

MODES OF ANALOGY “WHAT HUMAN COGNITIVE ABILITIES CAPTURE AS STRUCTURES FROM THE WORLD?”

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ABSTRACT

Every new things and ideas involve any inventions inside. If people attempts to elucidate those creative abilities to make them being enable, there would be one question that people could come up with. “What human cognitive abilities capture as structures from the world?” Structuralisme gave an answer to this problem through Metonymy and Metaphor. Recently those questions are relocated in analogies. However those solutions have not been reached out to concise suggestions to apply analogies to several fields in practical way due to be unclear and uncomfortable to utilize them.

Analogies are generally described in these three; proportional analogies, predictive analogies and analogical problem solving in existing research on analogies. These classifications are fit to comparing results which are available to observe from outside as data, but not good enough for analogies generation processes which are ways to know human cognitive effect. By current general cognitive processes of analogies, it begins with source domain and target domain to get analogy. Then there are key effects in middle of analogies processes; retrieval, mapping and transfer. In order to make the capacity for putting analogies to practical use, it should be considered to refine the works on some key elements on cognitive processes like memories, abstraction and transfer. To those problems, this study has been approached to make an addition to types of memory by Larry Squire with ‘memory of image’ as the third memory. Therefore, in this study it is considered that most of metaphors are utilized to understand things to make them outstanding, and metonymy refers to describe things through part-whole relation. In addition, it is concerned that synecdoche based on concept hierarchy is also a class of metonymy. It attempts to formulate analogies for analogies research by categorizing analogies as working modes to find out relations. Considering these points, this paper provides 5 types of modes of analogy in the categories of metonymical and metaphorical at first, then 3 types of modes of analogy which could be located in new categories between metonymy and metaphor to give an answer to “What human cognitive abilities capture as structures from the world?”

The previous study of analogies generation processes in human cognitive science has been adopted in this study to make processes more clear. In evaluating modes of analogy, ‘transfer’ which is a key element on analogies processes should be also refined. For this problem, this paper gives an attention to what things make relations on each domains; source and target. Then this paper gives two classifications to show features of relations between source and Target domains. Also, this paper provides one more kind of classification to know features from modes of analogy. According to features of existing analogies, modes of analogy could be divided in case-based analogies and no case-based

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analogies. Through these framings, this study found that some modes of analogy could be considered that they displays more creativity on the analogies generation processes than other modes of analogy.

As a result of this achievement, this study found one unique way to capture structures by human cognitive besides metonymical and metaphorical ways. It shows relations even there is no common axis to link between things. Some part of this field were mentioned in philosophy as ‘strength’. It means human cognitive captures structures in infinity, and this is before representations. This field will be discussed in future work.

Keywords: modes of analogy, human cognitive abilities, creativity

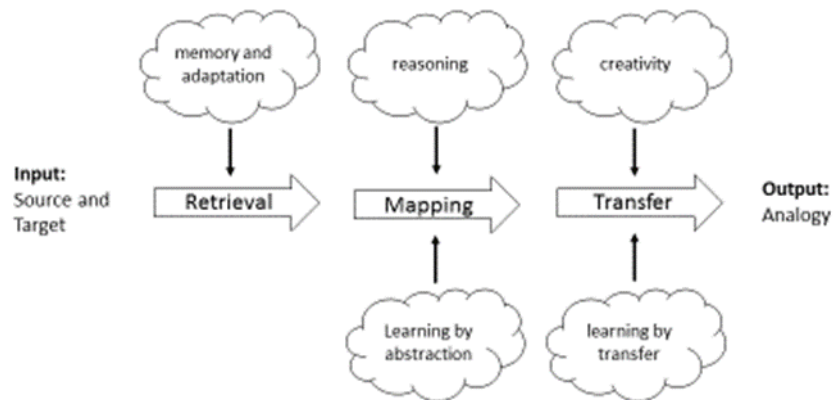
HOW TO UTILIZE ANALOGY IN PRACTCAL USE

Human naturally has abilities to capture similarities. According to those human cognitive processes, analogy makes being able to predict what some objects are. This kinds of human experiences can be described with some feelings such like a sort of nostalgia, which you know well what it is somehow, even though that is so ambiguous to explain. It hasn’t been discussed so much what human cognition captures as similarities in practical way. For instance, even we know well about ourselves facial condition through photos, then able to give some comment to ourselves such like “This picture hasn’t perfect smile on my face.” People knew well which face is more perfect, even we can’t see our faces on time to take photo. This can be sort of abilities capturing degree. It is obvious for human to know which one has 100 percentages of similarity with concepts, and which one has only 70, 50 or 10 percentages of similarity. In human cognition, ambiguous information is available processed by finding some similarities. In particular, analogy takes aim at a sophisticated cognitive process to transfer information from a specific domain to other domain through some similarities. History of analogy research has taken long time, then people has understood value of analogies. However, it is still insufficient for practical use due to the lack of setting for applying. This study takes an attitude to make setting with precision through understanding what kinds of similarities could be captured by human cognitive abilities toward this problem on analogy research. Therefore, it has focused more on human cognitive abilities for finding links between things to see distance in similarity and some structures which are generated. This paper is proposing modes of analogy to categorize analogies with consideration on way to get analogies by human cognitive abilities.

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MEMORY OF IMAGE AS THE THIRD MODE

Analogy making process is usually described in cognitive science. Figure 1 shows a brief procedure to get analogy. There are three key activities on this process: retrieval, mapping and transfer. This study has approached to these points to figure out for modes of analogy and also focused on memory.



**Figure
Analogy**

process in cognitive science

**1.
making**

According to Squire's model of memory, memory can be divided into two categories: declarative memory, which can be divided into episodic memory and semantic memory, and procedural memory, which are created through procedural learning. For instance, procedural memory takes part in how to take a bicycle. However, there is no description in model of memory by image. In myths about image, people think that image should be classified from sensations and perception. In fact, it doesn't locate in the parallel with sensations and perception to know reality. Image usually relates with fantasy and fiction, and only few times it is able to work for imagination and creativity. Despite image can be fiction which is created by human, it supports enormous area to keep our daily life. In this study, memory of image by Kawamoto has been considered as the third memory.

Image provides a better effect to create experiences. Among others, it can be a clue for body action. It generally has been described with representations from visual images due to easiness to share what it is in our own minds. However, there are unrepresented images which sometimes has been expressed through a figurative word by poets. Essentially, image is divided into two categories: performative image and motility image. The performative image is image of motion and movement. It makes people available to imagine a scene including themselves while they walk. Secondly, the motility image is

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image of motions which makes people understandable such as sense of speed, pressure and sensitivity to temperature which are information to human through skin. An image when you are trying to remind some feelings is a performative image. Hence, this study has been adopted those kinds of memories of image.

HOW ANALYZE STRUCTURES ON ANALOGY

It can be classified into analogy and homology in science to take up similarity. For instance, human heart and water pump have a common thing in a way to work, then this can be locate as analogy. On the other hands, it shows a different type of similarity as a location for a part in a whole such as human hand and fin of fish. This kids of similarities in structures is called homology.

In analogy research to date, analogy has been divided in these three: proportional analogies, predictive analogies and Proportional analogies. According to previous research, proportional analogies is more essential in metaphoric expression. Also, predictive analogies describe a new domain (target) not only by specifying structural commonalities with a given domain (source), but also by transferring information and explanations from the source to the target. Then, analogical problem solving can be used to solve a problem by transferring a solution from a well-known domain to an unknown domain.

Metonymy and metaphor in linguistic analogies

This paper provides modes of analogy through metonymy and metaphor as basic categories to compare exiting analogies on similarity in structure. It shouldn't be considered structures which make links, but also whether something to make link is available specified or not. Metonymical way is much more clear what things make a link as concept between things. Metaphorical way is more complex to find clear reason for link. It is necessary to capture structures to make similarity at first.

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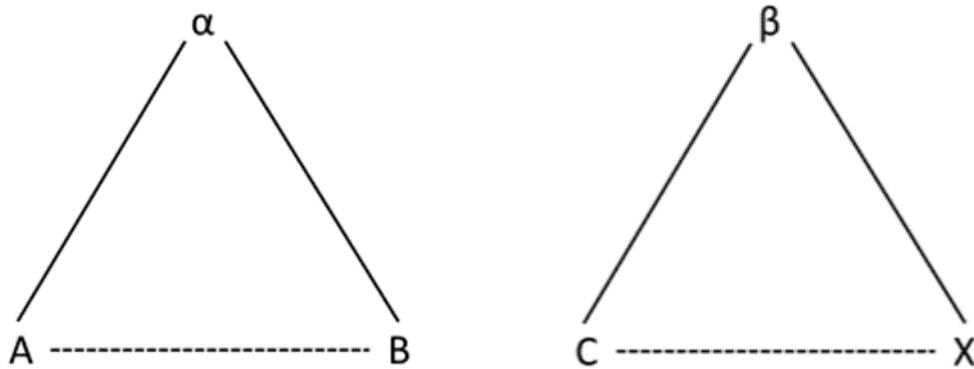


Figure 2. Structure models in source and target domains

Analogy is a cognitive process to apply similarity by two things which will be compared from source domain to target domain. Analogies has formation in basic such like $(A : B) :: (C : X)$, which is from pairs of key elements to take a similarity on source and target domains. Those relations as structure can be described such like Figure 2. It shows outline for A and B on source domain through α . C and X, which will be located on target domain also have a structure through β . 'A and B' or 'C and X' are conceptualized as metonymy in some cases, and in some cases through metaphor in general.

Broadly speaking, metonymy takes a part-whole relation including hierarchy in concepts which was called as synecdoche. For example, a girl who take a red riding hood can be called 'Red riding hood' in a metonymic expression. On the other hand, metaphor has more complex structure than metonymy. A sentence such as "Love is a smiling tiny stone getting sunlight" shows a metaphorical structure. Metaphor often utilize to make thing understandable in outstanding way. Firstly, α and β ($\alpha - \beta$), it can be considered as two types of relations into 'known-known', which are specified what they are on source and target domains, and 'known-unknown', which aren't specified what β is on target domain. These classifications can be a way to clarify effects of 'abstraction' on the analogy making process (Figure 1).

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MODES OF ANALOGY IN METONYMY AND METAPHOR

Figure3 is divided through viewpoints by kinds of discoveries which can be possible in the analogy making process. Compared to those viewpoints, modes of analogy can be applied as inventive viewpoints to change some components and rearrange whole system to get different result which can't be expected from now. In this paper, analogies including existing categories and proposal for modes of analogy are located in the same diagram for comparison between heuristic viewpoint and inventive viewpoint. First of all, this paper explains five types of modes of analogies called homology, functional similarity, proximity, projection, which has four different types of projections, and copying.

		(A:B) :: (C:X)			
		METONYMY		METAPHOR	
		Known known	Known unknown	Known known	Known unknown
No case-based reasoning					
		PROPORTIONAL ANALOGIES PREDICTIVE ANALOGIES			
Case-based reasoning		ANALOGICAL PROBLEM SOLVING			

Figure 3.
compare with

analogy classifications

Mapping to
existing

Modes of analogy

Homology

Homology is proposed as one of structural analogies among modes of analogy in this study. It describes similarity on location in whole structure such like to represent born structure between human hand and fin of fish.

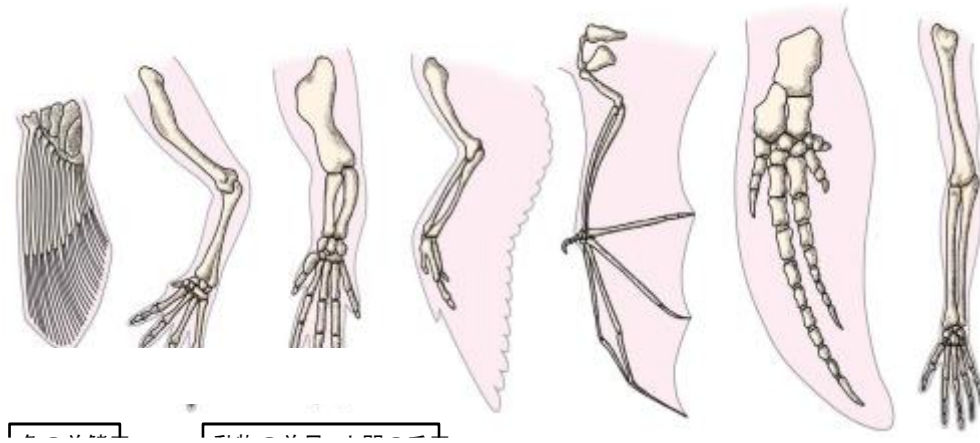


Figure 4. Example of homology (fin of fish and human hand)

It is a part-whole relation as metonymy. Also, this is a relation from case-based reasoning and known-known relation between source and target.

		(A:B) :: (C:X)			
		METONYMY		METAPHOR	
		Known known	Known unknown	Known known	Known unknown
No case-based reasoning					
Case-based reasoning		Homology			

Figure 5. Mapping of homology

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Functional similarity

Functional similarity shows a similarity in functions between source and target domains. For example, potato and sweet potato have a similarity which shows a role to keep nutrition. As homology, potato is located as stalk in the whole, and sweet potato is located as root in the whole by viewpoint of organ.

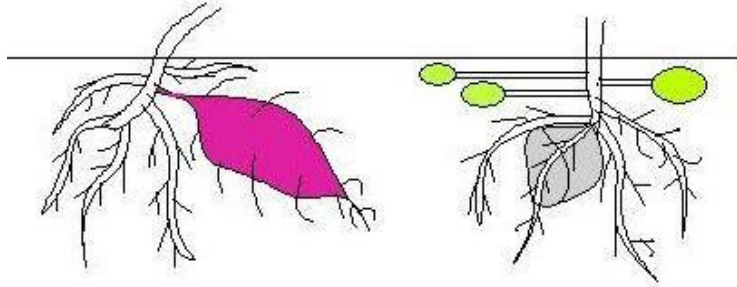


Figure 6. Example of functional similarity (origin of sweet potato and potato)

If some people took their stomach due to a stomach ulcer, sometimes the duodenum takes work instead of stomach. This sort of alternate function can also be belonged to functional similarity. This mode of analogy can be located in metaphor and have known-known relation with case-based reasoning.

		(A:B) :: (C:X)			
		METONYMY		METAPHOR	
		Known known	Known unknown	Known known	Known unknown
No case-based reasoning					
Case-based reasoning				Functional similarity	

Figure 7. Mapping of functional similarity

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Proximity

Proximity shows a similarity to represent distance in similarity.



Figure 8. Example of proximity and representation (Colour circle)

In case of the colour circle (Figure 7), yellow and yellow green can be called being in proximity, red and purple as well. This similarity is from metonymy by distance how much close between A and B, C and X in $(A : B) :: (C : X)$. Thus, it is in know-known relation, but it can be created in no case-based reasoning because of position of colours in the colour circle could be changed.

		(A:B) :: (C:X)			
		METONYMY		METAPHOR	
		Known known	Known unknown	Known known	Known unknown
No case-based reasoning	Proximity				
Case-based reasoning					

Figure 9. Mapping of proximity

Modes of analogy

Projection

Projection is to be in use regarding to draw a straight line between every points on the same plane and one point from outside in mathematics. The correspondence of thing to structure on different spaces can be projection. Besides, projection can be categorized into topology and copying.

- Topology

Topology can be divided into these three: projection beyond spatial dimension, which presents such like projecting a thing from two dimensions to four dimensions, projection by transformation between the front and the reverse side, which presents the correspondence of inside to outside of the same object, and projection by transformation between coordinate axes, which is an analogy by manipulating structures on coordinate axes according to change coordinate axes through compressing and stretching and also an angle. As an example for projection by transformation between coordinate axes, Figure 10 shows analogy between star fish and squid in topological way.

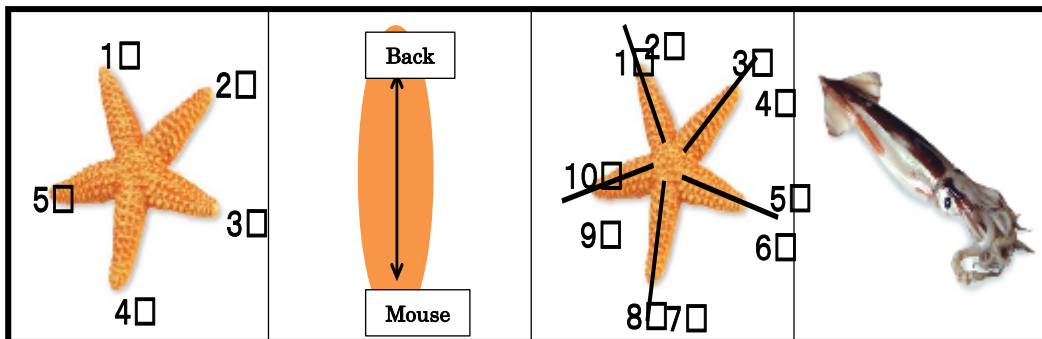


Figure 10. Example of topology (star fish and squid)

Star fish has five finger forms. If it is stretched to expend between mouse and back, then folded five finger forms down toward head part and finally cut every fingers in two, it could be looking like a squid. This is a topological transformation which is by topological transfer. However, it has not been usual transformation by perception which can see objects in direct to know what thing is. Those modes of analogy still have problems to be solved for practical use.

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- Copying

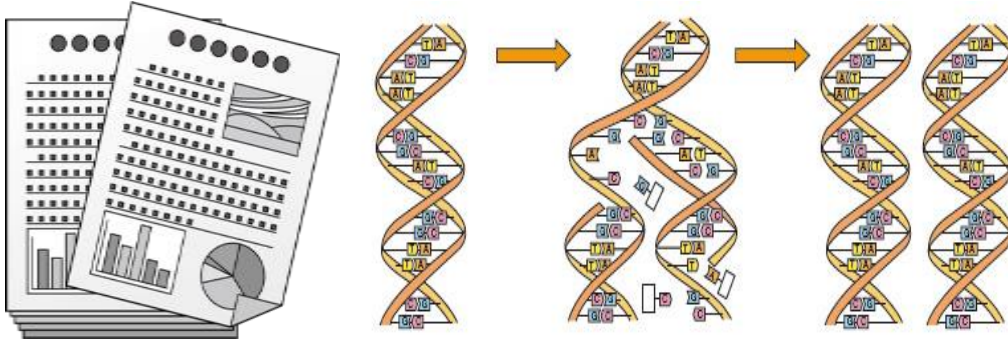


Figure 11. Examples of copying

Copying, one of projection modes, shows to copy down between things. In case of DNA, it works in semi-conservative replication. For other example, the printer copies exactly the same contents from previous contents in paper.

		(A:B) :: (C:X)			
		METONYMY		METAPHOR	
		Known known	Known unknown	Known known	Known unknown
No case-based reasoning					
		Projection: Copying		Projection: Topology	
Case-based reasoning					
		Projection: Copying		Projection: Topology	

Figure 12. Mapping of projection

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Representation (Darstellen)

Representation shows analogy in the aggregate which can be changed for combinations inside of the aggregate, but the aggregate still has been remained. As an example in Figure 8, each colours are in representation on the colour circle.

Representation means that it is exactly same thing as the aggregate, but it could be changed components inside of the aggregate. Those are in metonymy with no case-based reasoning, and occupies both relations in known-known and known- unknown.

		(A:B) :: (C:X)			
		METONYMY		METAPHOR	
		Known known	Known unknown	Known known	Known unknown
No case-based reasoning		Representation (Darstellen)			
Case-based reasoning					

Figure 13. Mapping of representation

Modes of analogy

MODES OF ANALOGY IN A CROSS BETWEEN METONYMY AND METAPHOR

Subsequently to five types of modes on metonymy and metaphor, this paper provides three types of other unique modes of analogy in a cross between metonymy and metaphor. Those three modes of analogy can be located on middle of metonymy and metaphor. They has been involved with no case-based reasoning and case-based reasoning in order to be able to belong in metonymy and metaphor sometimes. Particularly, dimensional analogy and infinite analogy can be considered taking relations for α and β from known-known to unknown-unknown. Limited analogy is always following some cases to reach one which never will get there. This also shows similar analogies with functional similarity in some cases.

Dimensional analogy

Dimensional analogy literally presents a mode capturing similarity and structure between things which take in different dimensions. As an example to understand this mode, there is the art piece by Arakawa, a Japanese artist which shows one dimensional analogy. (Figure 14) He mentioned about this working mode in a book named “Mechanism of meaning” through how meaning could be generated in the gap between structures.

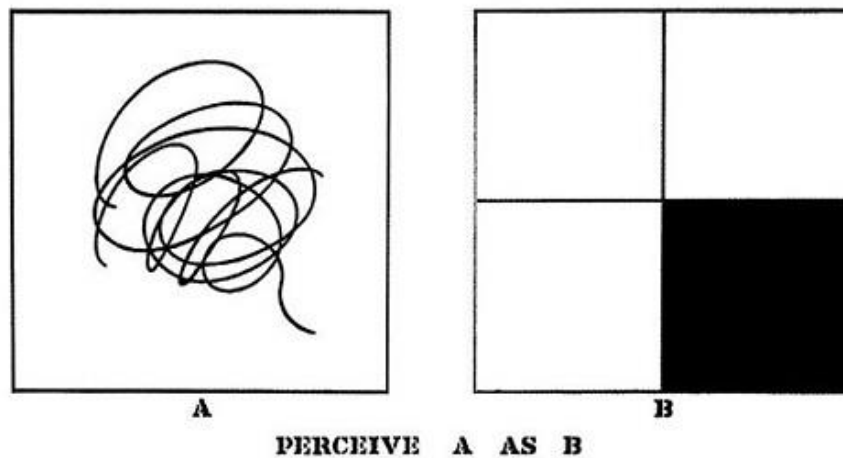


Figure 14. Example of dimensional analogy (the art piece by Arakawa)

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“Perceive A as B” is a problem to be solved for viewers. It can predict in several ways, and get viewpoints from these transformations. By perception, however, there is some barrier to perceive A as B. Using images to reach B from A can be useful to get dimensional analogy.

		(A:B) :: (C:X)					
		METONYMY			METAPHOR		
		known	known	unknown	known	known	unknown
		known	unknown	unknown	known	unknown	unknown
No case-based reasoning							
Case-based reasoning							

Dimensional analogy

Figure 15. Mapping of dimensional analogy

Infinite analogy

This is one mode of analogy incorporated with concept of infinity in proportional relation.

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Table 1. Basic structures in proportional analogies and infinite analogy

Proportional analogies	$(A : B) :: (C : X)$
Infinite analogy	$(A : \{(B_1, B_2, B_3, \dots, B_i)\}) :: (C : \{(X_1, X_2, X_3, \dots, X_i)\})$

The existing proportional analogies has been found through clear structure in source domain. In this analogies, there are unlimited possibilities for structures to see similarity. A and B which has unlimited possibilities and C and X which has also unlimited possibilities.

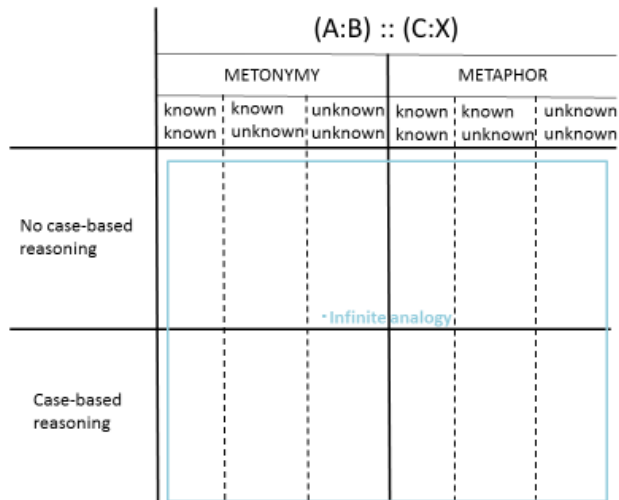


Figure 16. Mapping of infinite analogy

Limited analogy

Limited analogy can be utilized as a reasoning from convergence. A thought experiment called the falling bodies experiment by Galileo Galilei can be considered as one instance of this mode of analogy. In general, thought experiments is discussed through experiments under impracticable scheme. This paper give a name to this kinds of analogies to capture similarity in situation of limited which is going to get close some result with reasoning.

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		(A:B) :: (C:X)			
		METONYMY		METAPHOR	
		Known known	Known unknown	Known known	Known unknown
No case-based reasoning					
Case-based reasoning		• Limited analogy			

Figure 17.
limited analogy

Mapping of

ENHANCING CREATIVITY THROUGH ANALOGY

Analogy making depends on individual preferences. In finding structures by metonymic or metaphorical ways, creativity can be required some abilities such like sensibility for solving problems, fluency for ideas, flexibility, originality, transforming to get new viewpoints, then accuracy and so on. In this study, metaphor is more creative analogies than metonymy regarding to complexity of conceptualizations. Also, known-unknown relation between α and β to make connection for similarity can be more creative with no case-based reasoning than other areas. As a result of mapping for modes of analogy,

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topology, dimensional analogy and infinite analogy can be modes of analogy which need creativity in most than other modes.

FUTURE WORK

Modes of analogy can be categorized more in the future. It will be helpful to solve ambiguous problems in several fields. According to this study so far, it has been revealed some preferences on individual how to capture structures from the world. Sometimes it is mentioned as bias. Personal experiences are strongly working on selection for ways of creating analogy. All in all, creating new solutions are related in creativity.

Lastly, on the relations between α and β , this paper provides new discussion with concept of infinite in analogy. If we try to capture α and β , there are nothing to be located. However, there is a structure to make relations between things in source and target domains. It looks like a sort of mystery in analogy. But it is still understandable through such as a relation between feeling and form of object by human being without any words.

REFERENCES

Helmar Gust, Angela Schwering (2008). *Analogical Reasoning: A Core of Cognition*, DFG, Germany

George Lakoff and Mark Johnsen (2003). *Metaphors We Live By*, University of Chicago Press, USA

Shusak Arakawa and Madeline Gins (1981). *Mechanism of meaning*, Abbeville Press, USA

Hideo Kawamoto (2012). *Metamorphose*, Seidosha, Japan