.”

“a pair of images with a high perceptual similarity index is more likely to be given a metaphorical interpretation.”

“perceptual similarity correlates positively with emergent features that are neither part of the target nor of the source. “

With dis-similar images “the left image (target) gets focused attention, whereas the right image (source) gets distributed attention [suggesting feature search, while] for high-similarity images, both the target and the source get similar attention patterns, ... suggest[ing] a feature-based comparison.”

“... the source can create new features in the target [in both] low-similarity [and] high-similarity image pairs.”

Analogy Formulation and Modification in Geometry

Alison Pease, Markus Guhe and Alan Smail

“Analogies in geometry between two and three dimensions have been bearing both healthy and unhealthy fruit for millennia.”

“Taking a descriptive rather than normative approach, and analysing historical analogies and mappings in different contexts and domains is important for testing the generality of ideas in analogy research.”

Is It Possible To Manipulate The Strength of the Structural Consistency Pressure?

Georgi Petkov

Abstract: The one-to-one mapping constraint has been implemented in almost all of models for analogy making, but has not yet been studied systematically. A psychological experiment was performed that tested whether the strength of one-to-one mapping pressure can be manipulated by a prior task unrelated to analogy-making. The results demonstrate that people’s answers to match-to-sample tasks can be systematically shifted toward one or another direction by a relatively short manipulation. “

However, the results of the psychological experiment did not support the original hypothesis and opened new questions.

Evidence for One-To-One Mapping Constraint in Object Categorization

Georgi Petkov and Ivan Vankov

“This paper described an attempt to find empirical support for the analogy-driven models of object categorization. [based on] the one-to-one mapping constraint. It was hypothesized that an object will be categorized slower if it is presented together with other objects belonging to the same category. [Supporting evidence was found for] categorization of simple geometrical shapes [and for] stimuli belonging to natural categories. [Hence] the mechanisms of analogy-making could be fast enough to be employed by highly automated cognitive processes. [Providing] an argument in favour of the view that the principles of analogy-making lie at the core of human cognition. “

No Representation Without Taxation: The Costs and Benefits of Learning To Conceptualize the Environment

Michael Ramscar and Melody Dye

“... theories of cognition of all persuasions tend to assume that symbolic thought is referential. That is, they subscribe to the idea that symbols both represent, and in an—important sense—point to, meanings, so that symbols and their meanings share a bi-directional relationship.”

“Abstraction involves reducing the information content of a representation, such that only information relevant to a particular purpose is retained. As such, abstraction is an inherently directed [and irreversible] process. ... given that symbols serve as abstractions in communication and thought, ... we take an explicitly predictive [and non referential] approach to symbolic thought. ... we treat symbols as abstractions in a literal sense, and ... take the view that symbolic processing must be directed as well. Prediction is by its very nature directed. ... we argue that the relationship between symbols and the concepts underlying their use is not bi-directional, and that symbolic processing is a process of predicting symbols.”

“... we conceive of learning as a process by which information is acquired about the probabilistic relationship between important regularities in the environment (such as objects or events) and the cues that allow those regularities to be predicted “

“LF-learning is a process of acquiring information that allows the prediction of a feature or set of features given a label, whereas ... FL-learning, learning is a process of acquiring information that allows the prediction of a label from a given feature or set of features.”

“Both FL and LF-learning capture probabilistic information predictive relationships in the environment. However, there are fundamental differences between the two. In FL-learning predictive power, not frequency or simple probability, determines cue values; LF-learning is probabilistic in far more simple

terms. Given this, it seems that the sequencing of labels and features ought to have a marked affect on learning. We call this the Feature-Label-Order (FLO) hypothesis. “

“In LF-learning, a single cue will be predictive of each of the features encountered in an object or event. Because no other cues are available to compete for associative value, there can be no loss of potential associative value to other cues over the course of learning trials. By contrast, in FL-learning, because many cues are available to compete for relevance, learning will separate the highly salient cues from the less salient cues, favouring cues with a high degree of positive evidence and disfavouring those with a high degree of negative evidence.”

“Learning to “represent” the world through LF-learning involves discovering the conditional probabilities of features given events and labels. In this case, similarity will be determined by the probability of the features that any two objects share; objects will be similar to the degree that they have salient (i.e., frequent) features in common. However, as learners come to conceptualize—i.e. discover the predictive structure of—their environments, they learn the predictive value of cues. As we have shown above, when learned in a system, predictive values can differ greatly from conditional probabilities. In this case, we would expect similarity to be governed by predictive value, not frequency”

“While our view of learning is associative, it is compatible with approaches that emphasize the role of structural alignment in similarity, analogy and categorization. It is, however, incompatible with the idea that similarity drives categorization. In our view, similarity and categorization are products of learning.

Structure Mapping Theory as a Formalism for Instructional Game Design and Assessment

Debbie Denise Reese

CyGaMEs, which stands for Cyberlearning through Game-based, Metaphor Enhanced Learning Objects, is a formal approach to the design of instructional learning environments through applied structure mapping theory.

A CyGaME translates an abstract concept into procedural, goal-driven, embodied interactions. Because a CyGaME is the analog of the to-be-learned, it prepares learners to make viable

inferences about the targeted domain. When learners can infer relational structure of a to-be-learned domain, knowledge acquisition is more intuitive. As with methods proposed by Schwartz, Martin and their colleagues (2004), CyGAMES is an approach for producing learning environments designed as “preparation for future learning.”

“The GaME design team specifies the targeted, to-be-learned concept and then maps out a concrete domain that highlights just the salient relationships that constrain it as isomorphic to the target. “

1. Select Complex introductory concept (systematicity driven)
2. Specify and clean the domain (Structure mapping principles, especially parallel connectivity, constrain specification)
3. Source Domain Specification and Mapping. (inventing engaging gameplay within a game world while adhering to isomorphism and parallel connectivity constraints.)
4. Game Design and development (maintaining mapping integrity and targeted learning goals, key understandings, and underlying science.

The Impact of Gestalt Principles on Solving Geometric Proportional Analogies

Angela Schwering, Clemens Bauer, Irena Dorceva, Helmar Gust, Ulf Krumnack and Kai-Uwe Kuehnberger

In this paper, we investigate solution strategies for ambiguous proportional geometric analogies. We constructed different analogies which were varied in such a way that they trigger different perceptions. Different solutions were constructed when subjects perceived different dominant structural patterns. The experiment investigates preferred solutions for these analogy variations, analyzes the influence of Gestalt principles on the perception of structural patterns in geometric figures, and examines how this influence leads to different solutions for the same analogy problem.

In our experiment, subjects constructed their solution, rather than select from predefined options – which is particularly important for ambiguous analogies) and may encourage focus on relational rather than superficial aspects.

The results reveal a set of different strategies for building structural representations.

- color or shape to discriminate between groups (Gestalt dominance of the similarity)
- relative position to form coherent groups

(Gestalt spatial proximity and of similarity)

- constant direction of movement (Gestalt good continuation).
- a combination of several criteria to form groups but only in complex analogies.
- perceived a whole figure as one single group and applied the transformation to the whole figure (no grouping).
- perceived every object as separate.

Transformations mentioned included the rotation, reflection, retention/removal and movement of groups of objects.

Relational Language and Inhibitory Control in the Development of Analogical Ability

Nina Simms and Dedre Gentner

Abstract “This paper explores the role of relational language and inhibitory control in the development of children’s analogical reasoning ability. In two experiments, children were asked to make a relational mapping between two pictures while ignoring a competing object match. Experiment 1 demonstrated that children were more successful at this task when they heard relational language. The performance of children who heard relational language was equally good with and without a distracting object match present. Experiment 2 asks whether children with better inhibitory control are also better at ignoring object matches when mapping relations. Results suggest that the impact of inhibitory control may differ across ages. Future work will address how the factors of relational language and inhibition interact in the development of analogical ability. “

The Role of Analogies in College Students’ Understanding of Counter-Intuitive Expository Texts

Irina Kopeliti, Svetlana Gerakaki and Stella Vosniadou.

“...readers find it difficult to understand texts which present scientific information incongruent to their background knowledge [but] the inclusion of an analogy from a different but highly familiar domain helped participants to recall more information from the Analogy text as compared to

the No-Analogy text.”

“In some cases the participants who read the No-Analogy text changed only their verbal explanations and not their drawings which remained the same as in the pretest. This difference caused several incongruities between the same participant’s verbal explanation and his/her drawing in the post-test. In other cases, the participants who read the No-Analogy text added the scientific information into their existing knowledge base creating erroneous inferences which represented major distortions of the text information.”

The inclusion of an analogy typically resulted in improved integration of the information, and restructuring of their original explanatory frameworks into more sophisticated ones that were closer to the scientific explanation.

Structural Alignment of Visual Stimuli Influences Human Object Categorization

Rolf Stollinski, Angela Schwering, Kai-Uwe Kuehnberger and Ulf Krumnack.

“Subjects needed significantly more time to react to both non-structurally and structurally manipulated object stimuli as opposed to the unaltered black and white line drawings in the match condition. ... this result supports our prediction that it is generally harder to make a binary decision about non-structurally and structurally modified objects ... Additionally, the experiments showed that complete mismatch tasks (filler condition) can be solved very rapidly by the subjects. [our explanation assumes] that subjects try to match a structured representation of both stimuli. In the modified case, they need to adapt these representations. In the mismatch case, the structures are too different, such that match attempts do not take place.

Dissolving the Analogical Paradox: Retrieval Under a Production Paradigm is Highly Constrained by Superficial Similarity

Maximo Trench, Nicolas Oberholzer and Ricardo Minervino

“Results showed that the likelihood of reporting a retrieved source is more than three times higher when such source is interdomain, as compared to when such source is intradomain. Most importantly, the likelihood of retrieving a naturally encoded source is three times higher when that source is intradomain, as compared to when it is interdomain.

This demonstrates that under a production paradigm - just as under a reception paradigm - the retrieval of a naturally encoded source analog is highly constrained by superficial similarity.”

Resource Allocation and Problem Solving Strategies During a Geometric Analogy Task in Individuals Differing in Fluid Intelligence

Dorothea Ullwer, Boris Bornemann, Elke van der Meer, Isabell Wartenburger, Franziska Preusse, Jan Ries, Judith Horn and Manja Foth

“In two studies, we investigated the impact of fluid intelligence on the allocation of cognitive resources and problem solving behavior during a geometric analogy task. Individuals of high fluid intelligence showed superior performance in both studies.

In the first study, we found that the hf-IQ individuals outperform af-IQ individuals because they have more cognitive resources available which they allocate to the analogical reasoning process when task demands require it. The second study showed that hf-IQ individuals differ from af-IQ individuals by spending more time on the representation and retrieval phase of the analogical reasoning process at the expense of the mapping and evaluation phases. They scan the objects of the analogy more thoroughly to extract the relevant information for identifying the relations between them. The combination of pupillometry and eye-movement analysis thus helps to better understand processes of cognitive resource allocation and problem solving strategies in participants differing in fluid intelligence.

“All cognitive efforts, like physical efforts and sensory stimuli, cause pupil dilation. The more difficult a task, the more the pupil dilates “

Grounding Relations in Action

Ivan Vankov and Boicho Kokinov

“The symbol grounding problem is one of the most pervasive issues in cognitive science. And one of the toughest aspects of the problem is the question where the meaning of relations comes from. Earlier models of relational reasoning just disregarded the problem of the origin of relational meaning. They treated relations as symbolic propositions which were provided for free at the input of the models. [However] SEQL and DORA ... proposed that relational meaning is abstracted by comparing situations in which the relation is implicitly present. [Furthermore] DORA ... suggest[ed] that the representation of a relation is basically a temporal

organization of lower order propositions - relational roles. ... However [neither SEQL or DORA] solved the relational symbol grounding problem entirely, as they assumed the existence of unknown semantic units which are required to define a relational concept or a relation role.”

“The role of action in the representation of relations is twofold. Firstly, the execution or simulation of a specific action by itself brings meaning to the relation. The second role of action is to enable the role-filler binding.”

“The present paper described a new approach to solving the relational symbol grounding problem by suggesting that representations of relations involve real or simulated execution of actions. A computer simulation showed that such an approach is computationally feasible and an empirical investigation managed to find evidence that it is psychologically plausible.”

Analogical Learning and Inference in Overlapping Networks

Paul Munro and Yefei eng

This paper explored “the conjecture that the shared weights are more likely to encode common features under interleaved training, than they are by completing one training regimen before starting the second.” by using backpropagation to train a network to recognise analogous features on a 3x3 and 5x5 grid.

SYMPOSIA**Neural Correlates of Analogical Reasoning**

This symposium will focus on advances in our scientific understanding of the neural correlates of analogical reasoning processes, from relational mapping to multi-relational integration and metaphorical thought.

Analogy in the Brain: Neuropsychological and Computational Approaches

Robert G. Morrison

"... patients with Frontotemporal Dementia (FTD),... have primary damage in prefrontal cortex and have difficulty processing analogy problems requiring integration of multiple relations and/or resisting featural distraction. In contrast, patients diagnosed with temporal-variant FTD have primary damage to anterior temporal cortex and have difficulty only with analogy problems requiring retrieval of semantic information from long-term memory. ... Altering LISA's inhibitory functions and rapid learning algorithm captured the analogy performance of frontal patients, whereas disconnecting or adding noise to connections in LISA's semantic memory effectively captured analogy performance in temporal patients."

Frontopolar Cortex and Semantic Distance in Analogical Mapping

Adam E. Green, Jeremy R. Gray, Jonathan A. Fugelsang, Kevin N. Dunbar

"... we used fMRI to assess brain activity during verbal analogical reasoning in a series of studies. ... Activity in ... left frontopolar cortex covaried parametrically with increasing semantic distance after separating semantic distance from effects of task difficulty. "

The Effects of Neurological and Psychiatric Disorders on Analogical Reasoning

Daniel C. Krawczyk

"Scene analogy performance was assessed in adolescent and adult populations who have sustained moderate to severe Traumatic Brain Injuries (TBI), Evidence suggests that both adolescent and adult TBIs result in impaired analogical reasoning due to multiple cognitive factors. Key to analogical reasoning in the TBI individuals appears to be the capacity to update working memory."

Functional Neuroimaging of the Component Processes of Analogical Reasoning

Barbara Knowlton

"... we use fMRI to assess the neural substrates of these presumed components of analogical reasoning. ... A lateral frontopolar region that has been associated with relational integration showed increased activity with an increase in relational complexity. In the ventrolateral prefrontal cortex, a region that has been associated with inhibitory control in a variety of tasks, there was increased activity with increasing levels of interference.

Right and Left Hemisphere Semantic Processes and Possible Relation to Analogy

Mark Beeman

"I will present a framework for understanding semantic processes across the two cerebral hemispheres, including at least three processes: semantic activation (in what is essentially Wernicke's areas), semantic integration (anterior temporal lobes), and semantic selection (inferior frontal gyri)."

Unconscious Processes in Analogy-Making

The symposium focuses on the unconscious aspect of analogy-making bringing together researchers from analogy-making and relational priming domain.

Unconscious Analogical Alignments in Applied Arithmetic Problems

M. Bassok

“... people tend to align categorical object relations with the arguments of addition (e.g., 12 tulips + 3 daisies) and tend to align functional object relations with the arguments of division (e.g., 12 tulips ÷ 3 vases), but not vice versa. The results show that semantically misaligned arguments of addition (e.g., 3 tulips + 5 vases) evoke significant N400 incongruence effects. However, we did not find evidence that semantically misaligned arguments of division (e.g., 12 tulips ÷ 3 daisies) evoke similar incongruence effects.”

Unintentional and Unconscious Analogies between Superficially Dissimilar but Relatioanly Similar Simple Structures

P. Hristova

“... two experiments that demonstrate unintentional and unconscious analogies between 2 subsequent word pairs during color-naming task.”

Relational Priming in Childhood and its Relation to Analogical Completion

Denis Mareschal, Jo Wiltshire & Michael S. C. Thomas

“...describe[s] several studies using a lexical decision task to assess the emergence of lexical priming in children 8 years and older. A number of factors such as language fluency, reading level, and age are all found to influence the level of relational priming observed. In addition, a strong association was found between the amount of relational priming and the probability of successfully completing an analogy using the same words and relations in the younger age groups. “

Computational Models of Analogy

This symposium will present some of the most recent developments in the computational modelling of analogy, including models of the process of analogy-making, the processes whereby the relational representations responsible for analogy are acquired, and the manner in which analogies are integrated with and used for other cognitive processes.

Analogy as a Basis for Cognitive Architecture: The Companions Experience

Ken Forbus

“By using structure-mapping models of mapping, retrieval, and generalization, Companions have been able to learn to solve problems, play games, and learn causal models, using inputs that include sketches and natural language.”

Origins of Representations for Relational Thinking

Leonidas A. A. Dumas

“DORA is based on [the] LISA model, and uses a comparison based intersection discovery algorithm to learn relational concepts from unstructured holistic examples.“

Building Analogies From Recycled Parts

Denis Mareschal

The model “... is never trained on analogies, only on causal relations in the world. Analogical completion is tested by presenting the network with an object and a causal agent ... and allowing it to settle [then] it is presented with a new object ... and is allowed to settle once again. ... it now settles into a state consistent with [the original cause and the new object].”

Exploiting Cross-Domain Structure Similarity in a Distributed Connectionist Network

James L. McClelland, Timothy T. Rogers, and Paul Thibodeau

The model “... relies on learned distributed representations over a set of units that are used for all items in all domains and all contexts. The presence of structural similarity ... The exploitation of this structure leads to the sharing of information across unrelated domains that do have common structure, so that information in each domain affects attributions in the other. “

Analogy, Mind and Body: An Integrated Approach

Boicho Kokinov, Ivan Vankov, Georgi Petkov, Kiril Kiryazov, Veselina Feldman, Penka Hristova, Milena Mutafchieva, Luiza Shahbazyan, Svetoslav Bliznashki, and Svetlin Kosev

“This talk will summarize our attempts to build a model of analogy-making which integrates various cognitive processes and takes into account the abilities and the constraints of the human body.” The attempts include models and psychological experiments spanning embodiment, memory, categorisation, recognition, abstraction, judgement, unconscious analogy-making, and the role of emotion.

Explanatory Reasoning for Inductive Confidence

David H. Landy and John E. Hummel

“We present a novel strategy for combining a probabilistic logic with analogical inference. We apply this inference engine to the task of categorical induction--deciding whether a category bears a property, given that other, related categories do or do not have that property.”

Analogy and Creativity

We will look at the cognitive mechanisms based on analogy that help in generating creative ideas and insights.

Evocation processes in design activities: The impact of intra- and inter-domain sources and of sources conveying affects.

Nathalie Bonnardel

“According to the A-CM model, designers’ activities are based on two main processes: analogy making and the management of constraints. More precisely, we consider that these two main cognitive processes continuously interact during the design activity and can have opposite effects Our general hypothesis is that the designers’ research space of ideas depends on the kind of sources they are provided with. “

Experiments with a Creativity-Support System based on Perceptual Similarity

Bipin Indurkha

“... we are claiming that if the unrelated object that is introduced into a picture or paired with another object bears some low-level perceptual similarity with other objects in the picture, or with the paired object, it is likely to be more effective in stimulating creativity than a random unrelated object.”

How structure mapping between domains affects the creativity of solutions during analogical problem solving.

Cynthia Sifonis

“ research demonstrates that the specific information mapped between domains during problem solving is less important to the resultant creativity of the solution than the manner in which the mapping is conducted.” Creativity is boosted by the quantity of mappings moved across from a source domain.

Humorous Similes: Inside the Plumbing of Creative Language

Tony Veale

“... analogies and most metaphors construct ‘fat’ pipes between concepts and domains, allowing the transport of significant amounts of information from a source to a target along multiple points of alignment between both. [while] Many creative similes construct the slimmest of thin pipes between their topics and vehicles, to transport just a single property or emergent feeling between both. This is especially the case with humorous similes, which often employ complex vehicles that contain multiple entities, but which do not always presuppose a

mapping for these entities into the target domain. ... Humour is a special case, largely because humour revels in the generation of incongruity and the violation of expectations. “

Formal Models of Analogy

The models in question range from symbolic frameworks to subsymbolic research paradigms.

The Analogy via Abstraction Framework AvA

Ute Schmid,

“Analogy via Abstraction (AvA) is a framework for cognitive analogy models based on anti-unification, that is, constructing minimal generalizations over structured (term or graph) representations of a base and target domain together with mappings of variables to concrete objects from this generalized structure (anti-instance) to base and target.”

Unifying Analogy into a Term Logic

Pei Wang,

“In a general-purpose reasoning system NARS (Non-Axiomatic Reasoning System), analogy is taken as “similarity-based substitution”, and it is formalized together with several other types of inference (such as deduction, induction, abduction, exemplification, comparison, and resemblance).”

What Might We Ask of a Formal Model of Analogy?

Ross Gayler,

(see summary of paper above)

Heuristic-Driven Theory Projection and Analogy

Angela Schwering,

“Heuristic-Driven Theory Projection (HDTP) is a symbolic framework for analogy making. HDTP represents knowledge about the source and the target domain as first-order logic theories and compares them for structural commonalities using anti-unification. Anti-unification is the process of identifying the most specific generalization subsuming two formulae.”

Analogical Reasoning Development

The first talks describe mechanisms underlying developments in analogical skill, followed by talks reporting investigations of early analogical learning.

Executive Functioning and Analogy-making in Children

Jean-Pierre Thibaut, Robert French, Milena Vezneva

“We hypothesize that the selection of the common relational structure requires the inhibition of other salient features, such as, semantically related semantic“

Longitudinal Studies of Analogy Development

Lindsey Richland; Robert Morrison; Alex Doumas

“Both studies indicate that knowledge acquisition is essential to improvements in analogical reasoning over time, but that learning trajectories may vary with individual differences in executive function.”

Relational Reasoning and Conceptual Change

John E. Opfer

“... these studies suggest that what develops in relational reasoning is not a freedom from the bonds of perceptual similarity but an increase in the sensitivity to which relational similarities are—and are not—reliable. “

Analogical Learning in Cognitive Development

Dedre Gentner, Stella Christie

“We propose that comparison via structure-mapping processes is the major mechanism by which relational knowledge is extracted from experience. We further propose that language contributes to this process, both by inviting comparison and by preserving the relational insights thereby revealed.”

Instructional Strategies that Promote Analogical Transfer in Children’s Early Science Learning

Bryan J. Matlen & David Klahr

“It appears that directly providing children the schemas they are required to know is advantageous, and that the order in which different types of instruction are presented is of critical importance for facilitating analogical transfer in children.”

Analogies in the Animal Kingdom

“... studies ... challenge the assumption of a strict discontinuity in the perceptual, conceptual, and analogical capacities of nonhuman animals. ... provide insights into how and why analogical reasoning evolved from a foundation of more basic perceptual and cognitive processes. [and] identify proximate requisite environmental contingencies/scaffolding for analogical development in and its expression by individuals.“

Extents and Limits in the use of the Concept Same/Different to Solve Matching-to-Sample Tasks by Capuchin Monkeys

Valentina Truppa, Duilio Garofoli, Francesco Natale, Elisabetta Visalberghi.

“This study aimed at evaluating the extent to which tufted capuchin monkeys ... are able to acquire abstract same and different concepts and use them to solve matching-to-sample (MTS) tasks. ... six out of ten capuchins were able to judge physical similarity after thousands of trials” Phase 2 is underway.

Relational matching and perceptual grouping in baboons

Joel Fagot

“... results suggest the nonhuman primates [baboons] possess at least rudimentary skills for relational matching, and therefore that this ability is not fully controlled by either language or token training. “

Examining Analogical Reasoning in Capuchin Monkeys and Chimpanzees using a Three Dimensional Search Paradigm

Erica Hoy Kennedy, Timothy Flemming & Dorothy Frigaszy

“... this research investigated the ability of two primate species to solve an analogical problem in three dimensions [as opposed to 2D]. ... [and] One of four capuchins and three of four chimpanzees tested reached criterion on these tasks, ... “

Assessing Relational Similarity in Great apes and Children in a Spatial Task

Josep Call & Daniel Haun

“We investigated the ability to recognize relational similarities by testing five species of great apes, including human children in a spatial task. We found

that all species performed better if related elements are connected by logico-causal as opposed to non-causal relations. Further, we find that only children above 4 years of age, bonobos and chimpanzees, unlike younger children, gorillas and orangutans display some mastery of reasoning by non-causal relational similarity.“

Do capuchin monkeys show analogical reasoning when using tools?

Gloria Sabbatini, Valentina Truppa, Barbara Gambetta, Elisabetta Visalberghi

“... we investigated how capuchin monkeys (*Cebus apella*) solve tool problems requiring the appreciation of the length of the tool(s) in relation to the length of the tube(s) containing a reward. This same experiment is underway with chimpanzees and children.

Does the ‘Profound Disparity’ in Analogical Reasoning Still Stand? Current Lessons from Humans, Chimpanzees and Monkeys in Relational Matching Tasks.

Roger K. R. Thompson & Timothy M. Flemming

“We present results from recent studies with humans, chimpanzees, old-world and new-world monkeys on relational matching of spatial relations (above/below), stimulus ‘meaningfulness’, and differential outcome effects. Overall, the results call into question the claim for a ‘profound disparity’ between species, but they do point to significant disparities in the environmental ‘scaffolding’ likely necessary for the expression of relational matching skills in primates.“