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A Cognitive Linguistic Analysis of the Concept TEMPERATURE in English and Arabic

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Abstract

For various historical, political as well as economic reasons, the English language is favoured as the universal language of science over other languages including French and German (Tardy, 2004). This naturally entails that students who are conversant in English have an advantage over those who are not in the acquisition of scientific knowledge. In relation to this, research on the misunderstanding of scientific terms in different languages shows that students who are speakers of non-western languages in particular face difficulties in conceptualising scientific concepts. There is evidence to suggest that these students' pre-existing knowledge about scientific terms and the polysemous nature of such terms are factors that influence their conceptualisation of the terms. This finding is the motivation behind the present cognitive linguistic study of the term *temperature* and its equivalent in Arabic, the compound *درَجَةُ الْحَرَارَةِ* (*darajatu al-ḥarara*). Using a cognitive framework, namely Lakoff's Idealised Cognitive Models (ICMs), the study analyses the conceptual similarities as well as differences between the terms. The study also analyses the English term *heat* as the second free morpheme of the compound *درَجَةُ الْحَرَارَةِ* is *الْحَرَارَةُ* which is the Arabic rendering of *heat*. The meanings and different uses of the terms are examined to analyse the ICMs that are evoked in each language. The results of the analysis reveal that the ICMs of English and Arabic terms under study overlap, and interestingly, also differ.

Keywords: Concept, idealised cognitive models, polysemy, temperature, heat

1. Introduction

Scientific concepts are denoted in lexical terms that are used in the teaching of science. Language therefore plays a crucial role as the medium of scientific knowledge. While scientific terms are usually associated with technical jargon, the fact remains that many of these terms, such as *heat*, *force* and *acceleration* are in fact common words which people use in their daily lives and which are found in non-scientific formal texts. These common terms can cause a problem for students when used in a scientific context because of the possibility of relating such terms to their pre-existing knowledge. Because English is the universal language of science (Tardy, 2004), for non-native speakers, this poses a much bigger challenge due to the possibility that they understand the scientific terms in relation to their cultural, social and bodily experience.

Past studies (e.g., Aikenhead, 2001; Kawasaki, 1996, 2002) found that in non-western contexts particularly, one of the main reasons for students' misunderstanding of scientific concepts is language. The studies suggest that translating scientific terms from western languages to other languages can be problematic because many real and physical phenomena are conceptualised differently across languages. This finding is the motivation behind this study to analyse the similarities and differences that lie between the English words used as terms of science and their Arabic counterparts. To this end, the study analyses one of the major scientific concepts in science, TEMPERATURE. This concept is chosen for the analysis because it is one of the major as well as complicated concepts learned in early primary education, and the terms denoting it in both English and Arabic, i.e., *temperature* and *تَرْجَةُ الْحَرَارَةِ* (*darajatu al-ḥarara*), do not have the same senses in science as they do in ordinary language.

It is worth mentioning here that concepts will be written in capital letters while terms and words will be in italics in this paper to draw a distinction between them. The scientific concept TEMPERATURE is linguistically denoted by the word *temperature* in English and by *تَرْجَةُ الْحَرَارَةِ* (*darajatu al-ḥarara*) in Arabic. However, given that Arabic uses *الْحَرَارَةُ* (i.e., the Arabic equivalent of the English term *heat*) in the compound *تَرْجَةُ الْحَرَارَةِ* to denote TEMPERATURE, the paper will also compare the concept HEAT in both English and Arabic. The English and Arabic terms denoting the two concepts will be analysed using a cognitive linguistic approach. Cognitive linguistics normally interprets language in accordance with the concepts that underlie words and terms, taking both language universal and language-specific aspects. For this purpose, Lakoff's (1987) Idealised Cognitive Models (ICMs) are employed to examine the concept of TEMPERATURE in English and Standard Arabic to identify the gaps that may exist between the concepts which relate to both languages. In addition, Idealised Cognitive Models provide a better explication of humans' categorisation and understanding of concepts.

2. Idealised Cognitive Models (ICMs)

Lakoff (1987) considers ICMs as a basic part of humans' ability to conceptualise. Idealised Cognitive Models (ICMs) are "rich conceptual structures that capture relevant aspects of reality on the basis of a number of structuring principles" (Knop & Rycker, 2008, p. 126). They are highly abstract frames that can explicate some kinds of typicality effects in categorisation (Evans & Green, 2006, p. 169). The concept BACHELOR, for example, is understood with regard to a relatively schematic MARRIAGE ICM that comprises the knowledge that 'bachelors' are unmarried adult males. Hence, some members of the category BACHELOR (e.g., eligible young men) are better or more typical examples than others (e.g., the

Pope). The knowledge related to the MARRIAGE ICM requires that bachelors can marry, while the knowledge pertaining to CATHOLICISM requires that the Pope cannot marry. The gap between the MARRIAGE ICM and the CATHOLICISM ICM constitutes the source of such particular typicality effect to rise (Evans & Green, 2006, p. 169). Therefore, categories are related to ICMs that “are stable mental representations that represent theories about the world” (ibid., 2006, p. 270). While “they are rich in detail, they are ‘idealised’ because they abstract across a range of experiences” (ibid.). Lakoff (1987) mentions that the word *bachelor* is defined in terms of a model of the world in which some expectations hold (e.g., opposite-sex partnership, typical marriageable age), and the model against which the word *bachelor* is defined is idealised in that it denies many possible aspects of the real world (e.g., a role in a religious institution which requires a vow of chastity) (Cited in Cienki, 2007, p. 177).

3. Analysis

As stated earlier, the concept TEMPERATURE is denoted by *temperature* and *دَرَجَةُ الْحَرَارَةِ* (darajatu al-ḥarara) in English and Arabic respectively. And because the Arabic compound includes the form *الْحَرَارَةُ*, which is equivalent to the term *heat*, the concept HEAT in both English and Arabic are also analysed. To compare and contrast the terms *temperature* and *دَرَجَةُ الْحَرَارَةِ* as well as the word *heat* and its Arabic equivalent *الْحَرَارَةُ* (al-ḥarara), it was necessary to firstly investigate all the possible meanings of the words. For this purpose, various English and Arabic dictionaries, encyclopaedias and lexical databases were consulted. After consulting more than fifty dictionaries, encyclopaedias and lexical databases on each language of the two languages, four English dictionaries, an English lexical database, four Arabic dictionaries and an Arabic-English dictionary were selected for the examination of meanings of the terms. This is to avoid redundancy and to have a more exhaustive and diverse set of meanings. The selected dictionaries, encyclopaedias and lexical databases are *The Concise Oxford Dictionary*, *Oxford English Reference Dictionary*, *Merriam-Webster's Online Dictionary*, *Longman Dictionary of the English Language*, *WordNet*, *Al-Mawrid: A Modern Arabic-English Dictionary*, *Muajam Al-lugha Al-Arabia Almuasira*, *Al-Muajam Al-Ghania*, *Lisaan Al-Arab* and *An Arabic-English Lexicon*. In the following sections, the analysis of the words based on the meanings derived from the sources listed above is presented.

TEMPERATURE – *temperature*, *دَرَجَةُ الْحَرَارَةِ* (darajatu al-ḥarara)

The concept TEMPERATURE is linguistically denoted by the term *temperature* in English. The word *temperature* is derived from Latin, *temperatura* which means ‘the state of being mixed’ (*Compact Oxford English Dictionary*, 2008). In Arabic, the same concept is represented by the compound *دَرَجَةُ الْحَرَارَةِ* (darajatu al-ḥarara). The structure of *دَرَجَةُ الْحَرَارَةِ* (darajatu al-ḥarara) is a compound noun or rather a grammatical combination of noun + noun (i.e., *دَرَجَةُ* [darajatu] + *الْحَرَارَةُ* [al-ḥarara]).

Clearly, there is major difference in the morpho-syntactic form of the English and Arabic terms for the concept TEMPERATURE; that is, English uses a noun (*temperature*) while Arabic uses a compound noun (*دَرَجَةُ الْحَرَارَةِ* (darajatu al-ḥarara)). The first part of the Arabic form *دَرَجَةُ* (darajatu) means “degree” while the second part *الْحَرَارَةُ* (al-ḥarara) essentially means “heat”. The whole compound therefore literally means “the degree of heat”. Arabic then uses *الْحَرَارَةُ* to mean both *heat* and *temperature* when it is adjacent to *دَرَجَةُ* (i.e., degree) in order to denote the concept TEMPERATURE. Having discussed the forms of the terms *temperature* and *دَرَجَةُ الْحَرَارَةِ*

, it is necessary to examine the entries for the meanings of the two terms in the various English and Arabic sources listed earlier.

Table 1: The English and Arabic Dictionary Entries for Temperature and *درجَةُ الحرارة*

English Dictionaries	Meanings
<i>The Concise Oxford Dictionary/ Oxford English Reference Dictionary</i>	<ul style="list-style-type: none"> • “the degree or intensity of heat of a body in relation to others, esp. as shown by a thermometer or perceived by touch, etc.” • “the degree of internal heat of the body (in Medicine)” • “a body temperature above the normal (have a temperature)” • “the degree of excitement in a discussion etc.”
<i>Merriam-Webster’s Online Dictionary</i>	<ul style="list-style-type: none"> • "degree of hotness or coldness measured on a definite scale", "the degree of heat that is natural to the body of a living being" or "abnormally high body heat" • "relative state of emotional warmth" or "mood"
<i>Longman Dictionary of the English Language</i>	<ul style="list-style-type: none"> • “temperament” • “degree of hotness or coldness as measured on an arbitrary scale (e.g., a mercury thermometer graduated in degrees Celsius)” • “the degree of heat that is natural to the body of a living being” • an abnormally high body heat” • “relative state of emotional warmth (e.g., “aware of a change in the temperature of our friendship- Christopher Isherwood”
<i>WordNet</i>	<ul style="list-style-type: none"> • "the degree of hotness or coldness of a body or environment (corresponding to its molecular activity)" • "the somatic sensation of cold or heat"
Arabic Dictionaries	Meanings
<i>Al-Mawrid: A Modern Arabic-English Dictionary</i>	<ul style="list-style-type: none"> • “(degree of) temperature”
<i>Muajam Al-lugha Al-Arabia Almuasira</i>	<ul style="list-style-type: none"> • “(nature and physics) the intensity of thermal energy in the body or space. The temperature depends on the average kinetic energy of molecules in a certain space. It can be expressed in terms of a number of gradients, such as Fahrenheit and Celsius scales (percentile ranking)”
<i>Al-Muajam Al-Ghania</i>	<ul style="list-style-type: none"> • “the degree of hotness or coldness”

The definitions of the concept TEMPERATURE provided in the above-mentioned dictionaries and lexical database reflect the following basic ideas:

English

- the degree of hotness or coldness of a body/ environment
- the degree of heat of a body in relation to others
- relative state of emotional warmth or temperament
- a body temperature above the normal/ fever

Arabic

- the degree of hotness or coldness

As the dictionary and lexical database entries show, while the Arabic term *درَجَةُ الحرارة* can only mean “the degree of hotness or cold”, the English term *temperature* can also mean “mood” and “degree of excitement”. It is interesting to note that the terms *temperature* and *درَجَةُ الحرارة* meet at the PHYSICS ICM which consists of many related concepts such as body, environment, vertical measurement and thermometer. This is because *درَجَةُ الحرارة* is only used as a science term, and therefore it literally means “the degree of heat”, where *heat* designates both *heat* and *cold*. This postulates that some conflict may happen in the conceptualisation of the concept TEMPERATURE within the Arabic context

HEAT- heat, الحرارة (al-ḥarara)

It was established earlier that the Arabic form *درَجَةُ الحرارة* (*darajatu al-ḥarara*) comprises two nouns. And the form *الحرارة*, meaning *heat*, constitutes the bulk meaning of the compound noun. The meanings of the words in English and Arabic derived from the various sources are listed below.

الحرارة : The English and Arabic Dictionary Entries for Heat and 2Table

English Dictionaries	Meanings
<i>The Concise Oxford Dictionary</i>	<ul style="list-style-type: none"> • “the condition of being hot”, “the sensation or perception of this”, or “high temperature of the body” • (Physics) “a form of energy arising from the random motion of the molecules of bodies, which may be transferred by conduction, convection, or radiation”, “the amount of this needed to cause a specific process, or evolved in a process” • “hot weather” • “warmth of feeling”, or “anger or excitement (the heat of the argument)” • (followed by of) the most intense part or period of an activity (in the heat of the battle)” • (usu. preliminary or trial) “round in a race or contest” • “the receptive period of the sexual cycle, esp. in female mammals” • “redness of the skin with a sensation of heat (prickly heat)” • “pungency of flavour” • (slang) “intensive pursuit, e.g., by the police”

<p><i>Merriam-Webster's Online Dictionary</i></p>	<ul style="list-style-type: none"> • "a condition of being hot : warmth" or "a marked or notable degree of hotness", "pathological excessive bodily temperature", "a hot place or situation", "a period of heat" or "a single complete operation of heating and also the quantity of material so heated", "added energy that causes substances to rise in temperature, fuse, evaporate, expand, or undergo any of various other related changes, that flows to a body by contact with or radiation from bodies at higher temperatures, and that can be produced in a body (as by compression)" or "the energy associated with the random motions of the molecules, atoms, or smaller structural units of which matter is composed", or "appearance, condition, or color of a body as indicating its temperature" • "intensity of feeling or reaction : passion", "the height or stress of an action or condition <in the heat of battle>", or "sexual excitement especially in a female mammal; specifically: estrus" • "a single continuous effort: as a: a single round of a contest (as a race) having two or more rounds for each contestant", or "one of several preliminary contests held to eliminate less competent contenders" • "pungency of flavor " • (a slang)"the intensification of law-enforcement activity or investigation" or "police", "pressure, coercion", or "abuse, criticism <took heat for her mistakes>" • "smoke" • (slang) "gun"
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<p><i>Longman Dictionary of the English Language</i></p>	<ul style="list-style-type: none"> • “the condition of being hot; warmth”, “a marked or notable degree of hotness”, abnormally high bodily temperature”, “a single complete operation of heating (e.g., in a furnace) or the quantity of material so heated”, “the form of energy that is produced by the random motions of the molecules, atoms or smaller structural units of which matter is composed and that can be transmitted by CONDUCTION, CONVECTION, or RADIATION from a body or region of higher temperature”, “the appearance, condition, or colour of a body as an indication of its temperature”, or “any of a series of degrees of heating” • “intensity of a feeling or reaction”, “the height or stress of an action or condition”, “readiness for sexual intercourse in a female mammal” • “pungency of flavor” • “a single round of a context (e.g., race) that has two or more rounds for each contestant”, “any of several preliminary contests whose winners go to the final” • (chiefly, Am slang) “the intensification of police activity or investigation”, “the police”, or “pressure, coercion”
<p><i>Wordnet</i></p>	<ul style="list-style-type: none"> • “heat energy (a form of energy that is transferred by a difference in temperature)” • “hotness, heat, high temperature (the presence of heat)” • “warmth, the sensation caused by heat energy)” • “warmth, passion (the trait of being intensely emotional) • “estrus , heat, rut (applies to non-human mammals: a state or period of heightened sexual arousal and activity)” • “(a preliminary race in which the winner advances to a more important race)” • “heating system, heating plant, heating, heat (utility to warm a building) “the heating system was not working”, “they have radiant heating”
<p>Arabic Dictionaries</p>	<p>Meanings</p>
<p><i>Al-Mawrid: A Modern Arabic-English Dictionary</i></p>	<ul style="list-style-type: none"> • “heat, hotness, warmth, warmness” • “fever, temperature” • “temperature, degree of temperature” • “enthusiasm and zeal” • “warm feeling, intimacy and emotion”

<i>Muajam Al-lugha Al-Arabia Almuasira</i>	<ul style="list-style-type: none"> • “enthusiasm, zeal and passion” • “of affection, being deep and strong” • “warmth, contr. <i>cold</i>” • “fever, temperature” • “(in science and physics) a form of energy that melts, heats or evaporates”
<i>Lisaan Al-Arab</i>	<ul style="list-style-type: none"> • “heat (contr. <i>cold</i>)” • “thirst” • “burning in the mouth from the taste of something, and in the heart from pain”
<i>An Arabic-English Lexicon</i>	<ul style="list-style-type: none"> • “contr. of برودة (<i>cold</i>)” • “a burning in the mouth from the taste of a thing, and in the heart from pain” • “heat or burning in the throat”

It is worthy of note here that the researcher’s focus is mainly on the basic meanings and ICMs of the terms *temperature* and *تَرَجُّهُ الْحَرَارَةِ* (*darajatu al-ḥarara*); therefore, the informal language or slang will be avoided in the current study.

Based on the above-mentioned dictionary and lexical database entries, the major definitions of *الحرارة* and *heat* can be summed up as follows:

English

- the condition or sensation of being hot
- high temperature of the body
- a form of energy (in physics)
- hot weather
- intensity of a feeling or reaction
- the height or stress of an action or condition
- readiness for sexual intercourse in a female mammal
- pungency of flavour
- a preliminary race in which the winner advances to a more important race
- the operation of the heating or the quantity of material so heated.
- the redness of the skin with a sensation of heat

Arabic

- warmth (as opposite to *cold*)
- fever
- form of energy (in physics)
- enthusiasm and passion
- of affection, being deep and strong
- thirst

- burning in the mouth from the taste of something, and in the heart from pain

A comparison of the above definitions demonstrates that the English term *heat* and the Arabic term *الحرارة* overlap in terms of meaning. Yet, they also differ. In a number of definitions, it is clear that the English and Arabic terms for the concept HEAT share the same denotations as well as ICMs. These include the English and Arabic denotations “the condition or sensation of being hot”, “hot weather” and “warmth (as opposite to *cold*)” can be defined in terms of an idealised model which consists of warmth, cold and location (i.e., body or environment) or cause (i.e., causing warmth). The denotations “high temperature of the body” and “fever” can be defined according to features like high temperature, body, disease, weakness and danger. The English and Arabic denotation “a form of energy” also overlaps and can be described in relation to a SCIENCE or PHYSICS ICM in which such elements as difference in temperature, heat transfer or motion, molecules and conduction, convection, or radiation are evoked. The English and Arabic denotations “intensity of a feeling or reaction”, “the height or stress of an action or condition”, “enthusiasm and passion” and “of affection, being deep and strong” also overlap as they can be described in relation to such elements as emotions, action, human contact and strength. It may be argued that the denotations “pungency of flavour” in English and “burning in the mouth from the taste of something” in Arabic also overlap as they can evoke features like mouth, food or drink and strong taste, smell or flavour.

The meanings for *heat* in English and Arabic, as the data in Table 2 suggest, also contrast. Firstly the Arabic term *الحرارة* cannot be used to denote “a round in a race”, “estrus”, or “operation of the heating” and the English term *heat* is not used with the meaning of “thirst” or “the burning in the heart from pain”. The meaning of *heat* as “a round in a race” may involve such elements as initial race, competitors, winners, losers and the final. The definition of *heat* as “estrus” can evoke features like non-human mammals and readiness or excitement for mating. Its meaning as “operation of the heating” has an ICM which may involve elements like a building, utility and causing heat or warmth. These three English extended meanings of *heat* are not found in the use of *الحرارة* (*al-ḥarara*). In the same vein, the English term *heat* does not denote “thirst”. The latter evokes throat, need for drink, water and pain. Furthermore, it does not denote “the burning in the heart from pain”, which can be defined in terms of pain, sufferance, heart and feelings.

The definitions as well as ICMs of the term *الحرارة* (the Arabic equivalent of *heat*) discussed above show that *cold* is an opposite of *heat* and so cannot be part of its meaning. However, when the noun *درجة* (*degree*) is added to the noun *الحرارة* (*heat*) to form the compound *درجة الحرارة*, the form *الحرارة* (*heat*) is semantically extended to include cold in denoting the degree of hotness or coldness. Arab students may face difficulty in understanding *درجة الحرارة* if they are not aware of the semantic extension that took place. Instead, they may understand that *temperature* only comprises measurement of heat and not coldness. In contrast, this is represented by a different word than *heat* in English, i.e., *temperature*, and therefore such confusion may not occur in English.

Finally, *درجة الحرارة* (*darajatu al-ḥarara*) and *temperature* can be seen as a space that has only a vertical dimension along which it moves, taking the notion of measurement scale into consideration. In contrast, the terms *الحرارة* and *heat* can be perceived as a spatial entity or a

causal entity (i.e., a source of hotness), which shows the similarity between English and Arabic in the Idealised Cognitive Models related to the terms under consideration.

4. Conclusion

Both linguistic denotations of the concept TEMPERATURE and HEAT involve the word *الحرارة* in Arabic unlike in English where different terms, that is, *temperature* and *heat*, are used to designate the concepts concerned. The Arabic compound *درجة الحرارة* is basically used as a scientific term in which the meaning of *الحرارة* is semantically extended with the addition of *درجة* to include the meaning of cold in addition. The analysis shows that the various meanings of *heat* and *الحرارة* do not only overlap, but they also differ. The differences that have been identified are more related to the semantic, metaphorical and metonymic extensions and to the ICMs evoked when the terms are used.

The polysemous nature of the Arabic term *الحرارة* (*heat*) can pose a real challenge to Arab students' understanding of the concepts TEMPERATURE and HEAT in the context of physics. Familiar terms such as these which are used in their daily speech can affect their understanding when they are used in the science classes. Students may categorise them according to their pre-existing knowledge, cultural and social background and experience, leading to difficulties in learning scientific concepts.

The findings from the present analysis do not suggest that only students who study physics or science in Arabic face problems in conceptualising scientific terms. Students who are native speakers of English also experience difficulty due to the polysemous nature of familiar words that are used as scientific terms. As Strömdahl (2007) points out, the terms borrowed from everyday speech and used in formal scientific language constitute an issue to learning as well as teaching. Given this, it is necessary for teachers to bear in mind the gaps that exist between the different meanings in scientific terms that are also common in everyday language. This is to ensure that students are aware of such gaps, hence avoiding the problem of misunderstanding the concepts in learning science.

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