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DOMAIN SPECIFICITY AND CROSS-DOMAIN TRANSFER *

The reality of the idea of domain specificity, and its consequences for the formation of complex cross-domain mental constructions, like causal chains, analogies and metaphors, were the subject of this research. Two developmental studies: an experiment and an analysis of speech diaries, confirmed the hypothesis that domain specificity is one of the main rules applied by young children to construct mental representations of causal chains. Results of a series of experiments with adults on metaphors and ad hoc categorization enabled a partial reconstruction of complex links between domain specificity and systematicity of naive theories of domain. Objects belonging to highly systematic domains, e.g. animals or plants, are poor exemplars of ad hoc categories based on criteria which are true but not relevant for the domain theory, whilst objects in less systematic domains (e.g. artefacts) could be included in the category on the basis of any true criterion. On the contrary, in metaphor processing it is easier to interpret cross-domain metaphorical descriptions of objects in a systematic domain than those in a less systematic one. Systematic domains supply the mind with a net of causal-explanatory concepts which form the base for metaphor interpretation and the construction of true metaphors, but on the other hand make categories more theory-dependent and so "domain-specific".

> "A domain is a body of knowledge that identifies and interprets a class of phenomena assumed to share certain properties and to be of a distinct and general type. A domain functions as a stable response to a set of recurring and complex problems faced by the organism. This response involves difficult-to-access perceptual, encoding and retrieval, and inferential processes dedicated to that solution." (Hirschfeld & Gelman, 1994, p. 21)

The principle of domain specificity has been widely accepted in the research on concepts and conceptual development across the last ten years. There are serious reasons, of both a theoretical and empirical nature, to believe that conceptual knowledge is organized into modular, or quasi-modular structures, each of which refers to distinct sets of real phenomena, and is governed by a specific set of rules. Ecological-evolutionary arguments (Cosmides and Tooby, 1994), the solution (at least partial) to the frame problem,[1]

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[1] Taking it very generally the frame problem is that of an appropriate level of organization of knowledge which would allow the system to find in real time solution(s) (but only relevant) of a given situation. Fodor's (1983) modularity thesis is one of the attempts to solve the frame problem. It is important to note, however, that Fodor himself disfavours the idea of modularity in conceptual knowledge (see e.g. Fodor, 1994).

(see papers in Pylyshyn, 1987), Keil's studies of ontological constraints (1979) and natural kinds, artifacts, and nominal kinds (1989), numerous studies of early perception, understanding, and differentiation of physical and intentional causation (see e.g., papers in Sperber, Premack, and Premack, 1995), all provide examples of arguments supporting the idea of domain-specificity in conceptual knowledge.

On the other hand, the idea of domain specificity raises many problems. First, there is a complex issue of conceptual development: do the set of domains at the start correspond with the set of mature domains? What is the role of previously formed domains in the acquisition of new ones? Does domain specificity characterize conceptual knowledge at every stage of development, or rather only specific stages (initial, intermediate, mature-expert)?.

The second group of issues concerns domain boundaries and cross-domain transfer. The list of examples could be expanded endlessly, e.g. intentionally initiated movements are at the same time appropriate subjects for the laws of mechanics; people are intentional beings, but any intentional being is also biological (let us skip here the "can-computer-think" debate), and biological objects are also physical ones; some natural objects can be used as tools, while some artifacts can substitute for natural objects and substances. What about categories like foods — are they natural or artifactual? If rules of inference are domain-specific, how can a cross-domain transfer be realized (e.g., in analogies and metaphors)? How is it possible to form the representations of cross-domain causal chains, so often met in the natural world?

While the first group of problems will be discussed in the final debate chapter of this volume, the idea of this paper is to present briefly a large project addressing at least some of the questions in the second list concerning the relations between specific domains, and to describe some very initial research aimed to answer some of these questions.

There is no reason to believe that domain specificity is a single "domain-general" factor. It has rather many different, specific, non-compatible manifestations. The most appropriate approach to domain-specificity is to study peculiarities of specific domains, e.g. naive knowledge of mind, naive knowledge of physical bodies, naive astronomy etc. There are numerous studies following this approach, and I myself endorse it too. Such an approach allows for verification of the psychological reality of each separate domain; paradoxically however it fails to address the reality of the construct of domain-specificity itself and, moreover anything that is on the line of domain junction. In this project we have followed a different direction. Our research consists of two parts. The first part was intended to approach directly the issue of domain-specificity in development of everyday reasoning and constructing causal chains. The second part was an attempt to find the evidence for domain-specificity in the transfer tasks at different levels of representation: explanatory scheme, object, and object features.

Developmental study of domain specificity in everyday reasoning

Consider a simple story: sunshine and rain caused the growth of tree roots, which in turn destroyed the sidewalk surface, and an "absent-minded" person has fallen on it. This sequence consists of a chain of causes linked to different naive theories: naive "natural sciences" (astronomy, meteorology and geology: rain and sunshine), biology (roots growth), psychology ("absent-mindness"). Some elements of this chain could be substituted by others (e.g. mole's tunnel, or subterranean water flaw instead of root growth). The chain could still incorporate new elements from other domains.

Understanding causal relations seems to be vital in science and common sense reasoning. Causal explanations and the development of understanding causality have been frequently studied in cognitive psychology (e.g. Bullock, Gelman and Baillargeon, 1982, White, 1994, Sperber, Premack and Premack, 1995), as well as in the Piagetian tradition (Piaget, 1929, Laurandeau and Pinard, 1962). Recently, it was suggested that knowledge of causal relations forms a base for domain-specific conceptual knowledge and its use in reasoning at any developmental stage (see papers in Sperber, Premack and Premack, 1995).

How could an everyday story that links together elements of different domains into a causal chain (like the above) be worked out by domain-specific inferential mechanisms? What are the competitive mechanisms that could integrate the chain? I have designed two studies to deal with those questions (Haman, 1994). In the first study, children aged between 3 and 11 years were asked to perform some operations on a set of picture stories combining elements from different domains. The second study was the analysis of CHILDES protocols of spontaneous speech of nine Polish children between two and seven in search for domain-consistent and cross-domain causal constructions.

Domain specificity, similarity, and familiarity in integration and substitution of causal chains

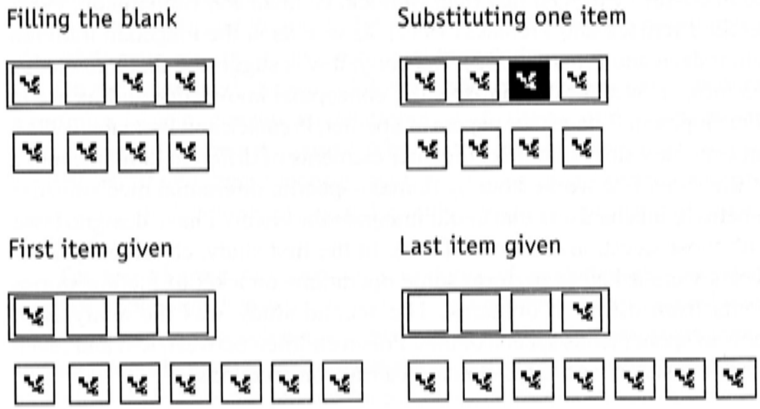
Does domain specificity appear early in the development of everyday causal reasoning, or are there other, domain-general, and more superficial mechanisms to integrate causal events into chains? Four experimental tasks were designed to test the role of domain specificity against two other candidate integratory mechanisms: similarity and familiarity (or typicality). Perceptual similarity seems to be a powerful non-conceptual mechanism grouping objects and events into coherent chains or categories, without or in addition to conceptual analysis (Medin, Goldstone and Gentner, 1993). Familiarity or typicality of a given sequence or configuration could provide reinforcement for some links between events or elements of categories. All four tasks were based on the same sets of picture stories, and the same group of subjects was tested. The following section is a summary description of the study.

Subjects. 88 children from two pre-schools and one primary school in Warsaw were recruited for the study. Children were divided into four age groups: 3;6 - 4;11, 5;0 - 6;5, 6;6 - 7;6 and 9;10 - 11;2. The three younger groups consisted of 24 children each, and the oldest group consisted of 16 children.

Materials: 12 sets of pictures were designed. Each set consisted of 8 to 10 pictures[2], each of which depicted a single event. The events in the set could be integrated into different variants of the causal chain (the absent-minded man story mentioned above is one of the examples, the story of a snowman melted by the sun or radiator, or destroyed by dogs is another one), and belonged to at least two (sometime three) different domains. One of the domains formed the main line of the story, while the remaining were the alternative solutions. The domains in the study were: intentional, mechanical, biological, and natural (geo-astronomical).

[2] Depending on the task 7 or 8 elements were used. However some sets differed slightly depending on the task, and so could consist of more than 8 elements.

Fig. 1. Graphic representation of child's tasks



Procedure. Children were tested individually at their schools. Each child was tested twice with 1 to 3 weeks interval between sessions. Every session consisted of two tasks, so each child was asked to solve each task only once[3] . The four tasks were:

(i.) Filling the blank in a four-item story. A special frame with four positions in line was displayed in front of the child. Three places in the frame were just filled by the experimenter. The experimenter asked the child to tell what happened in the pictures and then to look at an additional set of four pictures, tell about them, and fill the blank (on second, third or fourth position) with the picture which fits best the story in the frame (see Fig. 1 for graphic representation of all four tasks).

(ii.) Substituting one element of a four item story. The general procedure was similar, except that all four places were initially filled. The child's task was to substitute one of the pictures with one of an additional four.

(iii.) Filling three blanks in a four item story (first item given). Within the same general procedure children were asked to choose three pictures from a set of seven items to fill the blanks in the frame. Only the first item in the frame was given.

(iv.) Filling three blanks in a four item story (last item given). The same procedure as in the previous task was applied except that only the last (fourth) item in the frame was filled by the experimenter.

Each time children were asked to tell something about each picture in the set and, after filling the frame, to tell the entire story.

The first task (filling a single blank) was designed primarily to test the role of domain-specificity and typicality/familiarity in integrating causal chains, as the child was looking for one item which fitted the chain constructed out of three other pictures. The second task (substitution of one item) was to test the role of similarity and domain-specificity

[3]Because there were 12 picture sets, each in each age group was processed by two children in each task. The picture sets for a single child were selected to skip cross-set similarities in domains and scenes. Children from the oldest group, performed two tasks twice (either task "i" or "ii" and "iii" or "iv"; degrees of freedom in analysis were adjusted appropriately.

in substitution of causal events — the point of reference for the child was first of all a single picture in the chain to be replaced by one of four alternatives, and the entire chain formed only the background. Both tasks were relatively simple — they required the selection of only one picture out of four.

The two remaining tasks were more complex: the child was asked to choose three pictures out of a set of seven. The aim of these tasks was to test the role of all three factors: domain specificity, similarity, and typicality at once. The difference was on the level of causal determination. If only the first element was given there were different possible lines to develop the story. On the contrary, with the last element given the causal structure was much more apparent, as the picture displayed in the frame represented the final state. We expected that this kind of emphasis on the causal structure of the story could enhance domain-specific choices, assuming that it is a causal-explanatory network that makes the domains coherent.

Since the pictures represented relatively complex scenes, composed of many elements and varying on different dimensions, it was impossible to vary the factors in the study systematically and independently. For those reasons another design was adapted. Domain-consistency, similarity, and typicality were estimated for each alternative choice, using the technics described in footnote fourth[4], and analysis of covariance (MANOVA/ ANCOVA) was performed on the scores obtained from children's choices. Two ANCOVA were run for both substitution and filling single blank tasks (one with domain specificity as a dependent measure and typicality or similarity respectively as a covariate, and one in the reverse design, with age group and story as independent variables each time). Next, six ANCOVA were computed for two remaining tasks (with each of three variables as dependent and two remaining as covariates).

Results. Figure 2. represents means (adjusted for covariates) of three variables in the study, with respect to the task and age group. To test effects of domain, similarity, and typicality *t-tests* were computed for each age level against the expected random (chance) level. As expected, the most apparent tendency for domain-specific choices was found in the two tasks which forced the focus on the remaining pictures in the sequence, or causal structure of the story (filling a single blank and filling the frame with the last element given). However even in the relatively complex task with first item given only the youngest group performed at the chance level, and there is a developmental trend of strengthening the role

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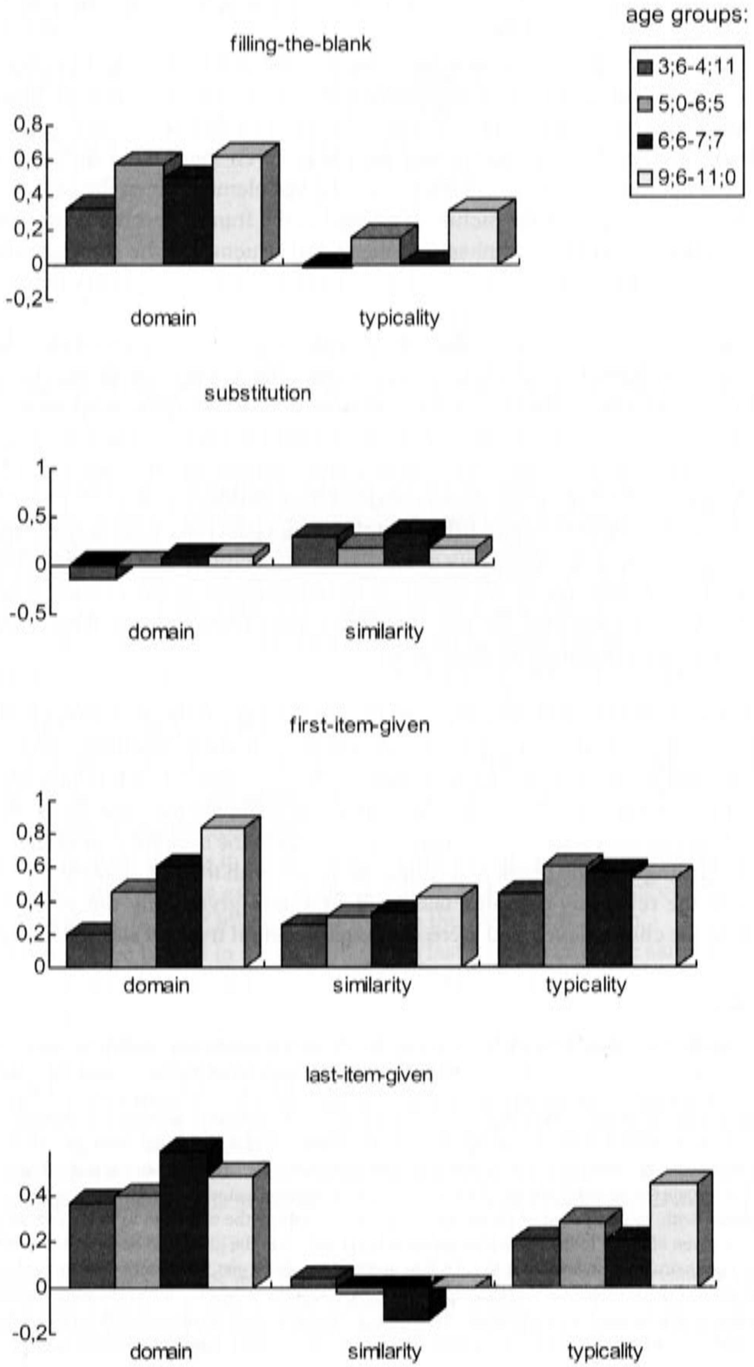
[4] For domain consistency the score was composed of the total number of elements consistent with selected one (in tasks "i" and "ii") or three (tasks "iii" and "iv") weighted by the referent item position in the story (weight 1 for last element, weight .5 for the neighbor items and weight .25 for the remaining items; for the substitution task also the substituted element was weighted 1). For typicality and similarity competent judges procedure was applied: 5 judges estimated the value of each item of the choice set for each task separately (only similarity judgments were made for substitution task, and typicality judgments for filling-the-blank task). The judges were instructed to estimate the typicality of the element in standard children's stories or activities starting with a given element (ending with, or composed of given elements, respectively to the task) and to judge overall perceptual similarity of a given element to the remaining pictures in the set, or to the picture to be substituted in the substitution task. The instruction stressed not to take into account the story gist, consistency, or any other causality related factors. All three measures were computed for any possible subjects' selection and relativized to the expected value assuming random selection by the subjects. Note that the measure for different variables or even the same variable in different tasks are not compatible except that value 0 represents chance level.

Fig. 2. Means for domain-consistency, similarity, and typicality adjusted for covariates (chance level=0)



Causal chains composed of two or three elements could already be found at the age of two. Most of them are domain-consistent. What is of special interest here, cross-domain chains usually are restricted to a few typical patterns, e.g., mental development and mental abilities are linked to biological growth (eating - getting bigger - the ability to read and write). It seems that the children in the study see and respect domain borders, even if they use a cross-domain metaphorical language, e.g. refer to the thunderbolt as a snake, but do not accept the comparison of that "snake" to real snakes in terms of their properties. There are some communicative means used by children to indicate oddness of most of cross-domain explanations: laugh, referring to non-real status of a statement, etc.

Another interesting observation concerns the role of animist and artificialist explanations in children's causal constructions. Psychological-intentional (including also magical and religious) causes are the most frequent in any corpus in the analysis (congruent with results of the study by Callanan and Oakes, 1992). Different psychological events are easily and creatively combined into complex chains, in a domain-consistent manner. Psychological-intentional causality is also broadly used by children as a supplementary source of explanation in both natural domains (biology and inanimate natural kinds) through different kinds of personifications. However, children seem to draw a sharp boundary between domain-specific and intentional explanations. These are rather different levels of thinking, and the domain specificity principle is not violated here. On the other hand, children differentiate also artificial origins of artifacts and natural origins of natural kinds, although it could be misinterpreted by adults. That could be illustrated by the following example: MIS (3;5) *What is wool made of?* MAM: *It's not made, it grows on the sheep.* MIS: *What is one doing to the sheep to grow the wool?* MAM: *One gives the sheep some food, and the wool grows like your hair.* MIS: *It's me that grows from food, not my hair. Mommy does not know about sheep: the sheep bows itself, bends, and then wool grows.* For MIS wool is a kind of material, so he cannot accept the biological explanation proposed by MAM. His own explanation is a kind of compromise: the sheep is performing some physical actions to produce wool.

Cross-domain transfer studies

Other research was designed to study the problems of a cross-domain transfer. A radical domain specificity hypothesis leaves no room for cross-domain transfer: objects, objects' properties, and causal schemes would not be compatible across domains. However, no one assumes absolute domain-specificity. Thus the questions arise: Which elements of conceptual representation are transferable, and which are not? Are there differences between domains in the pattern of cross-domain transfer? Other very important questions, which will not be discussed here, concern the developmental order of domains: are some domains acquired on the basis of domains developed earlier? Which domains are present at the start?

What is specific about domains? The following is a list of candidates:

- Objects
- Trait and properties
- Trait correlations
- Explanations and causal concepts
- Structural patterns
- Mode of acquisition
- Procedures of problem solving

Objects naturally group into kinds (Keil, 1979, 1989, Gelman, this volume). Explanations and causal concepts form domain-specific naive theories, and thus make the domain coherent. This explanatory framework accounts for specific object properties, and particularly for trait correlations (Murphy and Medin, 1985). We have started a large research project to systematically investigate the processes of cross-domain transfer of these elements of conceptual domains. The project is still in progress but some results can already be presented.

The project was motivated by two studies. Some years ago I tested preschoolers' understanding of spatial metaphors for mental transfer, e.g. "to give an idea" or "thoughts scattered" (Haman, 1991). In contrast to other research on children's understanding of metaphors (e.g. Keil, 1986) I tried to re-construct the entire mental model underlying metaphor interpretation. Apart from a proper interpretation (like "to give an idea is to tell it") I have also been checking further consequences of metaphorically expressed action (e.g. who has the idea when "given"). The developmental pattern of answers was intriguing. The most frequent pattern for five-year-old subjects was an appropriate interpretation, but incorrect consequences, specific to moving a real object (like "to give an idea means to tell it, but only the receiver has the idea then", or "if my thoughts scatter I cannot remember anything, they move somewhere else in my head, or to my legs", etc.). For older, about six-year-old subjects, the most frequent pattern (besides the fully correct interpretation) is a reverse one to that of five-year-olds: lack of a proper interpretation, but correctly predicted consequences (e.g. "I do not know what it could mean to give an idea, but both agent and recipient will have the idea afterwards" or "I do not know what it means that thoughts are scattered, but it does not make sense to say that the ideas are somewhere else in the head)[7]. Further studies rejected the possibilities that five-year-olds' model of mental transfer simply maps spatial properties of physical transfer, or that the metaphor is interpreted in terms of transfer of possession, or "copyright" for the idea. None of fifteen children in an additional sample of five-year-olds, and only one of six-year-olds did not fail when asked who had an idea which was told. So the problem is not in the lack of appropriate conceptual knowledge of domain-specific causal relations, but in correct mapping between two domains. It seems that younger children tried to map specific actions, so failed when action consequences conflicted, while older children made attempts to match abstract causal relations, but lost access to specific actions. Thus this is systematicity of domain knowledge that explains our results.

The second study which gave the impulse for the current project was done by my student, Agnieszka Grynkiewicz in collaboration with Krzysztof Najder and myself, and was a part of requirements for her master's thesis (Grynkiewicz, 1994). Using the "paper and pencil" procedure, she asked adult subjects to estimate the degree to what some properties could be assigned to certain objects. The list of objects consisted of intentional ones (man, nation, disembodied spirit), human body part (hand), animal (elephant), inanimate natural kinds (moon, river, rock) and artifacts (computer, comb). The list of properties was constructed to include intentional and behavioral properties (can remember, can think, makes choices, is brought-up), biological, related to intentional or social (has parents, childhood, has brain, is self-propelling) other biological and natural (can reproduce,

[7] Age-related differences in frequencies of these two patterns of answers were statistically significant.

breathes), general-spatial (size) and finally artefactual (is used for...). The name of each object was displayed on a separate page of a test booklet. Subjects used continuous, 6 cm long scales for each subsequent property with a "decisively no" value assigned to the left end and a "decisively yes" to a right one, which was later transformed into a 13 point discrete scale. There were two groups. One of them ("experimental") was exposed to special manipulation: before describing each object, subjects were instructed to imagine that the object will express some behavior (in the narrow, intentional sense), and asked what it will do then. In other words, subjects were asked to put an object into an intentional scheme. As expected, this manipulation increased subjects' inclination to assign intentional properties (and intentionality related biological properties) to the object. The effect was more apparent for objects from "less intentional" domains, like artifacts and inanimate natural kinds ("intentional objects" and animals got high ratings on intentional properties scales even in the control group). Substituting the nonintentional objects into an intentional explanatory framework involved also description of that object in intentional terms. This validates the hypothesis that it is a first-of-all causal-explanatory framework that makes a domain coherent.

In a series of subsequent experiments we were seeking other properties of domain knowledge which constrain cross-domain transfer. First, we tried to extend Grynkiewicz' results into other domains. Similar technics of manipulation were designed for biological, natural phenomena, and artifactual explanatory frameworks, also objects and properties were systematically varied across those domains. In one study, a similar "paper and pencil" procedure was used, whilst in still another one we measured reaction times for yes-no answers to questions like "is the rock man-made?" (while the subject had been asked before to imagine the rock behaving, breaking-down, or breathing, etc.). Each group of subjects processed only one kind of manipulation (intentional, biological, artefactual etc.) applying it to an entire range of objects, so the design was a complex ANOVA scheme with manipulation as a between-subject factor, and the domain of object and domain of property as within-subject factors. Surprisingly, no effect of manipulation, nor interaction of domain of object with manipulation and domain of property was found. There were however strong effects of the domain of object. The shortest RTs were found for natural kinds (both biological and non-animate), the longest ones for artifacts. A similar pattern of results was found for yes/no answers, except that the highest frequency of "no" answers was noted for "mental objects". We interpreted these results as an effect of higher consistency (systematicity) of natural kind domains: artifacts are more resistant to description in terms of other domains, because there is no coherent causal-explanatory network which could integrate metaphorically expressed relations. In some sense, the atomic structure of the domain of artifacts requires one-to-one mapping of single elements. Natural domains, which rely on systematic theories seek rather for structure mapping and thus make non-literal interpretation of metaphor more likely. The next studies seem to confirm that inference.

Why have we not been able to replicate the manipulation effect found in the Grynkiewicz study? One of the possibilities is that we tried to get too much from a single experimental design. In order to systematically combine five domains of objects and five domains of properties, we reduced radically the number of objects and properties in each domain (there were two objects and four properties in each). The variance caused by specific object-property combinations could totally override manipulation effects (moreover, it was rather interaction of manipulation by domain of property that was expected). A strong property effect (which was found only when each single property was treated as a separate factor level), contrasted with the lack of any effect of the domain of property, supports this conclusion. Further research is necessary to clear up this issue.

In another study, Elżbieta Filipek and myself (Filipek, 1995) investigated two kinds of cross-domain metaphors: direct comparison (x is like y, e.g. "a woman is like a star") and "functional metaphors" (x behaves like y, e.g. "a woman shines in the sky", which indirectly, via the causal-explanatory framework, compares a woman to sun or stars). Metaphors varied also on the dimension of generality (e.g. "a woman is like a star" vs. "an actress is like the morning star"). The subjects' task was to interpret the metaphor, and then decide whether the object in a metaphor tenor has the properties from a list of 12 items. The list consisted of 3 properties from the domain of metaphor vehicle true in the light of the metaphor, the next 3 specific to other domains and false, 3 properties true about the tenor but not linked to the metaphor, and 3 false, not linked to the metaphors. The score was an average reaction time for each group of properties[8].

As expected, it was found that specific features of the vehicle which were true about tenor in the light of the metaphor were accepted more easily than nonspecific true, specific false, and nonspecific false, respectively. The effect was most apparent in the case of social and biological domains, whilst nonspecific true were accepted more easily for artifacts (tenor domain by property type interaction was also significant). There was also an effect of tenor domain[9]: social and mental objects got generally highest scores on all properties (with an exception for the interaction described above), natural kinds had intermediate scores and artifacts had the lowest ones. Direct/indirect form and generality of the metaphor had no significant effect; there were significant, although weak interactions of both of these factors with tenor domain, for example, artifacts got higher scores on all properties in the case of indirect metaphors.

Highest acceptance of domain-specific properties is not surprising and provides a new argument for the idea of domain-specificity itself. The results also support the conclusion drawn from the previous study: more coherent domains (here natural kinds and "theory of mind") are "better" tenors for the metaphors, because their metaphorical descriptions are easier to integrate into the causal framework of the domain. Artifacts, which do not form a coherent domain, are more resistant to metaphorical descriptions, although easily accept nonspecific descriptions carried by metaphor. However, if substituted into other domain's causal network (indirect metaphor), they become a little better tenors. The following study provides further evidence for the role of systematicity in cross-domain transfer.

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[8] It was assumed that the quick "no" answer corresponds to rejection of the property with high certainty, and the quick "yes" answer corresponds to a high level of acceptance of the property. Delayed answers were accounted for as a lack of certainty. For that reason special recounting procedure was applied to the RTs for "no" answers: $2*MRT-RT_{no}$ where MRT is mean RT from the entire sample and RT_{no} is the individual reaction time for a given "no" answer. An analysis on the absolute RTs was also performed, but has not revealed any systematic effect, and that seems to validate our scoring system.

[9] Appropriate ANOVA for vehicle domain was also done, however the results are not warranted, as the design was not balanced for this factor.

Table 1. Percentage of objects from five domains in each ad hoc category type

OBJECT DOMAIN	artifacts	psycho-logical-social	animate	non-animate	other	overall
CATEGORY TYPE						
non-observable property	25.7	28.3	22.2	20.2	3.4	22.6
observable property	49.7	7.0	20.2	21.2	2.5	16.6
goal	52.9	29.8	11.1	3.3	3.3	23.9
function	50.7	16.5	24.7	6.0	2.1	17.7
social relation	24.5	66.4	6.4	1.7	1.0	20.0
overall	41	30	17	10	2	100

Cross-domain ad hoc categories

In some sense, we could describe the preceding studies as the investigation of cross-domain transfer of domain-specific explanations (manipulation in the first two experiments) and domain-specific properties. Another issue concerns cross-domain transfer of objects and cross-domain categorization. Goal-driven ad hoc categories, which grasped objects from different domains were extensively studied by Barsalou (1983, 1989). However most of the new categories in Barsalou's studies were based on social goals. My student, Sławomir Szafraniec and I have used the procedure of generating ad hoc categories to check if objects belonging to different domains could be used in ad hoc categorization based on different principles, not only goals, but also internal functions (e.g. internal circulation of fluids), social relations (e.g. displaying sympathy), observable and hidden properties (e.g. shape, size, color, texture, kind of substance, etc.). Whilst in the preceding studies objects were substituted in other domain causal structures, described in other domain-specific features, or simply compared to other domain objects, here the goal was to test the possibility to transfer an object to a domain-neutral category defined according to formally different principles.

54 adult subjects were tested with paper and pencil procedure. They received booklets of 30 pages, each page containing a definition of a single ad hoc category. Subjects' task was to generate as much objects as possible as exemplars of the category (the instruction defined the term "object" very broadly, including also non-material phenomena and events. Objects generated by subjects were then classified into 7 domains (artifacts, biological, inanimate natural, psychological-social, physical, like forces, atoms etc., some properties of situation, and other - nonclassified) and the numbers (proportions) of objects from each domain in a given category type (i.e. based on goal, function, observable property, etc.) were scored.

Some of the results are summarized in Table 1. Because physical, situational, and non-classified objects taken together never exceeded 3.5 per cent (2 per cent in the overall results) they are aggregated into a single position "other" in the table. The most prominent result was a very strong dominance of artifact objects. The second most frequent domain was psychological-social, but it was very broadly defined and contained mental and emotional states, non-material human products, cultural events, social events and relations, and so on. Although we were aware that such a defined domain is extremely eclectic, we did not have any clear criteria to make two or three more coherent domains out of it. Both domain and category type effects were statistically significant; however it is worth noting that it was relatively easy for subjects to generate exemplars of any category type. So, not only goal (as in the Barsalou studies) but also other criteria could start the process of ad hoc category formation.

The most interesting result is strong category type by domain interaction. While artifacts are very frequent in any type of category, and their proportion is significantly below 50 per cent only in two category types which involves complex causal dependencies (internal properties, and social relations), other domains behaved much more in the domain-specific manner, for example, the frequencies of natural kind domains radically increased when the category was defined by observable property, non-observable property, or function (only for living kinds), and were marginal in remaining category types. Psychological-social phenomena are of course most frequent in categories defined by social relations, and by goals, and marginal if category is defined by observable property.

A detailed analysis of categories based on observable property led to another interesting fact. While the properties defined in the study (shape, size, texture, color, state of substance, and hardness) apply almost to any material object, the proportion of particular natural kind domains significantly varied depending on the property. The categories defined by the color, texture, substance state, and hardness radically increased the proportion of non-animate natural kinds, while the categories defined by shape and size increased the proportion of biological kinds. Appropriate natural kinds were in some of those categories even more frequent than artifacts. The proportion of artifact objects was relatively stable across all these categories. It seems that in the case of artifacts the objects to be included into a category are retrieved (and the decision is made) on the basis of a single attribute, but in the case of natural kind (and psychological-social phenomena) the process involves domain theory, and the object could be retrieved as a category member when the defining criterion is a part of the theory.

Instead of conclusions: What next?

Studies presented in this paper have not given a definite answer to the questions concerning cross-domain transfer, although validated the domain-specificity hypothesis for both adults and young children and linked the pattern of domain-specificity to the systematicity of the causal-explanatory system in the domain. We have got a good starting position for ongoing research, and I am going to list now the most intriguing issues to be studied.

First, the most promising direction for new investigation on constraints on cross-domain transfer are the formal properties of domain theories. Our results are in intriguing contrast with Gentner's (1989) theory of analogy and Medin, Goldstone and Gentner's (1993) view of similarity. Systematicity of mapping seems to be crucial for both our and Gentner's and her colleagues hypotheses. However, while the structural alignment hypothesis suggests that a more systematic domain is the best candidate for reference object position (vehicle in metaphor), in our research more systematic domains were better tenors. We have to improve our procedure in the search for the solution of this controversy.

Also, we have just started to work on further research extending our findings in ad hoc categorization. One of the directions is to design new experiments with factors balanced and controlled in a better way, and other, alternative indices (for example, selection of objects to the category from a given, finite set, and reaction time as a measure). Our previous study was not fully reliable with respect to the specific formal patterns (types of category definition) and their effects on the domain of objects included in the category. We will pay more attention to this factor in new research.

Another line leads to the problem of domain-specific use of general, observable properties in categorization. I refer to that problem in the context of shape bias in naming in the final debate chapter of this volume.

Up to here we have almost ignored the problem of developmental succession of domains. There are other debates concerning this problem, see e.g. Keil (1994), Carey (1985), Carey and Spelke (1994). What do the later developed domains take from the earlier ones? Do early acquired domains "give birth" to later domains, or only transfer to them some structural patterns as first hypotheses? Some data from our speech diaries study, as well as from e.g. Springer and Keil's research (1991, Keil, 1994, 1995) suggest the later possibility. However, a totally distinct developmental pattern could be predicted on the basis of Lakoff and Johnson's (1980) vision of conceptual systems as based on imagery-spatial metaphors. We will try to contrast these two approaches (preliminary, and very provisional results indicate independent roles of both the domain-specific causal-explanatory network, and spatial imagery schemata, Barański, 1996).

And, finally, we will continue to search for the role of causal-explanatory systems in defining domain boundaries and constraining transfer.

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