The Creative Value of Distant Analogies

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Abstract: Analogical or metaphorical reasoning is a key cognitive strategy linked to the generation of creative ideas. The research presented in this paper extracts conceptual categories from a large database of everyday analogies and applies a lexical approach as a way to objectively estimate their conceptual distance, which is shown to be significantly aligned with the subjective assessment criteria of human judges.

Keywords: Creativity, Design by Analogy

1. Introduction

Language plays a fundamental role in defining our "everyday realities" as it represents our conceptual system and shapes our perceptions, thoughts and actions [1]. The role of language in design has been studied, for example, in design concept formation where the choice of particular concepts in team conversations triggers other related concepts from teammates [2]. Analogical or metaphorical reasoning is a particularly powerful cognitive strategy that has been linked to the emergence of creative insights [3, 4]. Analogies or conceptual metaphors are defined here as ideas with a three-part structure of the form: *source* <is like> *target* <because> *entailment*; while the first two are necessary, the third is optional, although often critical particularly in their potential creative value.

The research presented in this paper extracts conceptual categories from a large database of everyday analogies and applies a lexical approach as a way to objectively estimate their conceptual distance, which is shown to be significantly aligned with the subjective assessment criteria of human judges. The significance of this work is that it demonstrates the relevance of a scalable approach to the retrieval and analysis of analogies from everyday conversations that are likely to be regarded as novel and useful by creative practitioners. Conventional research approaches in this field tend to focus on the linguistic analysis of design conversations or the study of experimental ideation sessions. In contrast, we see here online micro-blogging as a natural, ongoing massive ideation process from which analogies are retrieved to form open repositories of key relevance for future design research, education and practice.

Some analogies can be well-known, even conventional to the point of becoming literal expressions in everyday language ("the odds are against us"). In contrast, imaginative analogies are continuously created as new vehicles to understand ideas or events, and therefore can be critical for creative design. New analogies are said to have creative value if and when they "alter the conceptual system and the perceptions and actions that the system gives rise to" [1]. The long-term aim of this intellectual effort is to reveal the principles by which creative analogies may transform the conceptual system, and ultimately shape the diversity and the quality of ideas that designers generate. The rest of this paper presents the initial steps of this work as follows: Section 2 surveys previous work including the role of analogies in creativity, analogy in design, and recent work on online massive collaboration for creativity. Section 3 presents our approach to the retrieval and analysis of over one thousand analogies, leading

to a typology of analogical structure created from inductive reasoning and a deeper understanding of semantic categories and distributions. In Section 4, the conceptual distance of analogies is estimated using lexical analysis. Section 5 presents a preliminary study where conceptual distance is shown to be significantly aligned with the ascription of creative value by human subjects. The paper closes with a discussion of the implications and limitations of this work, and future extensions.

2. Analogical reasoning

Analogical reasoning is a fundamental cognitive skill with deep implications for everyday thinking [5] and learning [6]. Its basic mechanism is a mapping function between specific exemplars or cases so that what is known about one is transferred to infer new information and reveal a new understanding about the other. Analogy has been considered as the basis of cognition, inasmuch as every lexical item, when used in everyday speech constitutes one side of an analogy [7].

Several computational approaches have contributed to our understanding of the fundamental mechanisms of analogy making, although key challenges lie ahead including three that are particularly relevant for our work: accounting for contextual information, choosing appropriate representational modes and cross-domain applications [8, 9, 10]. One of the main advantages of analogies is that they draw parallels between seemingly different concepts, a potential source of creative insights in design [11].

In design, analogical distance and commonness have been shown to influence the effects of priming examples on creative design ideation [12]. In that work, a combination of 'more distant and less common' examples as judged by the researchers were drawn from a patent database showing a positive effect on the creation of more novel concepts by design students. In a related work, the authors develop a computational approach to establish 'near' and 'far' analogical stimuli from the structure of patents, demonstrating that 'far but not too far' analogical stimuli are more likely to lead to the generation of innovative ideas [13].

WordTree is a Design-by-Analogy method aimed at generating distant-domain analogies that seeks to maximize linguistic representations by extracting action verbs from the initial stages of a design project and using the team's knowledge and WordNet as sources of unexpected and unique solutions [14]. Overall, there seems to be a clear consensus in design research on the need to improve our understanding of analogical reasoning in general, and to build systematic techniques and tools to support this important cognitive mechanism in creative design. As noted before, designers today heavily rely on serendipity and personal style to take advantage of this fundamental design approach.

3. Analysis of analogies

A repository of analogies used in everyday speech as captured in online micro-blogging has been extracted for this project. The main keywords used for this purpose span three languages: English, Spanish and French and include: "is/are like", "es/son como", and "c'est/sont comme". In ten months, from May 2012 to February 2013, more than 1,200 analogies were included in the collection –available publicly online as a Twitter feed[1]. Advanced search modifiers have been applied to optimize and filter the results, which we are currently testing alongside viable approaches to automate this rather tedious process. The entire list of analogies is exported as a comma-separated

[1] Twitter account: @CreativeAnalogy

values (CSV) file to facilitate the analysis. Removing duplicate entries is non-trivial, due to slight grammatical and spelling variations, as well as translations across the three languages considered.

3.1 Structural analysis

An initial step consists of extracting source and target keywords for each analogy, and the entailment(s) when included. The source of an analogy is defined as the noun or verb extracted from the fragment adjacent to the left of the "is/are like" clause (or its equivalent in other languages), while the target is the noun or verb extracted from the fragment adjacent to its right. Most analogies include an explanation or elaboration of the mapping, this statement is registered as their entailment. Because the approach of this work is conceptual rather than linguistic, when source or target keywords are synonyms, the most common term is used ('woman' is used instead of 'girl', 'chick' or other slang terms when used accordingly). After processing and cleaning the collection of analogies, less than 10% of the original analogies are removed leaving a total of 1120 entries classified –the universe of analogies used throughout this paper.

From this substantial collection of analogies, a typology of analogical structure is created applying inductive reasoning. The following structural features are defined and an illustrative example is given for each case:

1. In regards to entailments, analogies may have:
    a. None: only the source-target mapping is provided ("Bubble wrap is like catnip for people" @iSpeakComedy)
    b. Single: one, usually simple, explanation is offered to justify the mapping ("Google is like a woman because before you can finish a sentence, it's making suggestions" @trinomonero)
    c. Multiple: analogy is explained by more than one shared attribute ("Love is like war: easy to start, difficult to finish, and impossible to forget" @ItsRealBrent)
    d. New entailments: a novel reasoning created to account for conventional analogies ("Life is like a box of chocolates, it doesn't last as long for fat people" @ophies_best)
2. In regards to mapping, analogies may exhibit:
    a. Direct relationship: mapping between source and target is directly proportional ("Love is like a disease: one always ends in bed" @elprota)
    b. Inverse relationship: source-target mapping includes an inverse or reciprocal relation ("My father is like Pope Benedict XVI, but without the sainthood, the Popemobile and the red shoes; he is just jobless" @TheOMGio)
    c. Incomplete relationship: source-target pairing includes an incomplete or exceptional relation ("Having a bad cold is like having a bad hangover without the exhilarating memories" @perlapell)
3. In regards to culture, analogies may be:
    a. Wordplay: language-specific figures of speech ("Hip hop is like scissors, it always loses to Rock" @BrodonRexx)
    b. Cultural references: involving signifiers specific to a community or country ("Une FIFA sans music c'est comme Tintin sans Milou" @OdaiaLcmb)
    c. Cross-cultural references: involving signifiers from different communities or countries ("Jack Nicholson es como el Loco Valdez gringo" @DrTopCat)
4. Formulaic analogies include:

a. Double-pair mappings: two verb-noun or noun-noun pairs mapped ("Arguing with a fool to prove your point is like trying to cool down a burning coal by fanning it, it'll only get worse" @IbnAther)
b. Impossible relationships: mapping used expressly to denote an impossibility ("Sleeping on Sunday nights is like a giraffe barking, it's impossible" @1DTMHUpdate)
c. Monotonic relationships: circular mappings ("Dennis Rodman being an Ambassador for the United States is like having Dennis Rodman as an Ambassador for the United States" @birbigs)

5. Analogies may be time-independent or seasonal, whether they refer to specific events ("The Oscars are like the weather: no one remembers what it was like last year, and thinks this year is worst ever" @willapaskin)
6. Semantic categories are extracted by capturing the nouns or verbs used as source and target, and clustering them into general groups, as shown in the next Subsection.

These structural features capture the main types of analogies in the collection and can be found in combined forms. Future work will enrich this classification as the collection grows, and will seek to validate its completeness and accuracy by using it to classify other analogy repositories, such as famous analogy quotes[2] and other online social and collaboration platforms.

3.2 Semantic analysis

Next, to characterize what topics are covered in everyday analogies, we study their semantic distribution across the collection in two modes: as a single list combining sources and targets, and separately. When all concepts are combined, a highly skewed distribution with a long tail is observed as shown in Figure 1 (Pearson mode skewness = 0.1938). The top 1% of concepts is mentioned in 264 entries either as source or target (12% of total analogies). This means that in this context, analogy making is rather 'fixated' drawing from a small set of concepts including: *love*, *life*, *women*, *Twitter* and *people*.

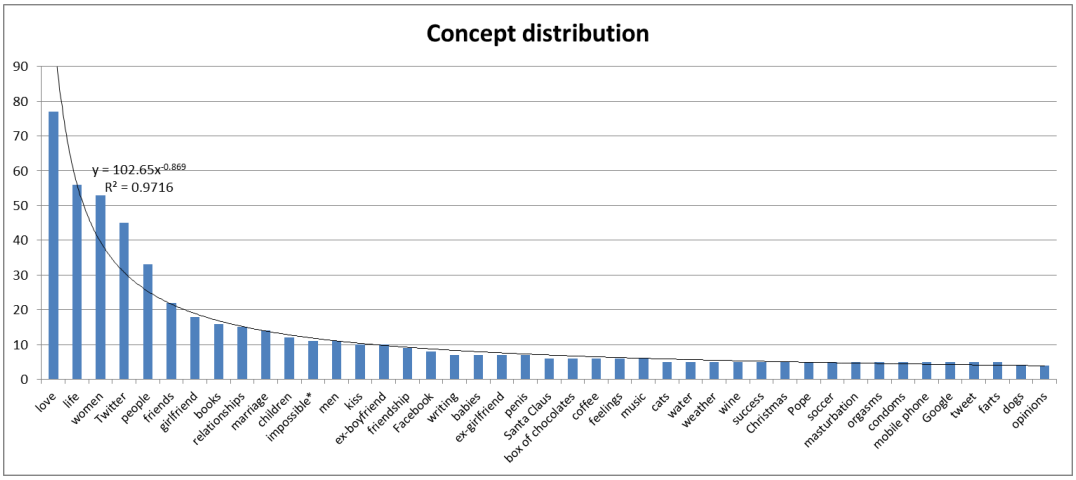

Figure.1 Skewed concept distribution in everyday analogies: 43 concepts shown (≥5 mentions)

Eight general semantic categories are abstracted from concepts used at least in three analogies in the collection (114 concepts with ≥3 mentions):

[2] http://www.brainyquote.com/quotes/keywords/analogy.html

1. Products/Things (28%): man-made physical and abstract things ranging from products to music, money, brands. Examples include: books, music, condoms, cars, money, drugs, underwear, and tattoos.
2. Humans (18%): people, relationships, and body parts. Examples: women, men, people, friends, marriage, children, babies, breasts, and muscles.
3. Animals/Nature (14%): animals, natural phenomena and food items. Examples: cats, coffee, water, weather, wine, dogs, alcohol, bacon, beer, chocolate, mosquito and rain.
4. Events/Characters (13%): famous personalities, holidays, and professions. Examples: Santa Claus, Christmas, Pope, Jesus, Mondays, Oscars, politicians, North Korea, party, and prostitutes.
5. Feelings/Emotions (10%): all kinds of feelings and emotions, and sexual terms. Examples: love, kiss, feelings, orgasms, happiness, depression, ego, and laughter.
6. Concepts (7%): intangible ideas including: life, success, opinions, religion, mind, opportunity, and war.
7. Technology (5%): arguably a sub-category of Products, but expressly related to (digital) technology (a way to de-bias the source of these analogies): Twitter, Facebook, Google, tweet, iPhone, and WiFi.
8. Verbs/Actions (5%): action verbs such as writing, advertising, dating, and exercise.

As Figure 2 shows, the distribution of concept categories also presents a skewed shape indicating that analogy making is convergent in keywords as well as in categories. Nearly half of all entries captured in this analysis (46% of 795 entries, which represent 35% of all concepts in the entire collection) fall under the two main categories: Products/Things and Humans. Although the remaining concepts are numerous (around 1,500), they are used only once or twice in the collection and deserve more extended analysis in the future.

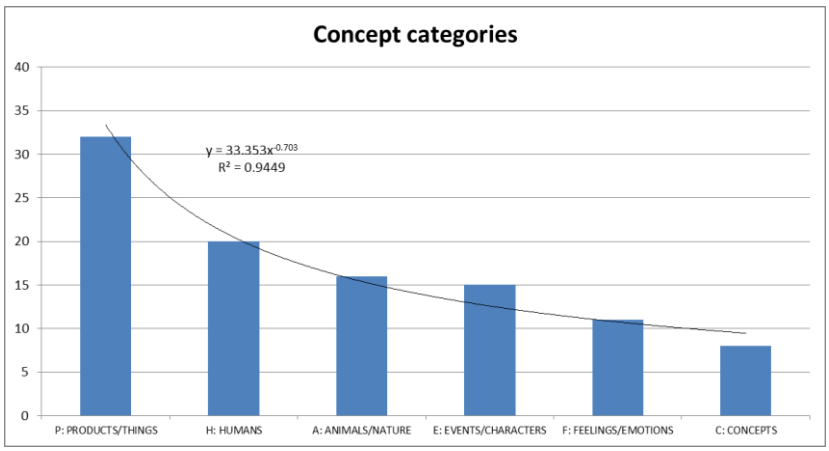

Figure 2. Skewed distribution of concept categories accounting for 795 concepts (≥3 mentions)

3.3 Commonness

To complete this initial semantic analysis, the distinction is made between source concepts and target concepts in order to characterize the conceptual commonness of both analogy elements in our collection. Table 1 shows the value for commonness for source and target concepts mentioned at least 4 times in our collection (≥4 mentions). The first thing to notice here is that, overall, sources are significantly more convergent than targets, i.e., a total of 423 analogies are accounted with the top 31 source concepts, while only 171 analogies include one of the top 33 target concepts. This means that whilst in everyday analogies people tend to focus on a narrow range of ideas to be

explained, they select a much wider range of ideas to map their explanations (target concepts are 2.5 times more diverse than source concepts).

The diversity or uncommonness of target concepts is further confirmed by the fact that more than 60% of target concepts are highly original in our collection (they occur only once), and an additional 20% of target concepts occur only twice. This is particularly encouraging for researchers and practitioners interested in the power of everyday analogies in creativity and it suggests that target concepts may play a fundamental role in creative analogies. For example, analogy harvesting in the future may be constrained to "is/are like x" where x is a concept not indexed in the repository.

Table 1. Semantic commonness of source and target concepts (≥4 mentions)

Source concepts		**Target concepts**	
love	67	women	12
life	54	girlfriend	9
women	47	books	7
Twitter	45	penis	7
people	32	babies	6
friends	16	box of chocolates	6
marriage	12	drunks	6
impossible	11	friends	6
relationships	11	Santa Claus	6
friendship	10	boyfriend	5
men	10	cars	5
ex-boyfriend	9	children	5
girlfriend	9	Christmas	5
feelings	7	condoms	5
kiss	7	dogs	5
writing	7	kiss	5
book	6	masturbation	5
Facebook	6	water	5
Google	6	weather	5
happiness	5	bees	4
mobile phone	5	cats	4
success	5	clock	4
advertising	4	Coca-Cola	4
children	4	coffee	4
laws	4	ex-girlfriend	4
Mondays	4	farts	4
opinions	4	films	4
Pope	4	Jesus	4
religion	4	Monopoly	4
St Patrick's Day	4	shoes	4
tweet	4	toilet paper	4
		underwear	4
		wine	4

A categorization approach based on commonness could be used in future studies to account for different types of source-target pairs in analogies. As our collection of multi-lingual everyday analogies grows, it will support more robust measures of originality that can be used to classify new analogies, to guide search processes, and ultimately to guide generative systems of computational analogy.

A total of 594 analogies are accounted for in Table 1, although a considerable overlap can be expected from analogies that combine common sources and common targets. In fact, four general types of analogies can be defined from a coarse distinction between common(c) and uncommon(u) concepts: Type 1 refers to analogies where both source and target are concepts commonly found in the repository, i.e., source(c), target(c) with the cut-off line set here to ≥4 mentions. Likewise, in Type 2 analogies: source(c), target(u); Type 3: source(u), target(c); and Type 4: source(u), target(u).

4. Concept distance

The domain or concept distance of an analogy is estimated here using WordNet, a lexical ontology well suited for distance measures, since nouns and verbs are organized into hierarchies defined by the following relations: *is–a*, *has–part*, *is–made–of*, and *is–an–attribute–of*. The lexical structure of WordNet consists of nine main noun hierarchies of 80,000 concepts, and 554 verb hierarchies of 13,500 concepts [15]. The measure path (path_length) is a baseline that is equal to the inverse of the shortest path between two concepts, and is used here to represent the concept distance of the source/target pair [15].

Illustrative path_length values between sample nouns and verbs are provided: vacation/holiday = 1; run/jog = 0.5; coffee/tea = 0.333; milk/water = 0.25; table/crab = 0.1429; vocabulary/violin = 0.0667; zebra/winter = 0.0476. Similarity measures in WordNet allow for the disambiguation of terms by choosing a sense using glosses, i.e., run#v#1 (as in "move fast by using one's feet") and jog#v#3 (as in "run for exercise") have a close path_length of 0.5, whereas run#v#4 (as in "direct or control; projects, businesses, etc.; "She is running a relief operation in the Sudan"") and jog#v#6 (as in "stimulate to remember; "jog my memory"") have a distant relation of merely 0.0625. For every analogy ranked here, the source/target definition (gloss) that best matches the analogy was selected. One possible line for further inquiry is to study the re-framing of analogies based on multiple definitions of their source/target concepts.

A subset of 150 analogies was assembled for this part of the study, ensuring a proportional number of analogies based on commonness Types 1 to 4 as defined above. The average path_length of this group is 0.153 with a standard deviation of 0.0829, and a median of 0.125. The path_length distribution in everyday analogies seems highly skewed as shown in Figure 3. This implies that only a few analogies tend to map concepts that are either very close (length > mean+stdev) or very far (length < mean-stdev) in the lexical database. The top path_length values (closer) include the following source/target pairs: softener/conditioner; saint_patrick's_day/saint_valentine's_day; and feet/hands. In contrast, the bottom path_length values (more distant) include the seemingly unrelated pairs: life/bull; love/hourglass; life/taxi; love/rain; and life/ice_cream.

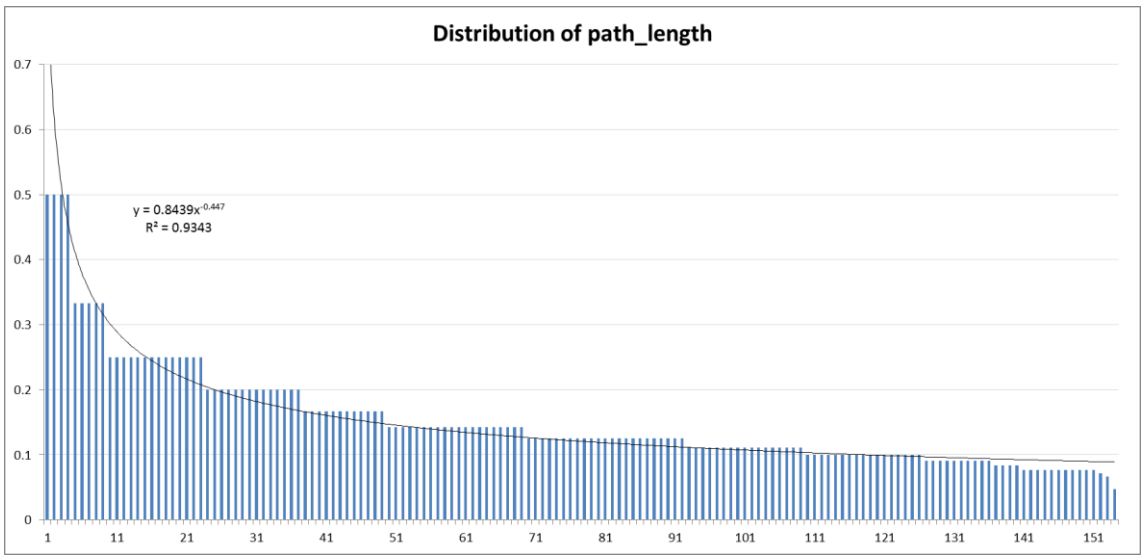

Figure 3. Skewed distribution of domain distance of 150 analogies spanning all commonness types

A large majority of the concept distances estimated fall within one standard deviation from the mean. Still, the path_length range from 0.0769 to 0.25 that accounts for 80% of analogies presents a considerable scale (3x) worth analyzing in relation to how humans perceive analogies, for example based on their creative value. The next Section presents a preliminary study of 33 analogies selected from this group to account for all path_length values to investigate whether they align with the rating of analogies by a panel of judges.

5. Creativity and distant analogies

The main hypothesis of this study is that the domain or concept distance of an analogy accounts for its perceived creative value by humans. To this end, a sample of 33 analogies is selected from our collection using the following criteria: a) proportional path_length values (as defined in Section 4), b) proportional commonness types (as defined in Subsection 3.3), and c) proportional semantic categories (as defined in Section 3.2). In this paper we only analyze the relation between concept distance and the overall rating assigned by judges.

The study is setup as an online survey where participants are asked to rate the analogies using a Likert scale from 1 (not creative) to 5 (extremely creative). The survey indicates that its aim is "to understand how people perceive everyday conceptual metaphors or analogies" without elaborating on the source or type of analogies; participants are encouraged to spread their ratings to have a uniform distribution from 1 to 5 across all analogies. An additional column is provided to check when an analogy is not understood; two analogies were discarded from the original set of 35 due to a high number of participants selecting this option. The responses from 29 participants are reported here, 16 female and 13 male. The survey ends with an optional question: "Explain briefly how did you personally define creativity to evaluate the analogies?" –a key aspect but beyond the scope of this paper.

The results show a close association between concept distance (path_length column in Table 2) and the score provided by human judges (survey column in Table 2) for every source/target pair tested. The statistically significant correlation between these two values is -0.5954 for Pearson's correlation with degree of freedom df=32, significance level α=0.01, and critical value R=0.4357.

Table 2. Source/target pairs for 33 analogies with overall survey score and concept distance (path_length) values –sorted by descending path_length values.

source	target	survey	path_length
softener	conditioner	0.61	0.5
saint_patrick's_day	saint_valentine's_day	0.62	0.3333
feet	hands	0.7	0.25
women	children	0.71	0.2
boss	killer	0.78	0.1667
abdomen	breasts	0.81	0.1429
sleep	die	0.69	0.125
die	sleep	0.79	0.125
woman	planet	0.71	0.1111
aloe_vera	politicians	0.95	0.1111
flu	hangover	0.71	0.1
communication	oxygen	0.73	0.1
father	Pope	0.85	0.1
life	karaoke	0.97	0.1
love	war	1	0.0909
love	santa_claus	0.69	0.0833
documentary	blockbuster	0.76	0.0833
courtship	murder	0.76	0.0833
life	chocolates	0.81	0.0833
love	diarrhoea	0.86	0.0833
love	water	0.9	0.0833
politics	religion	0.91	0.0769
lies	snowballs	0.79	0.0714

compliments	perfume	0.93	0.0714
love	soccer	0.73	0.0667
love	crayon	0.89	0.0667
life	soap	0.97	0.0667
intelligence	underwear	1.1	0.0667
love	rain	0.8	0.0625
life	ice_cream	0.92	0.0625
love	hourglass	0.87	0.0556
life	taxi	0.98	0.0556
life	bull	0.99	0.0417

Figure 4 shows a scatter plot of survey scores and path_length, sorted by descending path_length values. The skewness of path_length distribution shown in Figure 3 is kept as a result the selection criteria discussed above. As shown in Figure 4, analogies with closer source/target concepts (high path_lengths) tend to be rated lower by judges, and as the concept distance in an analogy increases (lower path_lengths), judges rate it as more creative. Such relation between the concept distance of an analogy and its independent perception by judges confirms our hypothesis but a number of key issues remain to be tested. For example, judges in this study rated the analogies with the entailments as originally included, some of which may be considered highly inventive. Although this study suggests that the creative value of analogies is largely explained by concept distance and not necessarily by the entailments or reasoning behind the mapping, we do observe that the only two analogies without an entailment included in the study are found in the bottom three ratings overall. Likewise, semantic categories may be considered in the future as this preliminary study is insufficient to demonstrate whether commonness plays a role in the assessment of creative analogies. Lastly, this type of studies can only target analogies amenable to path_length estimation, which leaves out a portion of entries in our collection, i.e., analogies of cultural and linguistic character as defined in Section 3.1.

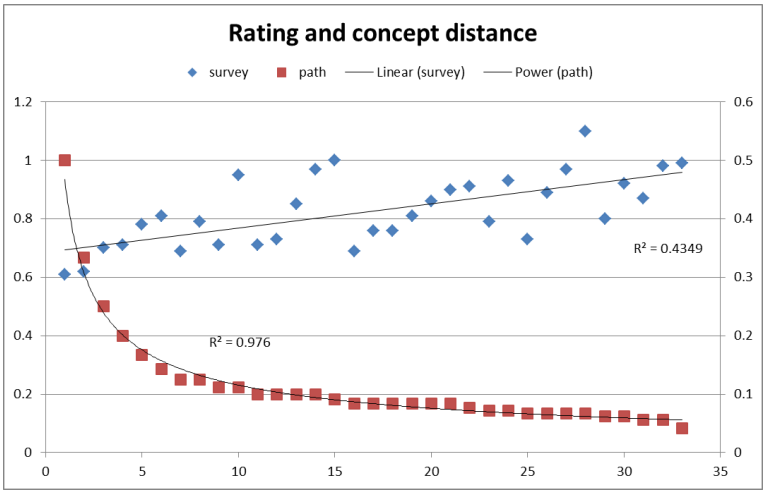

Figure 4. Scatter plot of the 33 analogies in our study with overall survey score (blue diamonds) and concept distance (red squares) –sorted by descending path_length values.

6. Discussion

This paper lays the foundation for the systematic study of epistemological principles of creative analogies. It has introduced a novel approach to the retrieval of everyday analogies from an online massive collaboration platform with millions of users and daily interactions. A collection of analogies has been presented and analyzed, deriving

structural features of analogies and semantic categories that are used to objectively define their originality via a commonness value of source and target concepts. A way to establish the domain or concept distance of analogies has been demonstrated, as well as its correlation with the ascription of creative value by a panel of judges.

Since distant analogies seem particularly useful for creativity, cultural and disciplinary diversity should be encouraged in creative teams as a strategy to build and apply distant analogies since they can draw from dissimilar conceptual spaces. However, the findings reported in this paper are preliminary and need to be considered in the context of: a) alternative retrieval means and sources are required to reinforce the quality of data; b) inter-rater reliability is recommended to validate the extraction of source and target terms; c) structural features and semantic categories need to be validated against other sources including computational approaches to the extraction of analogies from news sources, blogs and other sources; d) concept distance can be complemented with similarity measures from other sources such as ConceptNet [16]; e) human assessment needs to be extended to more participants and analogies, as well as other judging formats (deliberation, open voting, and confidence level).

Finally, in order to establish the creative value of analogies, we plan to test them in the context of design ideation. Our ultimate aim is to understand if and how analogies are likely to influence the quality and variety of creative ideas, and to build computational support systems that facilitate Design-by-Analogy. The literature shows that language shapes our thinking; the long-term of this work is to reveal how it shapes our designing.

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