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The statistical assessment of the source and target domains similarity

Abstract. The goal of the paper is to investigate the level of similarity between source and target domains of metaphors. The problem of similarity constitutes the crucial difference between the classical theory of metaphors and conceptual metaphor theory of Lakoff and Johnson (1980). The research method is based on statistical comparisons of the features of basic domains, which are grounded in the pre-conceptual sensory-motor perception. Applying the method to a particular generic metaphor indicates that visual similarities are much less prominent than the similarities based on other experiential domains, such us for example EMOTION or TEMPERATURE. Further application of the statistical method to a larger corpus of metaphorical expressions may help to find a rule-governed, systematic connection between the similarity of domains and conventional metaphors.

Key words. conceptual metaphors, basic domains, pre-conceptual perception

1. Introduction

George Lakoff, referring to the classical theory of metaphors, states that 'the word *metaphor* was defined as a novel or poetic linguistic expression where one or more words for a concept are used outside of its normal conventional meaning to express a *similar* concept' (1993 , 1). One of the charges Lakoff and Johnson put against the classical theory is the existence of similarities between the source and target domain,

> […] the claim that such similarities exist is highly questionable. For example, what possible similarities could there be that are shared by all of the concepts that are oriented up? What similarity could there be between UP, on the one hand, and HAPPINESS, HEALTH, CONTROL, CONSCIOUSNESS, VIRTUE, RATIONALITY, MORE, etc., on the other? What similarities (which are not themselves metaphorical)

could there be between a MIND and a BRITTLE OBJECT, or between IDEAS and FOOD? (Lakoff and Johnson 1980, 114)

However, in their theory of conceptual metaphor, Lakoff and Johnson do not deny the existence of correspondences between source and target domains: 'Metaphor is mostly based on **correspondences in our experiences**[1], rather than on similarity' (Lakoff 1993, 40). The word *correspondence* is a synonym of *similarity*[2] which makes the above quotation rather difficult to interpret, because the question that should be answered first is, "what exactly are the correspondences (similarities) in our experiences"? The aim of this paper is to propose a method of comparing conceptual domains[3], which will allow us, at least partly, to answer the above question. The word "partly" in the previous sentence should be stressed because the method which will be presented in the next section concerns only the building blocks of the conceptual domain – the set of basic domains such as SPACE, COLOUR, TEMPERATURE, EMOTIONS, PRESSURE, ODOUR, etc.

At this point it should be stated very clearly that the intention of this article is not to support the classical theory of metaphor, which claims that metaphors are just stylistic tropes motivated by the similarity of the tenor and the vehicle. The analysis of only basic domains cannot possibly account for the infinitely complicated and intricate network of cross-domain relations which constitute source and target domain matrices, neither will it help us to account for unidirectionality of metaphors or the invariance principle. To use a metaphor, the comparison of basic domains is like analyzing the chemical composition of the bricks – it has only very limited bearing on the structure of the whole building.

Nonetheless , despite the above mentioned limitations, the method of comparing basic domains may prove a useful and mathematically rigorous tool, which will shed some light on

[1] Underlining J.W.
[2] c.f. for example Roget's Thesaurus (http,//thesaurus.com/roget/I/17.html, Oct.30th 2012)
[3] The theory of conceptual domains was created by Langacker (1987). The term *conceptual domains* bears close affinity to *Idealised Cognitive Models* (Lakoff 1987) and *Frames* (Fillmore 1982). For a detailed comparison of *domains, ICM's* and *frames* c.f. for example Langacker (2008, 44).

the degree to which the similarity of the source and target basic domains motivates conventional metaphors. In other words, it can help to answer the question of why some domains are linked with conventional metaphors while others are not. Additionally, the statistical comparison of source and target basic domains is interesting in itself because it reveals which basic domains play the dominant role in accounting for the similarity. For example, as we will see in Section 3, the domains of TEMPERATURE and EMOTION are decidedly the most prominent in the COMPETITION IS 1 ON 1 PHYSICAL AGGRESSION metaphor. Section 2 offers an outline of the method of basic domain comparison and Section 3 contains an example of its practical application, i.e. the statistical assessment of source and target domain similarity for the COMPETITION IS 1 ON 1 PHYSICAL AGRESSION[4] metaphor.

2. The method of comparing conceptual domains

The basic notions of Ronald Langacker's (1987) theory of knowledge representation are those of *concept (profile)* and *domain (base)*. The first is described as the basic unit of mental representation and the second as the background knowledge in terms of which a particular concept is understood. Clausner and Croft (1999) explain the nature of the connection between concepts and domains in the following way:

> The nature of the concept-domain relation is such that any concept can in turn function as the domain for other concepts (e.g., arc-CIRCLE and circle-SPACE […] respectively). The embedding of domains as concepts in other domains eventually "bottoms out", according to Langacker, in basic domains, domains which are footed in fundamental human bodily experiences, such as SPACE, TIME, various sensations, emotions and perceptions. (6)

[4] This metaphor is the first one listed by Lakoff on his *Conceptual Metaphor Home Page* (http,//cogsci.berkeley.edu/lakoff/sources/, 29.10.2012)

As we can see, according to Langacker (1987)[5], all concepts are ultimately grounded in basic domains, which are directly based on human sensory-motor experience. Evans and Green (2006, 234) provide a list of such domains together with their sensory, pre-conceptual sources (Table 1).

Basic domain	Pre-conceptual basis
SPACE	Visual system; motion and position (proprioceptive) sensors in skin, muscles and joints; vestibular system(located in the auditory canal – detects motion and balance)
COLOUR	Visual system
PITCH	Auditory system
TEMPERATURE	Tactile (touch) system
PRESSURE	Pressure sensors in the skin, muscles and joints
PAIN	Detection of tissue damage by nerves under the skin
ODOUR	Olfactory (smell) system
TIME	Temporal awareness
EMOTION	Affective (emotion) system

Table 1. The inventory of basic domains

Having established that all conceptual domains can be finally analyzed in terms of a finite number of basic domains, we are now ready to begin defining the statistical notion of similarity between two domains. Let us start with an example. Table 2 in the next section contains the analysis of the features of the source and target domains of the metaphorical expression 'He clobbered me at tennis'. The features of both domains are arranged vertically with respect to the basic domains of SPACE, COLOUR, SOUND, TEMPERATURE,

[5] This assumption is one of the tenets of cognitive linguistics known as *embodiment*, and can be found in many other sources

PRESSURE, ODOUR, EMOTION and TIME[6]. As we can see in Table 2, the spatial features of the source domain (FIST FIGHT) are as follows:

two participants, moving, distance of about 1 meter

The analogous spatial features for the target domain (TENNIS) are the following:

two participants, moving, distance of about 10-20 meters

The comparison of both sets of three spatial features (number of participants, movement, distance) allows us to conclude that the degree of similarity is 2/3 (77%) because two of the three features (number of participants and movement) are equal. To use a mathematical formula,

$$S_1 = 77\% \quad (1)$$

where S_1 is the degree of similarity of the spatial features between the two domains. The similarity of the two domains will be calculated as follows:

$$S = (S_1 + S_2 + S_3 + \ldots + S_8) / 8 \quad (2)$$

The result is an average of the partial similarities for the 8 basic domains. As we can see from Table 2, the similarity between the two domains (FIST FIGHT and TENNIS) is finally calculated as follows:

$$S = (77\% + 0\% + 100\% + 100\% + 100\% + 100\% + 100\% + 50\%)/ 8 = 78.38\% \quad (3)$$

[6] The list of Basic domains is slightly different from the one presented in Table 1 for reasons that will be explained below.

Tables 3 to 8 contain analogous analyses for six other metaphorical expressions listed by Lakoff as examples of COMPETITION IS 1 ON 1 PHYSICAL AGRESSION[7]. Averaging the similarities S calculated from Tables 2 to 8, gives us an estimation[8] of the similarity of the source and target domains of the generic metaphor COMPETITION IS 1 ON 1 PHYSICAL AGRESSION,

$S_t = 52 +/- 17\ \%$ (4)

(See Table 9). The simple arithmetical operations exemplified above by equations (1) to (4) can be expressed by the following general formula, defining the statistical similarity of two domains:

$$S_t = \frac{1}{N}\sum_{n=1}^{N}\frac{1}{J}\sum_{j=1}^{J}\frac{1}{K_j}\sum_{k=1}^{K_j} f_{n,j,k} \times 100\% \quad (5)$$

where N is the number of metaphorical expressions analyzed (or number of texts in the corpus sample, in our case $N=7$), J is the number of basic domains (in our case $J=8$), K_j is the number of analyzed features of basic domain j (for example, we analyzed 3 features of the domain SPACE – number of participants, movement and distance, so $K_1 = 3$) , and $f_{n,j,k}$ is a two valued function equal either *0* (if the specific feature does not match) or *1* (if it does)[9].

The better to understand Formula (5), we may look at the three summation symbols as three averages. Starting from the right, we calculate an average number of matching features for a particular basic domain, then we average it over all the basic domains and, finally, over all the metaphorical expressions in the considered sample. Of course, the statistical error is inversely proportional to N, J and K_j, which means that the larger the number of metaphorical

[7] *Conceptual Metaphor Home Page* (http://cogsci.berkeley.edu/lakoff/sources/, Accessed 29.10.2012)

[8] It is an estimation based on 7 metaphorical expressions listed by Lakoff. The generic metaphor COMPETITION IS 1 ON 1 PHYSICAL AGRESSION comprises a large number of such expressions and taking more of them into account would reduce the statistical error (standard deviation), which in our case is 17%.

[9] I would like to thank the reviewer of *Explorations* for pointing out that a finite number of domain sub-criteria will always result in 'quantum' (discrete) set of possible values of domain-match; however, one may expect this negative (for the precision of the assessment) effect to be diminished proportionally to the number of sub--criteria and the size of the corpus chosen. If we look at expression (5), we can see that in our case, even assuming say just two sub-criteria per basic domain, the number of possible results is 7x8x2= 112.

expressions analyzed and the greater the number of features of basic domains considered, the more precise the estimation of the similarity will be obtained from Formula (5).

As we can see from Formula (5), in order to establish the value of the $f_{n,j,k}$ function as 1 (match) or 0 (no match), we need a list of the basic domain features and, first of all, an inventory of basic domains. I decided to modify the list presented in Table 1 in the following way:

1. SPACE
2. COLOUR
3. SOUND
4. TEMPERATURE
5. PRESSURE
6. ODOUR
7. EMOTION
8. TIME

I excluded the basic domain of PAIN, because, according to Langacker (2008, 44) a basic domain should not be 'cognitively irreducible' and the physical sensation of pain is always caused by the factors connected with pressure, temperature, sound or odour. I also decided to replace PITCH with a more general domain of SOUND to include the feature of the sound volume. The list of specific basic domain features, I decided to use, is as follows:

1. SPACE
    - number of participants
    - movement (moving/stationary)
    - distance
2. COLOUR
3. SOUND
    - pitch
    - volume
    - variability
4. TEMPERATURE
    - variability (rising, falling)
5. PRESSURE

- value
- area (localized or not)
- variability

6. ODOUR
7. EMOTION
8. TIME
    - duration

As we can see, the domains of COLOUR, ODOUR and EMOTION were left to open and of course arbitrary and introspective interpretation. I have to agree with Langacker that

> We should not expect to arrive at any exhaustive list of the domains in a matrix or any unique way to divide an expression's content among them—how many domains we recognize, and which ones, depends on our purpose and to some extent is arbitrary. The important thing is to recognize the diverse and multifaceted nature of the conceptual content an expression evokes. (Langacker 2008, 44)

As we will see in the next section, the above list of basic domains and their features is sufficient to estimate the similarity of the source and target domains of COMPETITION IS 1 ON 1 PHYSICAL AGRESSION metaphor.

3. Applying the method

This section contains an example of applying the method described in Section 2 to estimate the level of similarity of the source and target domains of COMPETITION IS 1 ON 1 PHYSICAL AGRESSION metaphor, which is listed as the first one in the on-line inventory of metaphors prepared by George Lakoff and his students (http://cogsci.berkeley.edu/lakoff/sources/, Accessed 29.10.2012). The following seven metaphorical expressions are given as examples of the above generic metaphor:

1. He clobbered me at tennis.
2. I beat him at chess.
3. She kicked-butt at the audition.
4. She whipped him at handball.

5. They really murdered the other team.
6. Losing the contest was a real black eye for her.
7. Those swim teams have been slugging it out all season.

We will consider each source and target domain connected with a particular metaphorical expression separately because, for example, the pressure and the sounds connected with whipping, kicking, or giving someone a black eye, etc. are different and so are, for example, the colours typically associated with chess and tennis – black and white in the former and perhaps green and white in the latter. Tables 2 to 8 contain the analysis of the chosen features of the basic domains for each of the seven metaphorical expressions.

Basic domain	Source domain, fist fight	Target domain, tennis	Source and target domain match [%]
Space	two participants, moving, distance of about 1 meter	two participants, moving, distance of about 10-20 meters	77
Colour	red (of blood), mauve and black (of the bruises)	green (of the grass), white (of the costume)	0
Sound	high volume and varying in pitch, shouts, screams and grunts	the same (for example, Sharapova, Azarenka, Nadal)	100
Temperature	rising, fighters getting hot	the same	100
Pressure	high, localised	the same (high and localised pressure caused by the ball moving at high speed)	100
Odour	odour of sweat	the same	100
Emotion	hatred, triumph and elation of winning, fear and humiliation of losing	the same	100
Time	between a couple of minutes and a couple of hours	up to a couple of hours	50
Average match (similarity) [%]			78.38

Standard deviation [%]	36.43

Table 2. Basic domain features for 'He clobbered me at tennis' metaphor.

Basic domain	Source domain, fist fight	Target domain, chess	Source and target domain match [%]
Space	two participants, moving, about 1 meter from one another	two participants, stationary, about 1 meter from one another	77
Colour	red (of blood), mauve and black (of the bruises)	black and white (of the chess pieces)	0
Sound	high volume and varying in pitch, shouts, screams and grunts	silence	0
Temperature	rising due to physical and emotional exertion	stable, can be rising due to emotional exertion of the players	50
Pressure	high, localised	no pressure	0
Odour	odour of sweat	no odour	0
Emotion	hatred, triumph and elation of winning, fear and humiliation of losing	the same	100
Time	between a couple of minutes and a couple of hours	the same	100
Average match (similarity) [%]			40.88
Standard deviation [%]			46.39

Table 3. Basic domain features for 'I beat him at chess' metaphor.

Basic domain	Source domain, kicking a specific area of the body	Target domain, auditioning for a role in film or theatre	Source and target domain match [%]
Space	two stationary participants, distance of about 1 metre,	more participants, stationary or moving, distance of a couple of meters	0
Colour	mauve and black of the bruises	no specific colour	0

Sound	high volume and varying in pitch, shouts, screams and grunts, the thud of kicking	the sound of music or reciting	0
Temperature	temperature rising due to physical and emotional exertion	the same	100
Pressure	high varying and localised pressure	normal, constant pressure, not localised	0
Odour	odour of sweat due to physical exertion	no specific odour	0
Emotion	hatred, triumph and elation of winning, fear and humiliation of losing	the same hatred directed towards one's competitors, fear and humiliation of performing badly, satisfaction and triumph due to a good performance and securing the role	100
Time	from a couple of minutes to about an hour	the same	100
Average match (similarity) [%]			37.5
Standard deviation [%]			51.75

Table 4. Basic domain features for for 'She kicked-butt at the audition' metaphor.

Basic domain	Source domain, whipping	Target domain, handball	Source and target domain match [%]
Space	two participants, stationary, a meter or two from one another (depending on the length of the whip)	many participants, moving, spaced within about 20-30 meters	0
Colour	mauve and black of the bruises, red of blood	no specific colour	0

Sound	high volume and varying in pitch, shouts, screams and grunts, the sound of the whip hitting the target	the same, high volume and varying in pitch, shouts, screams and grunts of the players, the sound of the ball bouncing	100
Temperature	temperature rising due to physical and emotional exertion	the same	100
Pressure	high and localised pressure exerted by the whip	the same (exerted by the ball)	100
Odour	the odour of sweat due to physical exertion	the same	100
Emotion	hatred, triumph and elation of the attacker (the winner), fear and humiliation of the attacked (the loser)	the same	100
Time	half an hour to a couple of hours	the same	100
Average match (similarity) [%]			75.00
Standard deviation [%]			46.29

Table 5. Basic domain features for 'She whipped him at handball' metaphor.

Basic domain	Source domain, murder	Target domain, team game	Source and target domain match [%]

Space	two or more participants spaced within about 10 meters (depending on the weapon) moving or stationary	the same	100
Colour	red (of blood)	no specific colour	0
Sound	high volume and varying in pitch, shouts, screams and grunts, various other sounds depending on the weapon	high volume and varying in pitch, shouts, screams and grunts, various other sounds depending on the kind of the game	50
Temperature	temperature rising due to physical and emotional exertion, falling temperature of the victim's body	temperature rising due to physical and emotional exertion	50
Pressure	high varying and localised pressure	can be high varying and localised as well (as in football or handball)	50
Odour	odour of sweat blood	odour of sweat	50
Emotion	hatred, triumph and elation of the attacker (the winner), fear and humiliation of the attacked (the loser)	the same	100
Time	a couple of minutes	a couple of hours	0
Average match (similarity) [%]			50.00
Standard deviation [%]			37.80

Table 6. Basic domain features for 'They really murdered the other team' metaphor.

Basic domain	Source domain, hitting a specified area of the body with a fist	Target domain, sport contest	Source and target domain match [%]
Space	two participants, stationary, less than a metre from one another	two or more participants, moving or stationary from a metre to a couple of tens of metres.	33
Colour	black	no specific colour	0

Sound	high volume and varying in pitch, shouts, screams and grunts, the thud of the punch hitting the target	silence (as in chess) or high volume and varying in pitch, shouts, screams and grunts, other sounds depending on the kind of game	50
Temperature	rising due to physical and emotional exertion	the same	100
Pressure	high, varying and localised	can also be high, varying and localised, depending on the type of the contest	50
Odour	no specific odour	the odour of sweat, depending on the nature of the contest	0
Emotion	hatred, triumph and elation of the attacker (the winner), fear and humiliation of the attacked (the loser)	the same	100
Time	very short, a couple of seconds	half an hour to a couple of hours	0
average match (similarity) [%]			41.63
Standard deviation [%]			41.80

Table 7. Basic domain features for 'Losing the contest was a real black eye for her' metaphor.

Basic domain	Source domain, fist fight	Target domain, swimming competition	Source and target domain match [%]
Space	two participants, moving, less than 1 meter	two or more participants, moving within the distance of a couple of meters	25
Colour	red (of blood), mauve and black (of bruises)	blue (of the water)	0

Sound	high volume and varying in pitch, shouts, screams and grunts	participants are silent (on account of being in water), cheers and shouts from the spectators at the swimming pool	0
Temperature	rising due to the physical exertion	the same	100
Pressure	high, varying and localised	moderate pressure of water on the whole body of the swimmer, not localised	0
Odour	odour of sweat	chlorine smell of the swimming pool	0
Emotion	hatred, triumph and elation of the attacker (the winner), fear and humiliation of the attacked (the loser)	the same	100
Time	between a couple of minutes and a couple of hours	the same (depending on the swimming distance and the duration of the whole competition)	100
Average match (similarity) [%]			40.63
Standard deviation [%]			49.89

Table 8. Basic domain features for 'Those swim teams have been slugging it out all season' metaphor.

The numerical results presented in Tables Tables 2-8 are summarized in Table 9. The so called *average vertical match denotes* the degree of similarity for the seven metaphorical expressions analyzed. The *average horizontal match* indicates the degree of similarity for each of the eight basic domains. The total average similarity S_t calculated from Formula (5) (it is simply an average of the seven *average vertical match* values) is indicated in Table 9 as 52%. The table also contains standard deviations calculated for all vertical and horizontal average values.

Basic domain	1	2	3	4	5	6	7	Average horizontal match	Standard deviation
Space	77	77	0	0	100	33	25	44,57	40,14
Colour	0	0	0	0	0	0	0	0	0
Sound	100	0	0	100	50	50	0	42,86	44,99
Temperature	100	50	100	100	50	100	100	85,71	24,39
Pressure	100	0	0	100	50	50	0	42,85	44,99
Odour	100	0	0	100	50	0	0	35,71	47,56
Emotion	100	100	100	100	100	100	100	100	0
Time	50	100	100	100	0	0	100	64,29	47,56
Average vertical match [%]	78,38	40,88	37,50	75.00	50.00	41,63	40,63	Average match S_t (similarity), **52.00**	Standard deviation of the average match S_t, **17,32**
Standard deviation [%]	36,43	46,39	51,75	46,29	37,80	41,80	49,89		

Table 9. The results of source and target domain comparison.

Figure 1 shows the degree of source and target domain similarity for the 7 metaphorical expressions (the average vertical match) which are as follows:

1. He clobbered me at tennis.
2. I beat him at chess.
3. She kicked-butt at the audition.
4. She whipped him at handball.
5. They really murdered the other team.
6. Losing the contest was a real black eye for her.
7. Those swim teams have been slugging it out all season.

As we can see, expressions 1 and 4 are characterised by the largest degree of similarity between their source and target domains.

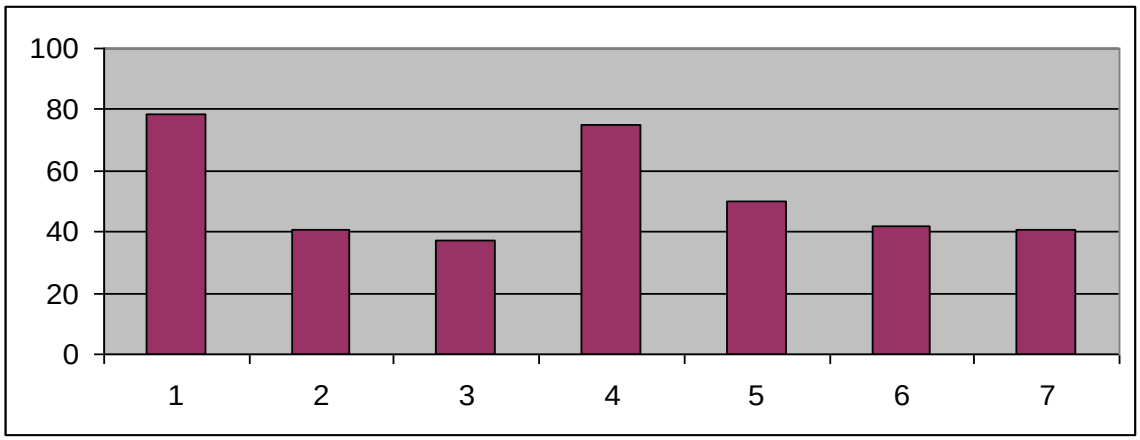

Figure 1. The average source/target domain match (similarity)
for the 7 metaphorical expressions

Figure 2 shows the average similarity of source and target domains for the 8 basic domains (*average horizontal match* values). The domains of EMOTION and TEMPERATURE display the greatest degree of similarity. Rather surprisingly, the average similarity value for the visual domain of COLOUR is zero, which means that the source and target domains for the seven metaphorical expressions analyzed have no common features in the domain of COLOUR. The other visual domain, SPACE, also shows a rather low degree of similarity of 45%. The average similarity (arithmetical mean value) for the two visual domains, (0 + 45%)/2 equals 22.5%, which is 4 times lower than the value for the domain of TEMPERATURE and almost 5 times lower than the average similarity in the domain of EMOTION, which can indicate that the metaphor COMPETITION IS 1 ON 1 PHYSICAL AGRESSION is not motivated by visual similarity

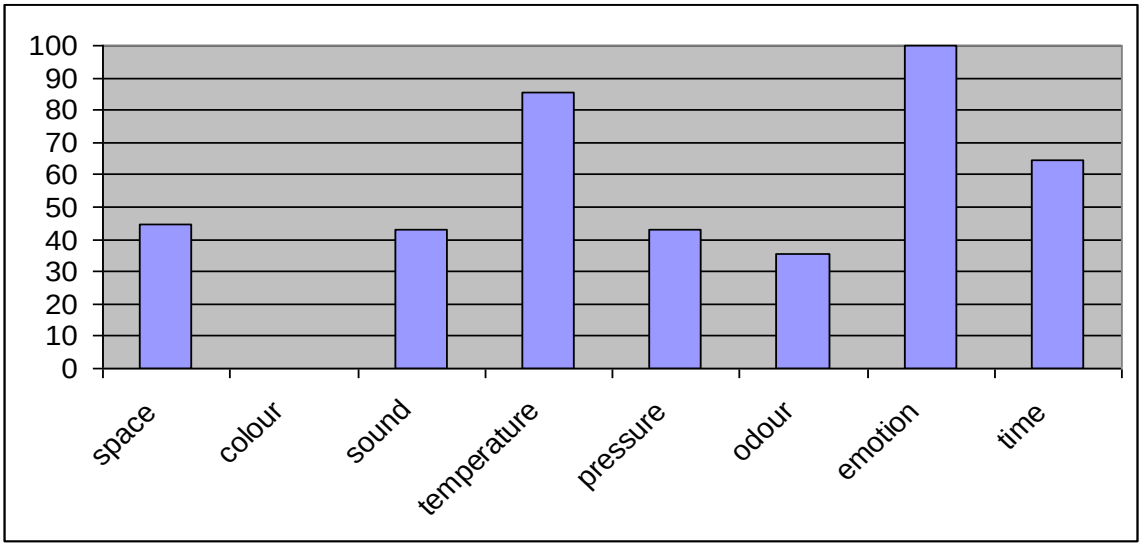

Figure 2. The average source/target domain match (similarity) for the 8 basic domains

4. Summary and conclusions

In Section 2 we presented a statistical method of calculating similarity of two conceptual domains. The method is based on dividing each of the domains into 8 basic domains and establishing how many singular features of the basic domains match. Formula (5) allows source and target domain similarity for generic metaphors to be calculated, which comprises of a given number of metaphorical expressions. Section 3 contains a practical application of the method described in Section 2. The results of source and target domains comparison for COMPETITION IS 1 ON 1 PHYSICAL AGRESSION metaphor are presented in Graphs 1 and 2. Graph 2 indicates that the greatest similarity between the source and target domains for the seven metaphorical expressions considered occurs in the domains of EMOTION and TEMPERATURE. We can also see that the source and target domains have no common features at all in the domain of COLOUR. As we have already observed in Section 3, the second visual domain, SPACE, also displays a rather low degree of similarity of 45%. The average similarity for both visual domains equals 22.5%, which is 4 times lower than the value for the domain of TEMPERATURE and almost 5 times lower than the average

similarity in the domain of EMOTION. This can lead us to a conclusion that the metaphor COMPETITION IS 1 ON 1 PHYSICAL AGRESSION is not motivated by visual similarity. This conclusion allows us to see Lakoff's (1993, 40) statement, already quoted in the introduction, in a new light. 'Metaphor is mostly based on correspondences in our experiences, rather than on similarity' can now be paraphrased as 'Metaphor is not based on visual similarity but rather on similarities grounded in other domains of experience, such as, for example, EMOTION or TEMPERATURE'. Naturally, this conclusion should be fortified with analyses of numerous other metaphors and it is to be hoped that the method of comparison presented in Section 2 will allow us to carry on further research toward this goal.

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