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The conceptual metaphors of memory: Cases of interdomanial nomadism from computer science to quantum computing

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Abstracts

English Français

Conceptual metaphors, which help conceptualizing one concept in terms of another (Lakoff & Johnson [1980]), often migrate from a source scientific domain onto another. This article aims at describing the "interdomanial nomadism" (Rossi [2015]) of the conceptual metaphors associated with memory from computer science to quantum computing. One corpus of 35 texts about quantum computing was compiled from the *Scientific American*. This corpus is made of all the texts ever published in the magazine which contain the keywords "quantum computing" or "quantum computer(s)". Another corpus of 15 texts about computer memory was compiled from the same magazine. The search for these texts was refined by looking for the keyword "computer memory" and excluding the keyword "quantum". Our analysis relies on the extraction of terms related to memory in both corpora (more specifically on the terms that the corpora have in common) and on the identification of their metaphoricity to investigate any potential interdomanial shifts. First, we extracted the keywords from both corpora in Sketch Engine (Kilgarriff *et al.* [2014]). This extraction gave us a general idea of the conceptual metaphors of memory in both computer science and quantum computing. Then, we observed, through the means of similarity analysis, the words which co-occur the most with the word "memory" in a close context. This observation enabled us to have a further look at potential metaphorical expressions associated with memory. The MIPVU method (Metaphor Identification Procedure Vrije Universiteit Amsterdam) developed by Steen *et al.* [2010] was selected to identify metaphorical items in the corpora. The analysis of the keywords resulted in the identification of 9 conceptual metaphors used to describe memory, among which 4 are common to both corpora, providing first evidence of metaphorical nomadism of memory from computer science to quantum computing. Additionally, 5 types of nomadic patterns were identified based on the examples from the corpora, providing better insight into metaphor interdomanial nomadism.

Les métaphores conceptuelles, qui permettent de conceptualiser un concept sous la forme d'un autre concept (Lakoff & Johnson [1980]), migrent souvent d'un domaine scientifique source vers un autre. Cet article a pour objectif de décrire le « nomadisme interdomanial » (Rossi [2015]) des métaphores conceptuelles associées à la mémoire en anglais depuis le domaine source de l'informatique vers l'informatique quantique. Un corpus de 35 textes sur l'informatique quantique a été compilé à partir du *Scientific American*. Ce corpus est constitué de tous les textes qui contiennent les mots-clefs « quantum computing » et « quantum computer(s) » publiés dans ce magazine. Un autre corpus de 15 textes a été compilé sur la mémoire des ordinateurs à partir du même magazine en filtrant les textes contenant l'expression « computer memory » et excluant le mot « quantique(s) » grâce à des opérateurs booléens. Notre analyse repose sur l'extraction de termes associés à la mémoire dans les deux corpus (et plus particulièrement les termes que ces corpus ont en commun) et sur l'identification de leur potentielle métaphoricité en vue d'observer des transferts interdomaniaux. En premier lieu, nous avons extrait les mots-clefs des corpus à l'aide de Sketch Engine (Kilgarriff *et al.* [2014]). Cette extraction nous a donné une vue générale des métaphores conceptuelles associées à la mémoire dans les domaines de l'informatique et de l'informatique quantique. Ensuite, nous avons observé, grâce à des analyses de similitude, les mots qui étaient le plus souvent présents dans le même contexte que le mot « memory » afin de sonder d'autres métaphores linguistiques associées à la mémoire. Nous avons exploité la méthode MIPVU (Metaphor Identification Procedure Vrije Universiteit Amsterdam) conçue par Steen *et al.* [2010] pour identifier les métaphores linguistiques dans les corpus. L'analyse des mots-clefs a mené à l'identification de 9 métaphores conceptuelles utilisées pour décrire la mémoire, dont 4 sont communes aux deux corpus, ce qui constitue un premier signe de nomadisme métaphorique depuis l'informatique jusqu'à l'informatique quantique. En outre, 5 cas de transferts nomades ont été identifiés à partir d'exemples tirés des corpus et permettent de mieux comprendre les mécanismes du nomadisme interdomanial des métaphores.

Index terms

Mots-clés : identification des métaphores, informatique, informatique quantique, mémoire, métaphores conceptuelles, MIPVU, théorie de la métaphore conceptuelle

Keywords: computer science, conceptual metaphors, conceptual metaphor theory, MIPVU, memory, metaphor identification, quantum computing

Full text

Introduction

1 A conceptual metaphor is the result of the mapping of a source domain onto a target domain which helps us understand an abstract concept in terms of a more concrete concept (Lakoff & Johnson [1980]). Famous conceptual metaphors include ARGUMENT IS WAR, LOVE IS A JOURNEY, TIME IS MONEY, etc. that are respectively expressed in language through the following examples: "you need to defend your point", "our marriage is on the rocks", "she promised to save some time for me".

2 In other words, conceptual metaphors are the product of a mental process that takes place in the mind and whose traces can be found in language through linguistics realizations. The *conceptual metaphor* takes place in the mind and refers to the process of representing or conceptualizing one thing in terms of another, while the *metaphorical expression* represents how the metaphor is expressed in language:

> The word 'metaphor' has come to be used differently in contemporary metaphor research. It has come to mean 'a cross-domain mapping in the conceptual system.' The term 'metaphorical expression' refers to a linguistic expression (a word, phrase, or sentence) that is the surface realization of such a cross-domain mapping. (Lakoff [1993: 203]).

3 The distinction between metaphorical expressions and conceptual metaphors based on a source domain and a target domain makes it possible to study different aspects of metaphors: (1) metaphorical expressions can be seen as linguistic clues to conceptual metaphors; (2) conceptual metaphors reveal how one thing is understood in terms of another; (3) source domains show *which* concrete domain is used to understand a more abstract domain; (4) target domains reveal *which* abstract domain needs to be understood through another, more concrete domain.

4 For a long time, metaphors were seen as ornamental tropes which did not have their place in specialized contexts. In fact, the use of metaphors in scientific discourse "tended to be an embarrassment to some scientists and philosophers" (Holton [1995: 259)], but since conceptual metaphors are produced in our minds and realized in language, "they are present in specialized language as well as in general language" (Tercedor-Sánchez *et al.* [2012: 33]) and are "used extensively in science in particular and specialist writing in general" (Ahmad [2006: 197]).

5 Contributions from epistemology (e.g. Boyd [1993]; Kuhn [1993]; and Brown [2003]), as well as the emergence of Socioterminology (Gaudin [2003]) and Sociocognitive terminology (Temmerman [2000]) allowed metaphors to find a place in terminology:

> We challenge the principle of traditional Vienna school terminology theory which claims that because unambiguous communication is the ideal in scientific communication, it is preferable to replace a metaphorical term by its literal equivalent (Temmerman [2002: 211]).

6 Consequently, the recognition of the legitimate presence of metaphors in terminology made it possible to formally acknowledge not only their presence in Language for Specific Purposes (Temmerman [2002]; Cabré [2016]) but also their role in building scientific knowledge (Temmerman [2000]; Resche [2002]; Vandaele & Lubin [2005]; Rossi [2015]; Tercedor & López-Rodríguez [2012]).

7 Numerous studies have indeed shown that scientific domains heavily rely on conceptual metaphors to coin new terms (Byrne [2012]), but also to shape theories or paradigms (Boyd [1993]; Resche [2002]; Vandaele [2006]) or to vulgarize knowledge (Oliveira [2009]). Metaphors are also pervasive in any kind of scientific domain from architecture (Caballero [2003]) to oenology (Rossi [2015, 2017]) or marine biology (Ureña Gómez-Moreno [2012]) to cite a few.

8 Computer science also follows this trend. As early as in the nineties, Meyer *et al.* [1997: 3] focused on the study of metaphors in this scientific domain and explained that "while metaphors probably appear in most domains, they are particularly prevalent in the language of computing". The authors stress the importance of the cognitive, vulgarizing function of metaphors in computing that is essential to understand abstract systems and concepts, but also their aesthetic function, which contributes to the "user-friendliness" of computers.

9 If metaphors are indeed based on the mapping of a conceptual domain onto another, they do not appear in a vacuum and are often the result of a migration from a source scientific domain onto another. This phenomenon of terminological migration of lexicalized metaphorical terms from one domain to another is what Rossi [2015] calls "interdomanial nomadism". Rossi [2015: 65] describes metaphors that are capable of nomadism as being "profoundly rooted in the culture / language that generated them" and adds that when metaphors start off their journey, "the source domain is chosen on the basis of eminently historical and cultural factors". As a result of the migration, "the connotations associated with the initial conceptual metaphor can significantly change" (Bordet & Pic [2015: 117]). According to Rossi [2015: 70-71], interdomanial nomadism is closely conditioned by the following parameters:

- the availability of the conceptual source domain: the source domain of the mapping should be readily available to have a higher chance of being selected for nomadism. This explains why personification and animalization metaphors (i.e. conceptualizing something as a human or animal) are so frequently used;
- the heuristic function of the metaphor: the mapping contributes to the emergence of new conceptualizations that help structure the target scientific domain;
- the nomadic opportunities of the scientific source domain: They depend on the intelligibility of the transferred metaphor, its importance in the new field and its necessity (to situate the target scientific domain in the lineage of the source

scientific domain and to make it theoretically aligned with it) (Schlanger [1995: 94]).

10 These parameters explain why metaphors are often transferred from older and well-established scientific paradigms. As a result, interdomanial nomadism operates in many fields including in computer sciences as pointed by Meyer *et al.* [1997: 4-5] when describing metaphors of the internet:

> A number of these terms did not necessarily *originate* in the domain of the Internet. Since we are dealing with a highly interdisciplinary domain, many terms have been borrowed from elsewhere: *surf*, for example, (as in *to surf the Net*) was probably borrowed from the domain of television, as in *channel surfing; anchor*, which occurs frequently in relation to Web pages, originated in the domain of hypertext; the omnipresent *virtual* can be traced back to *virtual reality* and other computing concepts.

11 The memory of computers follows the same trend and was borrowed from biology: it results from the mapping of *human* memory onto computers, which in itself is associated with the personification of computers through the conceptual metaphor A COMPUTER IS A PERSON. Yet, even if the mapping of memory from biology onto computers is well documented, to the best of our knowledge, the transfer of metaphors underlying memory from regular computers to quantum computers has not been the object of any research. It is our hypothesis that interdomanial nomadism makes no exception when it comes to the concept of memory in regular and quantum computers.

1. Conceptualizing memory

12 Computer science relied heavily on biology to describe computers in terms of brains: "a computer can be described in terms of a brain […]. It therefore conjures up thoughts about the qualities and functions of the brain." (Nagel [2007: 49]). Since one of the functions of a brain is to hold memory, human memory was naturally mapped onto computer memories.

13 Indeed, memory which was first studied as a neurobiological notion was later claimed by computer science to design data conservation and retrieval models in a series of metaphorical terms that are based on human brain memory. For instance, the *main memory* of a computer can be related to our *long-term memory*, while *cache memory* can be compared with our *short-term memory*, which stores *units of information* that are called *bits* in computer science. The *central processing unit* of a computer can be compared to the *human brain* which sends and receives *electrical signals* just like *neurons* to process *instructions from programs* in *binary signals*.

14 More recently, conceptual metaphors about memory have been borrowed and adapted from computer science to describe the memory of quantum computers (i.e. *qubits*, *quantum decoherence*, *quantum communication network*) and have even led to the emergence of a new cognitive science domain: quantum cognition, in which principles of quantum mechanics are applied to human cognition to model it.

15 This series of nomadic moves offers new evidence that metaphors evolve and migrate from one scientific domain to another where metaphors of well-established scientific domains usually help crystallize concepts of emerging scientific domains, but sometimes go full circle and end up reshaping concepts grounded in the original scientific domain in which they were originally coined.

2. Aim

16 The aim of this article is to analyze metaphors underlying the concept of memory in regular and quantum computers and identify the interdomanial nomadism patterns of

some of these metaphors from computer science to quantum computing.

3. Method

3.1. Compilation of corpora

17 To investigate metaphors about memory in computer science and quantum computing, searches conditioned by Boolean operators were launched in the popular science magazine *Scientific American*. On the one hand, we introduced the following research equation to collect texts about computer memory: “computer memory” NOT “quantum”. This equation allowed us to find articles about computer memory excluding the ones referring to quantum computers. This exclusion was necessary to ensure that the two corpora were thematically different. Additionally, it was also necessary to orient the search towards computer *memory* instead of computers in general. Indeed, since the aim of this paper is to investigate the metaphorical nomadism of memory between regular computers and quantum computers, it is essential that only the *memory* aspect of regular computers makes up the basis for analysis (rather than their other components or hardware for instance). The computer memory corpus is made of 15 texts (tokens= 35,423 words, types= 5,418 words).

18 On the other hand, the following equation led us to the compilation of the quantum computing corpus: “quantum computing” OR “quantum computer”. Since quantum computing is a rather emerging branch of computing, targeting the search to the *memory* aspect of quantum computers would have returned close to no results. This less oriented search also gave us the opportunity to explore aspects of quantum computing that could be related to memory without specifically pointing to the word *memory*. The quantum computing corpus is compiled of 35 texts (tokens= 77,969 words, types= 7,152 words).

3.2. Extraction of keywords and collocates

19 Keywords were used to analyze metaphorical candidates. They are words that are “key” in a corpus because they appear more frequently in the corpus under analysis in comparison with a reference corpus. Single-word keywords were extracted from both corpora with the help of Sketch Engine (Kilgarriff *et al.* [2014]). The English Web 2021 corpus was used by Sketch Engine as the reference corpus[1].

20 Table 1 provides an overview of the distribution of keywords in the corpora:

Table 1. Keywords distribution

	Single-word keywords frequency
Computer memory corpus	4,436
Quantum computer corpus	5,641
In common (freq > 5)	748

21 In total, 2434 single-word keywords were found in common in both corpora. We then excluded the keywords with a frequency lower than 5 in both corpora and ended up with 748 keywords in common.

3.3. MIPVU

22 The MIPVU was applied to lexical items extracted from the corpora to identify potential metaphors. This identification procedure relies on six steps in order to identify "metaphor related words" (MRWs) which correspond to the linguistic realizations of an underlying conceptual metaphor. The MIPVU is in fact a refined version of the MIP (Metaphor Identification Procedure) created by Steen *et al.* [2010] to be the most statistically reliable procedure to identify metaphors.

23 The MIPVU was adapted to study keywords through the lens of the concordancer AntConc (Anthony [2019]). This adaptation provided several advantages. First, working with the concordancer made the coding binary instead of linear (the original MIPVU stipulates that the coding should be done while reading the entire text) and enabled us to focus on one item at a time and to visualize all its concordances in a single window. Second, the visualization offered by the concordance window helps to see contrasts between the different tokens and therefore makes it easier to spot MRWs that would have seemed less obvious if they had been coded in a linear way (Meyers [2021: 181]).

24 Although the procedure normally requires calculating inter-coder agreement scores, since the coding was only performed by one researcher, we were unable to do these calculations. Nevertheless, we are convinced that the MIPVU is the most reliable identification procedure to date as its aim is to reduce coding bias by forcing the coder to rely on a systematic contrast of contextual meaning and dictionary meaning of a candidate MRW, but also because this identification method is fully compatible with the conceptual metaphor theory (Lakoff & Johnson [1980]), since MRWs can be seen as the linguistic realizations of conceptual metaphors.

4. Analysis

25 First, we will focus on the general structure of the corpora with the use of similarity analyses to have an overview of the corpora's thematic content. Second, we will explain how our keywords analysis led to the discovery of MRWs about memory and their related conceptual metaphors. Third, we will show how running a similarity analysis targeted at the word "memory" in both corpora enabled us to find further metaphors surrounding the concept of memory. Finally, we will demonstrate through several examples how the identification of these metaphors related to memory helped us identify various patterns of nomadic migrations from computer science to quantum computers.

4.1. General structure of the corpora

26 Based on graph theory, similarity analysis provides a visual representation of the general structure of a corpus and the association strength of its lemmatized content. Similarity is determined by a co-occurrence index (the tendency of words to co-occur in a segment). Similarity analysis helps visualize the way words are connected to each other in a corpus (Loubère & Ratinaud [2008]): the size of the word reveals its frequency in the corpus (and therefore its thematic importance) while the size of the links between the words is proportional to their co-occurrence patterns. The software used to generate this analysis, Iramuteq (Loubère & Ratinaud [2008]), creates communities (recognizable by their colors) to identify "clusters" of words that co-occur the most in the same segments.

27 A similarity analysis with the following parameters was run on both corpora: links between words in the communities have a minimum frequency of 10 and the font size of words is proportionate with their chi-square score in the corpus (simply said, their chi-square score is an index of their relative importance in the corpus).

28 As depicted in Figure 1, in the computer memory corpus, five "communities" of words are identified as having cooccurrence patterns with each other and three communities

seem to be more independent (namely the “read-write”, “current-flow”, and “photo-color” communities).

29 Lemmatized words that are in the direct vicinity of the word *memory* are logically associated with computer memory: *archive, area, call, chip, code, device, design, digital, disk, drive, energy, experience, form, hippocampus, new, process, represent, store, time*. On the other hand, words in the community of the node *computer* are related to *technology, power, tasks* and *systems*, while *build, human, information,* and *neural* are central to the node *brain*. *Data* (in its singular form *datum*) is another community with words such as *center, internet, network,* and *storage* in its vicinity. Finally, another community is composed of words related to *racetrack memory*, which is a domain-wall memory based on the spin of electric currents:

> Flash memory is fast and compact, but it’s also expensive. For decades, computer scientists have imagined another kind of memory based on magnetic spin at the quantum level – a new system of digital storage that’s as fast as flash memory but as cheap as magnetic disk, with storage capacities 100 times larger. It’s called racetrack memory. (IBM [2024])

This is why bit, domain, electron, field, magnetic, racetrack, spin, and wall are found in this community.

30 Moreover, it appears that *memory* is one of the central nodes of the corpus and that it has many connections with other nodes and more specifically with *computer, datum* [*data*] and *brain* that also show a high frequency in the corpus. These associations are a first indicator that a computer memory is probably explained by means of the characteristics of the human memory and brain, but also that data storage is a central issue to computer memory. The presence of the “racetrack” community, which is also closely linked with the node *memory*, probably indicates that research in this new memory type is underway. Although the word “quantum” was specifically excluded from the search to find and compile texts about computer memory, racetrack memory is a quantum technology. Therefore, the mention of racetrack memory in this corpus shows that computer memory is already concerned with types of memory working at the quantum level.

Figure 1. Similarity analysis of the computer memory corpus

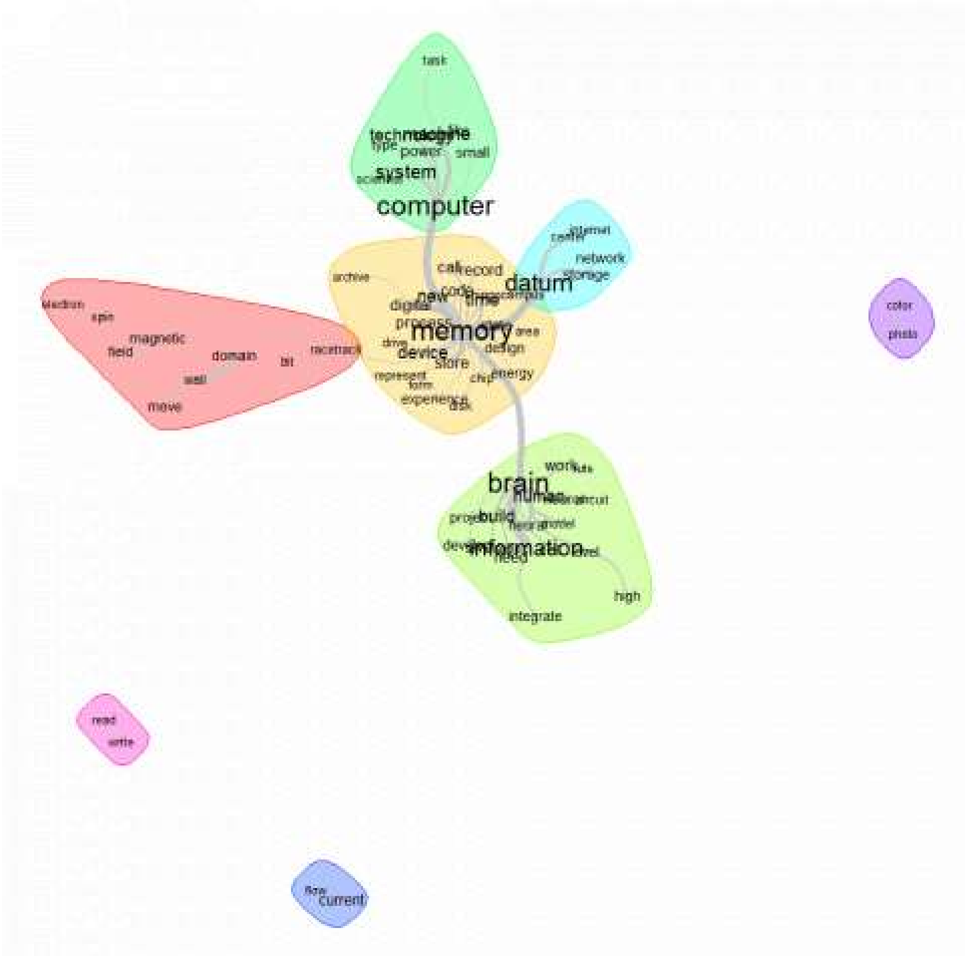
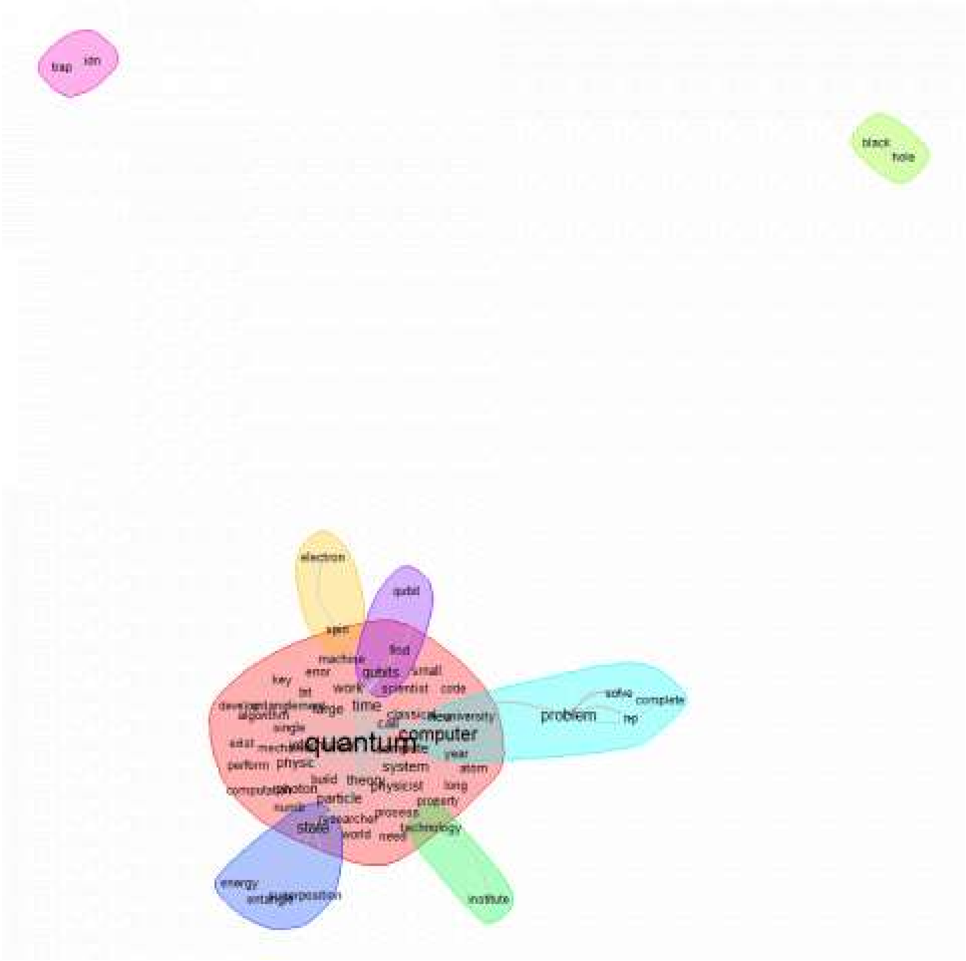


Figure 2. Similarity analysis of the quantum computer corpus

31 In the quantum computer corpus shown in Figure 2, six communities are associated with each other while two small communities are independent. Unsurprisingly, the central and biggest community is about *quantum computer* and contains words such as *algorithm, atom, computation, machine, particle physic[s], system,* etc. and specific words within this community have strong links with peripheral communities. The words *quantum* and *time* are strongly associated with the *spin – electron* community and the *qubit* (short form for *quantum bit*) community; the words *university* and *computer* are related to the *problem-solve-complete-np* community; *technology* is associated with the *institute* community; and finally, *particle* and *state* are related to the *energy-entangle-superposition* community.

32 It is important to note, however, that memory is not a central node and does not appear in the similarity analysis. Nevertheless, the word *qubit*, which is a quantum piece of information coined after the *bit* of regular computers, is an indicator that the notion of storage and memory is present in the corpus:

> Short for quantum bit, a qubit is similar to the classical computer bit, but where a bit is represented as a 0 or a 1, or "on" or "off", a qubit can be either or both at the same time. It is the qubit's versatility that allows it to perform efficient calculations at rates exponentially greater than current computer processes. (Termium Plus [2024])

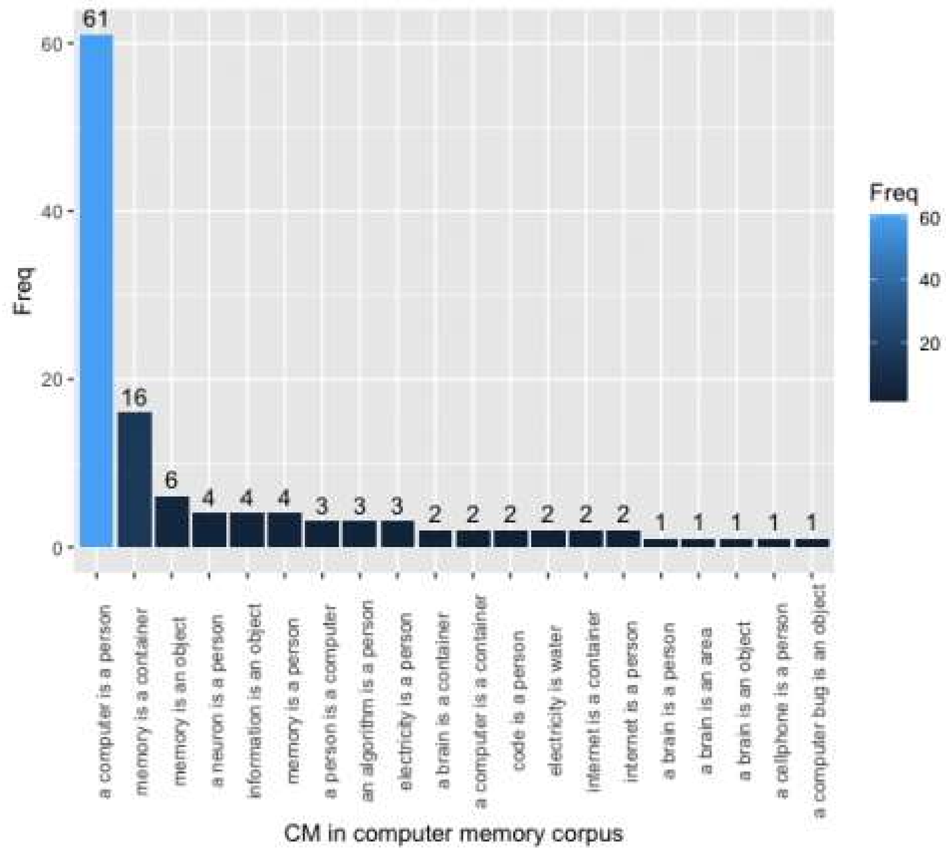


4.2. Keywords

33 To observe potential nomadic moves from the computer memory corpus to the quantum computer corpus, we applied the MIPVU to 748 keywords common to both corpora. After analysis, 153 items were identified as metaphorical in the computer memory corpus and associated with 51 conceptual metaphors. This means that 20.45% of the common keywords were identified as being metaphorical in this corpus. These figures align with another study applying the MIPVU to keywords, which shows that roughly a fifth of the analyzed items are metaphorical (Meyers [2021]).

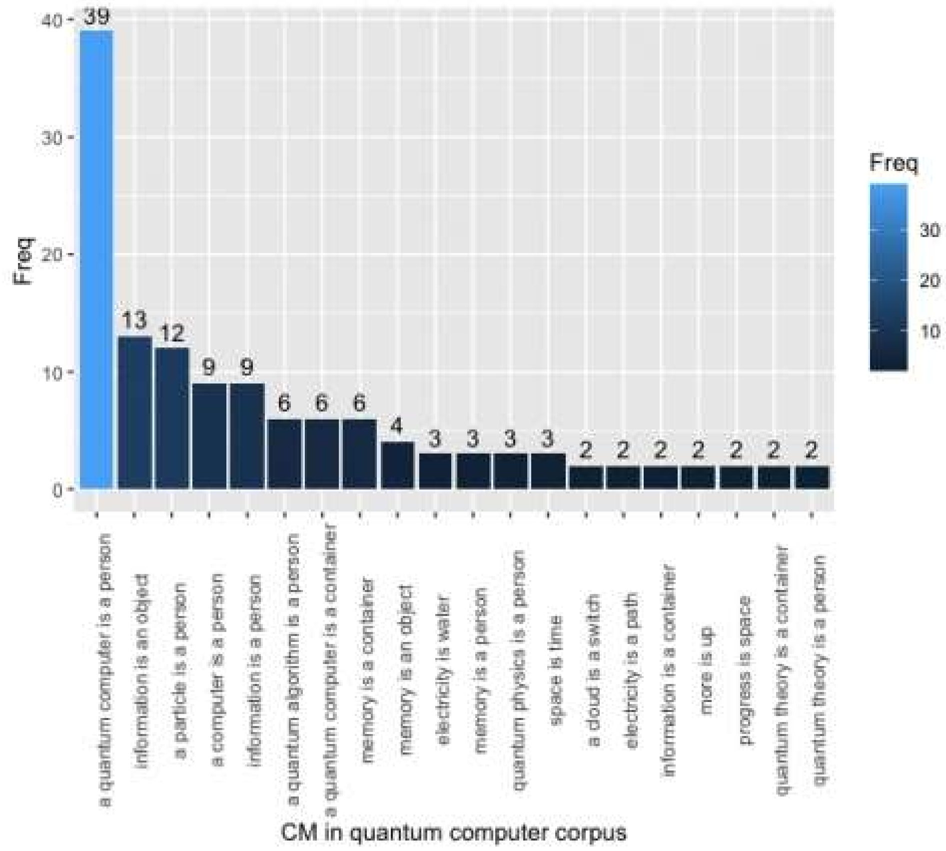
34 Figure 3 displays the top 20 most represented conceptual metaphors in the computer memory corpus. The personification of computers as humans is by far the most common conceptual metaphor in the corpus (A COMPUTER IS A PERSON). Although less frequent, several conceptual metaphors about memory are identified: MEMORY IS A CONTAINER, MEMORY IS AN OBJECT, MEMORY IS A PERSON.

Figure 3 Top 20 conceptual metaphors in the computer memory corpus



35 Moreover, 204 items were coded as being metaphor related (27.27%) in the quantum computer corpus. These MRWs were associated with 91 different conceptual metaphors. Personification of quantum computers is also the most frequent conceptual metaphor and the same conceptual metaphors about memory are found in the top 20 conceptual metaphors as in the quantum computer corpus, depicted in Figure 4.

Figure 4 Top 20 conceptual metaphors in the quantum computer corpus



36 Focusing on MRWs associated with memory, we noted that 30 of them were coded as part of a conceptual metaphor related to memory in the computer memory corpus as

opposed to 17 in the quantum computer corpus. Table 2 depicts the different conceptual metaphors having memory as a target domain in the corpora and the frequency of their related MRWs:

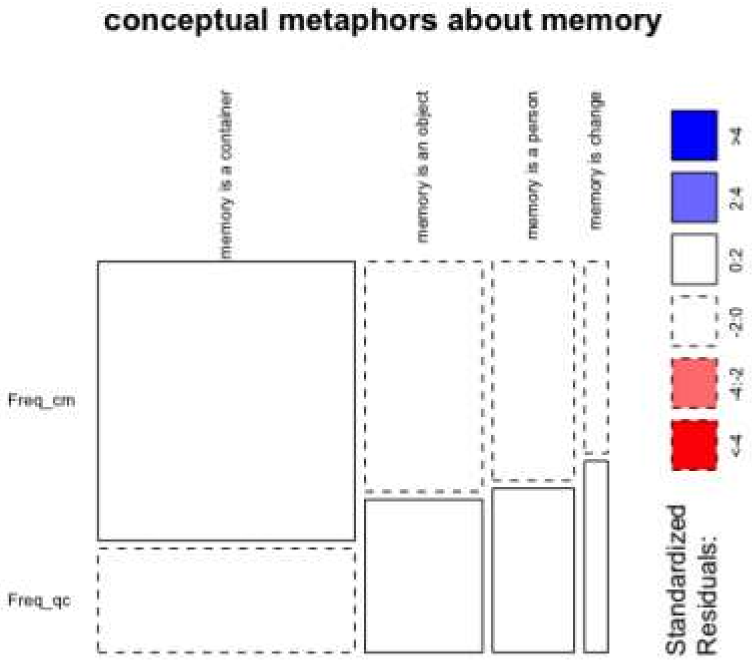
Table 2. Frequency of MRWs related to conceptual metaphors about memory in the corpora

Conceptual metaphor	Computer memory (Freq)	Quantum computer (Freq)
MEMORY IS A CONTAINER	16	6
MEMORY IS AN OBJECT	6	4
MEMORY IS A PERSON	4	4
MEMORY IS CHANGE	1	1
MEMORY IS A BUILDING	1	0
MEMORY IS A MAP	1	0
MEMORY IS SPACE	1	0
MEMORY IS A PATH	0	1
MEMORY IS MONEY	0	1

37 These results show that 4 conceptual metaphors about memory have made their way from the computer memory domain to the quantum computer domain: MEMORY IS A CONTAINER, MEMORY IS AN OBJECT, MEMORY IS A PERSON, and MEMORY IS CHANGE. The source domains in these metaphors are among the most common ones (Kövecses [2010: 18-22, 84]).

38 Moreover, as highlighted by the mosaic plot in Figure 5, it appears that the metaphor MEMORY IS A CONTAINER is proportionally more represented in the computer memory corpus than in the quantum computer corpus which makes more use of personification and the other types of conceptual metaphors in common about memory.

Figure 5 Mosaic plot of conceptual metaphors about memory



39 The following examples show how memory is conceptualized as a container, an object, a person and change in the two corpora. The MRWs have been italicized for emphasis. The first excerpts of the following examples were taken from the computer memory corpus while the second excerpts were extracted from the quantum computer corpus.

> MEMORY IS A CONTAINER
> (1) HDDs serve as temporary stores of excess data that will not *fit* in the RAM [Random Access Memory].
> (2) Quantum searches will require search engine databases to use a new kind of memory *storage*.
>
> MEMORY IS AN OBJECT
> (3) All of them, however, require a transistor connected in series with every resistive memory *element* to access each selected bit.
> (4) Nonvolatile memory *chips* could lead to computers that will not need to reload programs laboriously from a hard drive every time they are switched on.
>
> MEMORY IS A PERSON
> (5) Solid-state memories *read* and *write* data with great speed, enabling swift processing.
> (6) The quantum memory's got to *talk* to the quantum processor.
>
> MEMORY IS CHANGE
> (7) RM [random memory] would be *nonvolatile* – retaining its data when the power is turned off – but would not have the drawbacks of hard disk drives or present-day nonvolatile chips.
>
> (8) But we soon found out that others had thought of a similar design before and that anyway the design was too slow for classical RAM (although it could be an energy-saving solution for *nonvolatile* memories such as those used in digital cameras).

40 All these excerpts highlight that the basic conceptual metaphors of memory have effectively made their way from regular computers to quantum computers. The initial mapping was made between human memory to computer memory, and regular computer memory then became the source domain of quantum computer memory, gradually erasing the initial projection through a new layer of conceptualization.

41 In fact, other layers of the conceptualization of memory can be found in the corpora. By calling a memory storage device a “hard drive”, we conceptualize memory as a path as in the conceptual metaphor MEMORY IS A PATH, as in example (9) below from the computer memory corpus. However, in example (10), taken from the quantum computer corpus, a hard drive is conceptualized as Earth. This shows that conceptualization works in layers in which the target domain can always become the source domain of another metaphor, making the initial source domain less patent:

> (9) This measurement was finished and locally recorded on a *hard drive* before any information from the measurement on the other side could have arrived at light speed.

> (10) *Think of Earth as a hard drive.* According to Lloyd’s formula, the *planet* can store up to 1056 bits – roughly a trillion trillion trillion trillion gigabits. But is this *planetary hard drive* mostly empty or mostly full?

These new layers of conceptualizations act as evidence of metaphorical nomadism and will be discussed in greater detail in section 4.4.

4.3. Similarity analysis of the word “memory”

42 Whereas the analysis of similar keywords has been useful to identify metaphors about memory that are common in both corpora, similarity analyses were run on the word “memory” to observe potential metaphor-related words associated with memory that are different in the corpora. Similarity analyses can indeed also be targeted at a specific word in the corpora to create a graphical representation of the words that co-occur the most with the searched word. The following analyses were parameterized to display words with a semantic function (rather than a grammatical function such as determiners), called “active forms” in Iramuteq (Loubère & Ratinaud [2008]), that have a similar lexical distribution as the word “memory” in the same segments of the corpus and therefore co-occur with it. Thicker links reveal stronger association, while the font size of the words is determined by their chi-square score. 205 words were retained for analysis in the computer memory corpus in Figure 6, while 461 words were part of the analysis in the quantum computer corpus in Figure 7. The visual parameters were maximized so that words did not clutter on the graph[2], which resulted in the words with the weakest association with “memory” not being depicted in the graphs below.

Figure 6. Similarity analysis of the word “memory” in the computer memory corpus

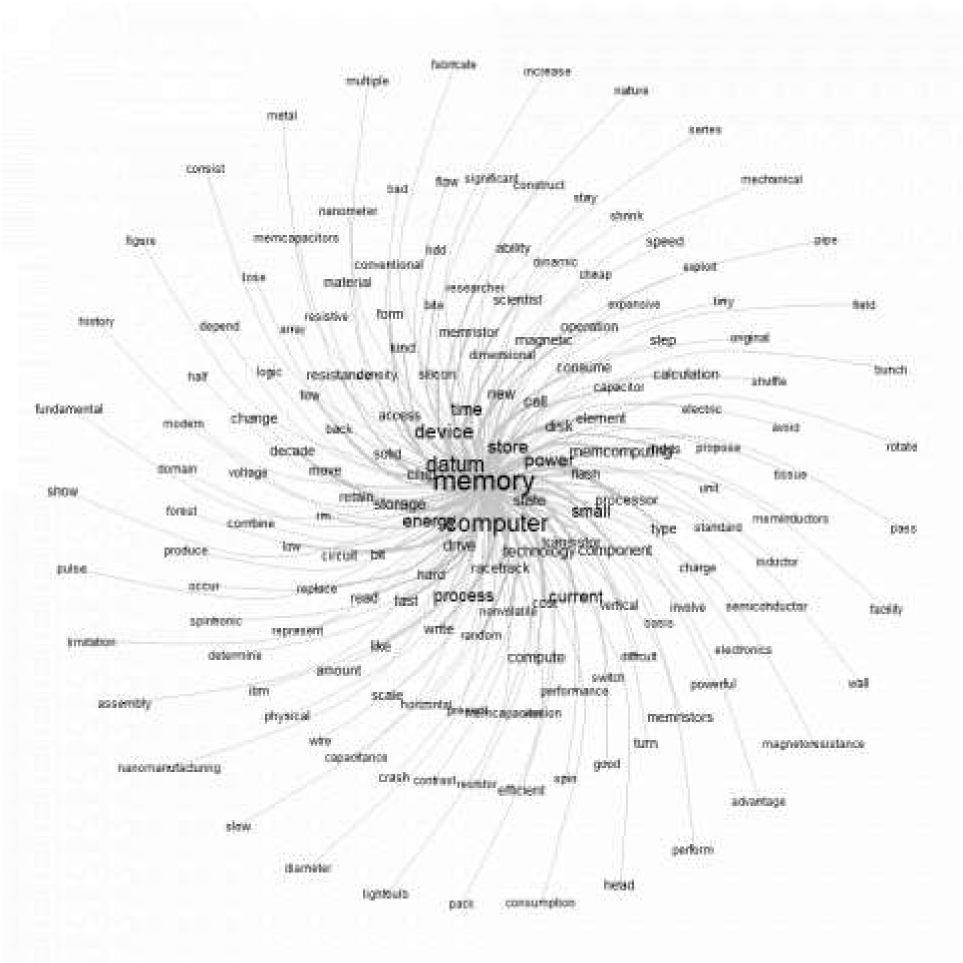
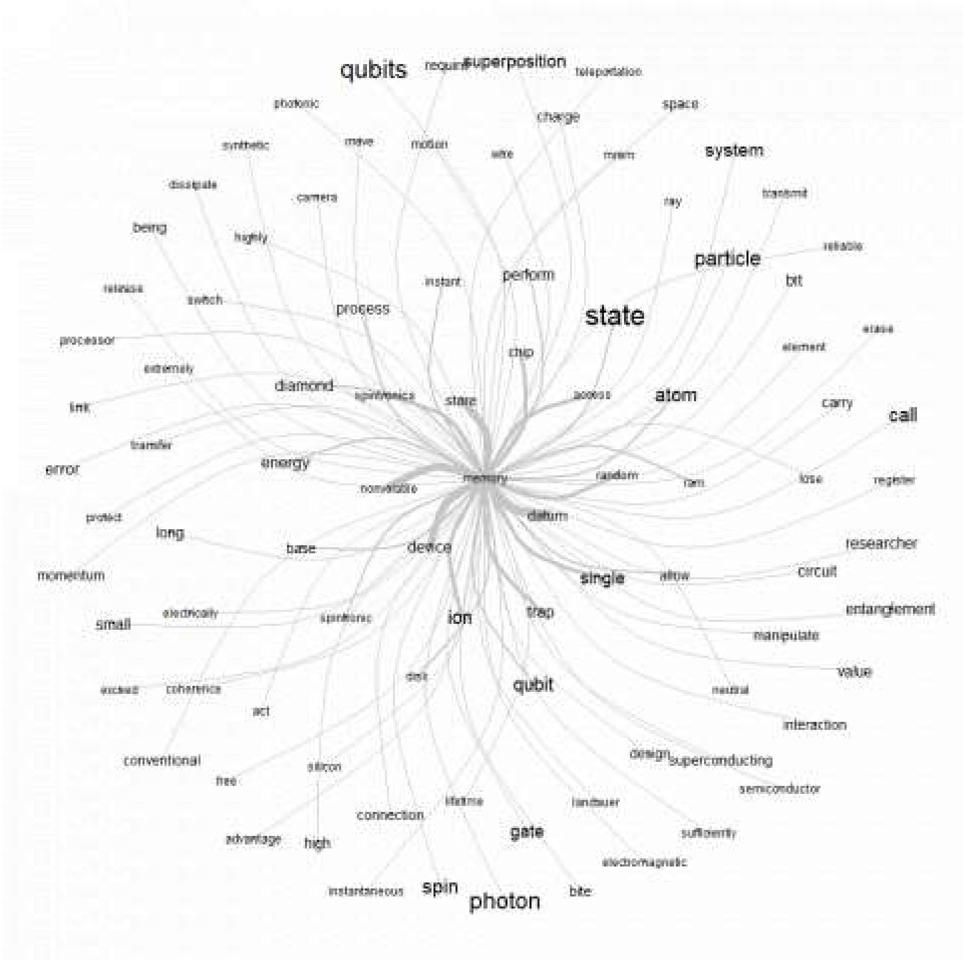


Figure 7. Similarity analysis of the word "memory" in the quantum computer corpus



43 These similarity analyses helped us identify other lexical items that are key to the concept of memory in the corpora. In the computer memory corpus, memory is mostly

related to the *storage* and *access* of *data* in the form of *bits* and the *power* of the *devices* in which they are *stored* (*chips, disk, flash drive, hard drive*). In contrast, although quantum memory is also related to similar items (*data, chip, store, access, device*), it also seems closely associated with the nature of the data to store, *qubits,* and quantum mechanics principles and concepts such as *entanglement, superposition, teleportation, spin, energy* as well as the *state* of *atoms, ions* and *particles*. These observations point to the fact that memory in regular computers and quantum computers do not work in the same way and could explain why memory is more conceptualized as a container in the computer memory corpus than in the quantum computer corpus.

4.4. Nomadic patterns of memory and related metaphors

44 The observation of the similarity analyses led to the discovery of other metaphorical lexical items and identification of migration patterns related to memory through further exploration of the corpora.

4.4.1. Humans, regular computers, and quantum computers

45 Memory can be seen as a natural ability found in certain species, such as humans at the cognitive level, that can help them *deal* with problems (from past experience) and *communicate* (by remembering the name of the person sitting next to you), but it can also be described as a container that comes in various sizes and states and where pieces of information can be *stored*, *lost, retrieved, erased,* etc.

46 The conceptualization of memory in regular computers is the result of a mapping from human memory. Indeed, as explained in section 4.2, regular computers are both personified or conceptualized as containers in the computer memory corpus:

> (11) Such a *machine* would be good at *dealing* with things not easily separable into independent tasks. [A COMPUTER IS A PERSON]
> (12) […] a large number of *processors* compute different parts of a program and then *communicate* with one another to come up with the final answer. [A COMPUTER IS A PERSON]
> (13) A spoken sentence such as "See Spot run" could be translated into the neural code and *stored* in a *computer*. [A COMPUTER IS A CONTAINER]
> (14) *Memristors*, in contrast, use all the energy *put into* them. [A COMPUTER IS A CONTAINER]

47 In fact, several examples from the computer memory corpus specifically establish this mapping by comparing the memory of regular computers with human memory in terms of their ability and container capacity:

> (15) For decades, computer scientists have strived to build *machines* that can *calculate* faster than the *human brain* and *store* more information.

48 Sometimes, memory itself is conceptualized as a container in the computer memory corpus:

> (16) HDDs serve as *temporary stores* of *excess data* that will not *fit in* the *RAM* [Random Access Memory]. [MEMORY IS A CONTAINER]
> (17) *RM* [Racetrack Memory] would be nonvolatile – *retaining its data* when the power is turned off. [MEMORY IS A CONTAINER]

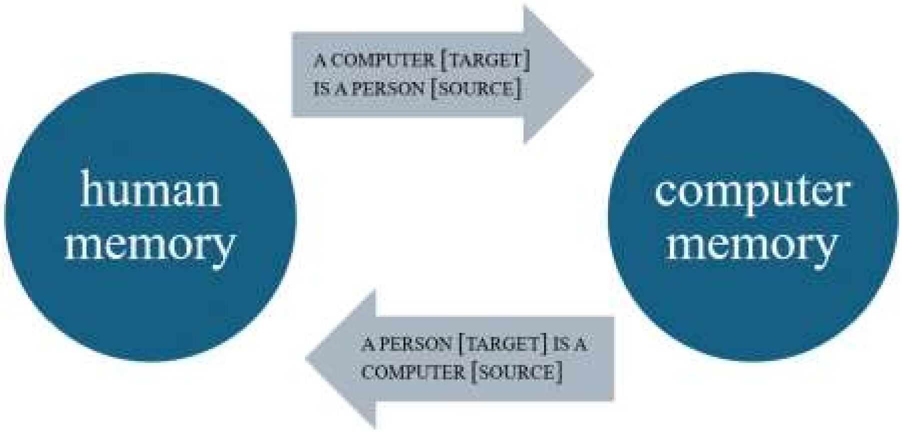
49 Most surprisingly, the metaphorical mapping from human memory to computer memory also seems to go in the opposite direction where the conceptual metaphors from computer memory is transferred *back* to human memory. Two excerpts from the computer memory corpus highlight this phenomenon. In (18) below, scientists

hypothesize that analyzing the human brain through the use of a *binary code*, which is typical of computer memory, would probably provide a better insight into human and animal *cognition* and human-to-computer *communication*. In (19), neurons are described as having the capacity to *encode* information, that is to convert a message into code, just like a machine:

> (18) Such a *binary code* of the *brain* could also provide a potentially unifying framework for studying *cognition*, even across animal species, and could greatly facilitate the design of more seamless, real-time brain-to-machine *communication*. [A PERSON IS A COMPUTER]
> (19) Recently published work supports the idea that some *neural cliques* in the *hippocampus* indeed *encode* abstract concepts. [A PERSON IS A COMPUTER]

50 This two-way mapping phenomenon can be schematized as in Figure 8:

Figure 8. Two-way mapping of memory between humans and computers



51 Similarly, Baria and Cross [2021: 4] stress that the "bidirectionality" of the metaphors A BRAIN IS A COMPUTER and A COMPUTER IS A BRAIN is entrenched in our everyday conversations and provide the following examples:

> Consider the following figures of speech which entail THE BRAIN IS A COMPUTER: "I can't *process* all that information"; "Let me *crunch the numbers*", "You can *ping* me later"; "He doesn't have the *bandwidth* for this". The reverse, THE COMPUTER IS A BRAIN, is also quite common: "My computer is *sleeping*"; "The upgraded model has tons of *memory*"; "The camera *sees* my face"; "My laptop won't *talk* to the projector".

52 Furthermore, the bidirectionality of this conceptual metaphor helps structure cognitive sciences and is commonly accepted and used by many cognitivists, who see "the brain as no more and no less than a computer syntactically manipulating symbols" (Vandaele [2007: 131], our translation)[3].

53 However, this type of mapping violates the directionality principle of conceptual metaphor according to which the more concrete and delineated source domain is mapped onto the fuzzier target domain:

> [...] we have suggested that there is directionality in metaphor, that is, that we understand one concept in terms of another. Specifically, we tend to structure the less concrete and inherently vaguer concepts (like those for emotions) in terms of more concrete concepts, which are more clearly delineated in our experience. (Lakoff & Johnson [1980: 112])

54 Kövecses [2010: 17] calls this phenomenon "the reversibility of source and target domains". He maintains that this reverse mapping is possible and is more common in the case of metaphors based on subcategorization (as in our examples where computer memory is classified as human memory and human memory as computer memory) and if the "the participating concepts are roughly at the same level of abstraction" [2010: 28], which also turns out to be the case in our examples.

55 In the light of regular computer memory often being compared with human memory, a first migration journey of this personification metaphor has led to the domain of quantum computing where quantum computer memory is even compared with the memory of God in the quantum computer corpus:

> (20) Not only are all NP-complete problems equally impossible to solve except in the simplest cases – even if your *computer* has more *memory* than *God* and the entire lifetime of the universe to work with – they seem to pop up everywhere. [QUANTUM MEMORY IS DIVINE MEMORY]

56 The personification metaphor has indeed migrated to the domain of quantum computing but in an "enhanced" version. In fact, on top of having quantum properties, quantum computer elements and characteristics tend to be described in more advantageous or prestigious ways in the quantum computer corpus, specifically when compared with classical computers. Many examples highlight the superiority of quantum computing by describing quantum computers and their components or characteristics as *efficient, special*, *unfathomably powerful, superconducting, superimaging, magic*, with *exceeding* memory capacity or similar to *heroes* and their weak points or to an *indie music group* known by a selected few:

> (21) To be sure, not all *quantum algorithms* are *so efficient*; many are no faster than their *classical counterparts*. [A QUANTUM ALGORITHM IS AN EFFICIENT PERSON]
> (22) But as we add qubits, it becomes ever more difficult to shield the system from the outside world – and any such interference dooms the *very properties that make a quantum computer special*. [A QUANTUM COMPUTER IS A SPECIAL PERSON]
> (23) *Communication* over *special "quantum channels"* already enables banks and other institutions to send data with virtually unbreakable encryption. [QUANTUM COMMUNICATION IS SPECIAL COMMUNICATION]
> (24) We will increasingly use *quantum phenomena* for communications and *computation systems* that are *unfathomably powerful* from a classical point of view. [A QUANTUM COMPUTER IS A VERY POWERFUL COMPUTER]
> (25) The modular approach with *superconducting* qubits has a number of *appealing features*. [QUANTUM ELECTRICITY IS SUPERCONDUCTING ELECTRICITY]
> (26) He proposes, for example, that the algorithm could be embodied in a *"superimaging device"* that would remove optical distortions in a telescope. [A QUANTUM COMPUTER IS A SUPERNATURAL PERSON]
> (27) If at the end of doing that we could read out the particles' final *quantum state* accurately, we really would have a *magic computer*. [A QUANTUM COMPUTER IS A MAGIC COMPUTER]
> (28) *Like Achilles without his heel* or *Superman without kryptonite*, a *[quantum] computer without any limitations* would get boring pretty quickly. [A QUANTUM COMPUTER IS A (SUPER)HERO]
> (29) A quantum computer with 1,000 qubits would *contain* 21,000 different possible quantum states, *exceeding by far the total number of particles in the universe.* [A QUANTUM COMPUTER IS A SUPER CONTAINER]
> (30) the *special abilities* of *quantum objects* are typically seen only in very small systems and break down when those objects become fully connected to a larger whole – *similar to the way an indie musical group might appeal most strongly to its fans when few people know of it*. [A QUANTUM COMPUTER IS A MUSIC BAND]

57 In other words, the nomadism of these metaphors has generated slightly different conceptualizations where the source domain of the metaphors in quantum computers is an "enhanced" version of the source domain used in the metaphors about regular computers, as illustrated in Table 3.

Table 3. Enhanced conceptualizations after nomadism

Regular computers		Quantum computers
A COMPUTER IS A PERSON	>>>	A QUANTUM COMPUTER IS A SUPERHERO
A COMPUTER IS A CONTAINER	>>>	A QUANTUM COMPUTER IS A SUPER CONTAINER
INFORMATION IS AN OBJECT	>>>	INFORMATION IS A SPECIAL OBJECT

4.4.2 Bits and qubits

58 The metaphor of a *bit* as a basic unit of information stored in the memory of regular computers has migrated to the field of quantum computers to become a *qubit*. A qubit is depicted in the quantum computer corpus as a special kind of bit with "special quantum ability" that can go back to become a "normal, classical" bit if this special ability is lost:

> (31) Getting to large numbers of *qubits*, however, is easier said than done. The more *qubits* we put together, the greater the chance they will lose their *special quantum ability* for superposition and *collapse back into normal, classical bits*.

The term *qubit* was intentionally coined on the basis of *bit* in classical computer science: "The first occurrence of the word qubit is due to Benjamin Schmacher, in 1995, in his famous paper 'Quantum coding' and it represents the quantum counterpart of a bit (binary digit)." (Kelai [2024], online)

59 It is a clear example of a nomadic transfer of the metaphor of *bit* (which is the lexical realization of the conceptual metaphor INFORMATION IS AN OBJECT) from regular computers into quantum computers:

> In classical computing, [a bit] is the basic unit of information and can be represented as two logical levels, commonly called 0 or 1. In contrast to the classical bit, the quantum bit that is so-called qubit, obeys quantum mechanics rules. Qubits can be found in the state 0,1, and any proportion of 0 and 1. (Kelai [2024], online)

60 Whereas the metaphorical word *bit* is strictly seen as an object *contained* in a memory and associated with the conceptual metaphor INFORMATION IS AN OBJECT in the computer memory corpus, a *qubit* is both conceptualized as an object (INFORMATION IS AN OBJECT) or as a person (INFORMATION IS A PERSON) sometimes in the same sentence in the quantum computer corpus:

> (32) In the early decades HDDs were refrigerator-size devices and the cost per *stored bit* was very high. [INFORMATION IS AN OBJECT]
> (33) A device that *slides* magnetic *bits back and forth* along nanowire "racetracks" could pack data in a three-dimensional microchip. [INFORMATION IS AN OBJECT]
> (34) We have some flexibility in what frequency we choose, and we set it when we *fabricate* the *qubit* [INFORMATION IS AN OBJECT], choosing different frequencies for different *qubits* to be able to *address* them individually. [INFORMATION IS A PERSON]
> (35) Researchers have long known that ions held in electromagnetic traps can act as very good *qubit memory registers*, with superposition *lifetimes* (also known as coherence times) exceeding 10 minutes. [INFORMATION IS A PERSON]
> (36) Our team decided to solve the problem by connecting each *qubit* to fewer *neighbors*. [INFORMATION IS A PERSON]
> (37) Correcting more errors means building a larger code, which employs more *physical qubits* [INFORMATION IS AN OBJECT] to create a single *logical qubit* [INFORMATION IS A PERSON].

61 This nomadic move from bits to qubits also gave rise to new conceptualizations illustrated in Figure 9. The metaphorical term *qubit* in turn gave rise to other special kinds of bits: *qudits* and *qutrits*, bits that have more dimensions than the two-dimensional *qubits*:

> (38) Whereas most of the community is working on increasing the number of qubits in a system, my lab is trying an alternative, less explored approach by using higher-dimensional "*qudits*" instead of two-dimensional qubits. [A HIGHER-DIMENSIONAL QUBIT IS A QUDIT]
> (39) Using the triple-slit system, we can create *three-dimensional qudits called qutrits*. [A THREE-DIMENSIONAL QUDIT IS A QUTRIT].

Figure 9. Nomadism of bit from computer science into the quantum computing domain

62 According to Prandi [2010, 2012] these newly coined metaphorical items evolve in networks he calls “metaphorical swarms”:

> Unlike catachresis, shared metaphorical concepts are grounded in living and productive schemes of thoughts and tend to form active and productive relational networks. […] projection is not an isolated transfer, but has the structure of a complex conceptual swarm: a whole system of interconnected concepts is ready to provide a conceptual model for categorizing a whole target domain. (Prandi [2010: 311-312]).

63 It is very likely that qudits and qutrits will generate a rich metaphorical swarm around them and will be the starting point of new nomadic journeys.

4.4.3. Other computing memory characteristics

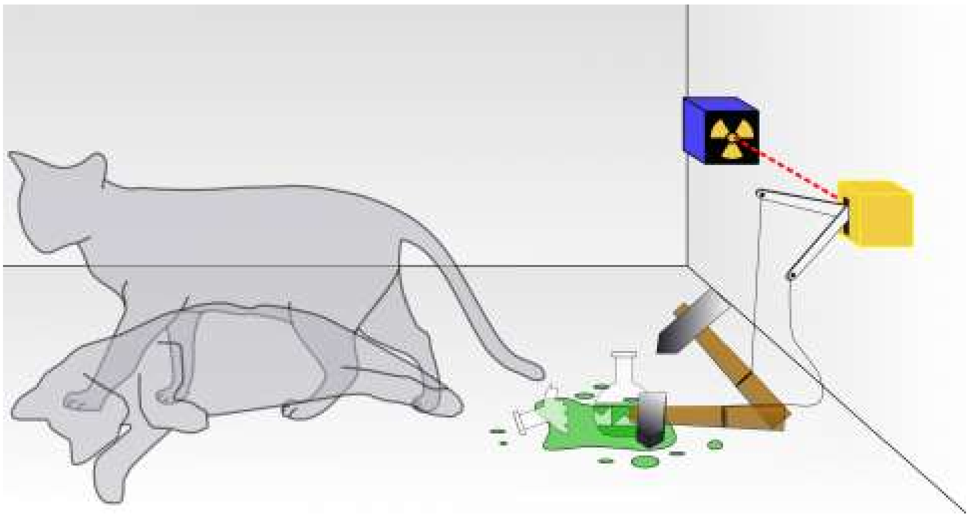
64 Other key metaphors of quantum computer memory did not migrate from computer science but rather from quantum physics. For example, the key to increase memory storage speed in quantum computers is to rely upon the *superposition* ability of qubits. Superposition can be defined as the ability of any quantum object to “exist in multiple states and even simultaneously in multiple places” (Sinha [2020: 56]), as highlighted in the following examples:

> (40) *Qubits* can be in a *“superposition”* of *multiple states*. [BEING IN DIFFERENT STATES AT THE SAME TIME IS SUPERPOSITION]
> (41) When a *qubit* is in a *superposition state*, it can have an *infinite number of possible coordinates*. [BEING AT DIFFERENT PLACES AT THE SAME TIME IS SUPERPOSITION]

65 The metaphorical term *superposition* derives from the idea that in quantum physics, two observable characteristics of an object exist at the same time, creating this illusion of overlap in our minds. A perfect example of this overlapping effect resulting from the principle of superposition is the representation of Schrödinger’s cat experiment illustrated in Figure 10: a cat trapped in a sealed radioactive box is both dead and alive until the observer opens the box to check on the cat.

> (42) The answer comes through one of the defining features of quantum mechanics: *superposition*, which is the ability of objects to occupy *many states simultaneously*, as, for instance, *Erwin Schrödinger’s famous quantum cat* can be *alive* and *dead* at the same time.

Figure 10. Schrödinger’s cat experiment



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66 The principle of superposition is associated with *entanglement*, which is another key metaphor associated with the memory of quantum computers. Entanglement could indeed speed up the communication between the quantum computer’s memory and

other constitutive elements to make it simultaneous. Entanglement is the ability of quantum objects' characteristics to be related, but not physically. In other words, entangled quantum objects form an inseparable whole and are not the mere sum of their individual entities. This implies that there is a correlation between their properties. Physicist Etienne Klein even describes entanglement through the conceptual metaphor ENTANGLEMENT IS LOVE: "Two hearts that have interacted in the past can no longer be considered in the same way as if they had never met. Marked forever by their meeting, they form an inseparable whole."[4] (Klein [1991] translated and cited by Kelai [2024, online]).

67 This bizarre principle gave rise to various metaphorical realizations in the quantum physics corpus in which entangled objects are seen as connected by an *invisible wire*, entanglement itself is described as a *spooky action at a distance*, and could one day make teleportation a reality, etc.:

> (43) *Quantum entanglement* can be thought of as an *invisible wiring* between particles that cannot be replicated in classical physics, a wiring that Einstein called *"spooky action at a distance."* [QUANTUM ENTANGLEMENT IS A MAGIC OBJECT]
> (44) The special resource that enables *teleportation* is *entanglement*. [ENTANGLEMENT IS MAGIC PHYSICS]
> (45) *Teleportation* is just a *fancy quantum wire*. [QUANTUM ENTANGLEMENT IS A MAGIC OBJECT]

68 What makes entanglement even more strange is that the very act of measuring the object's characteristics disturbs the process:

> (46) You're Alice (location A), and I hand you an electron in an unknown *quantum state*. Your job is to send the quantum state (not the electron) to location B, which is Bob. If you try to *measure* it directly, you necessarily *disturb* it. [A QUANTUM OBJECT IS A PERSON]

69 Moreover, the conceptual metaphor of entanglement in quantum physics is migrating to the domain of black holes physics to explain the potential existence of wormholes as being made of two black holes linked by quantum entanglement:

> (47) how might our two very different, bizarre phenomena – *wormholes* and *entanglement – be related*?

> (48) In other words, *quantum entanglement* creates a *geometric connection* between the two *black holes*. This result is surprising because *entanglement*, we thought, involves *correlations without a physical connection*.

70 Example (48) highlights that the conceptualization of entanglement has also changed from its classic definition and could imply geometric connection between black holes whereas it is impossible in quantum physics.

4.4.4. Quantum cognition

71 Two excerpts from the quantum computer corpus exemplify yet another case of nomadism from quantum computing back to human cognition. Quantum cognition is an emerging field in cognitive sciences that tries to apply principles of quantum mechanics and more specifically quantum probability to uncover inexplicable workings of our minds:

> (49) In this millennium, *human* and *machine* will merge through *devices* that will combine the *biological computers* housed between our ears and the *digital machines* that have emerged from our *curious minds*. […] But this *merger* between our *bodies* and the *information-processing machines our brains imagined* might be the only way to push the growth of information forward. We were *born from information*, and now, increasingly, *information is being born from us*.

> (50) *Biological cells* are *finite computers* that transcend their limitations through multi-cellularity.

72 Example (49) above clearly highlights the process of metaphorical nomadism coming full circle, as schematized below in Figure 11: human cognition and memory inspired engineers to design classical computers (*digital machines that have emerged from our curious minds*). Numerous conceptual metaphors and their associated lexical realizations emerged from this mapping. Then metaphors from computer science continued their journey to arrive in the field of quantum computers, where metaphors from computer science were borrowed and sometimes deviating from the conceptualization inherited from computer science. Finally, as human cognition takes an interest in quantum physics, quantum computers and quantum probability to browse the secrets of our minds, computer metaphors are used to describe our minds. This final move completes the nomadic circle of the conceptualization of a computer as a brain (and all its intrinsic characteristics such as memory) by conceptualizing the brain as a computer (*biological computers*, *information is being born from us*).

73 Besides, occurrences of metaphorical terms which directly migrated from quantum physics to quantum cognition can easily be found outside of the quantum computer corpus. The following excerpts from an article on quantum cognition (Marshall [2023]) show that the quantum physics concepts of *superposition, entanglement* and *interference* have all traveled to the field of quantum cognition:

> (51) By directing their attention (valence) and collapsing, at will, a *superposition* of possible states, *organisms* make choices in the exact manner of Maxwell's demon. This is how they initiate communication, harness stochasticity, generate negentropy, and evolve.

> (52) He is suggesting that the *first cell* began not as a self-replicating RNA but a *micelle* with particle *entanglement* powered by gravity impinging on the curved surface, making the micelle, in the language of this paper, an observer.

> (53) Radin asked whether trained *meditators* could influence the outcome of the double-slit experiment. He aimed to test if *conscious observation* by experienced meditators could influence this wave-particle duality. […] The study reported that, during periods when meditators were focusing their *attention* on the double-slit apparatus, there was a statistically significant shift in the *interference* pattern compared to the control group of non-meditators.

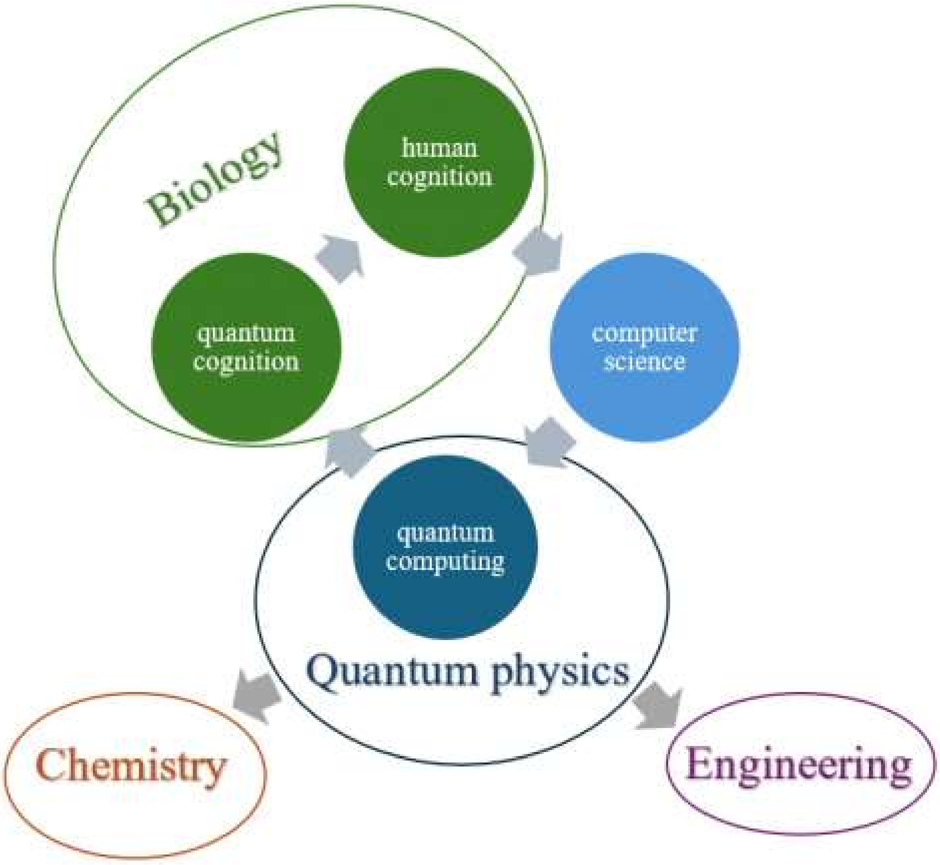
74 Finally, as the following excerpts from the quantum computer corpus show, quantum physics principles can very well be applied to other fields. It could therefore be expected to see some quantum physics metaphors also migrate to these fields (also represented in Figure 11 below):

> (54) *Quantum* is more than just a technology; it's a field of study that undergirds *chemistry*, *biology* and *engineering*;

> (55) *Quantum computing* has captured imaginations for almost 50 years. The reason is simple: it offers a path to solving problems that could never be answered with classical machines. Examples include *simulating chemistry* exactly to develop new molecules and materials, as well as *solving complex optimization problems*, which seek the best solution from among many possible alternatives. Every *industry* has a need for optimization, which is one reason this technology has so much disruptive potential.

> (56) The progress in recent years holds out the promise that *quantum computing* can serve as a powerful *catalyst* for *chemical discovery* in the near future.

Figure 11. Metaphorical nomadism coming full circle



5. Discussion

75 Although the MIPVU (Steen *et al*. [2010]) is a reliable method for identifying metaphors, it should be noted that it has certain limitations. Metaphor identification can indeed be highly subjective regardless of the identification method applied. This subjectivity may arise in many ways from the interpretation of the semantic meaning of a metaphor, but it may also be due to the complexity of analyzing metaphors within their discursive contexts. Furthermore, no inter-coder agreement scores could be calculated for the identification of the metaphors analyzed in this article, as it was carried out by only one researcher.

76 The analysis of keywords in common has shown that basic conceptual metaphors of memory have migrated from computer science to quantum computing: MEMORY IS A CONTAINER, MEMORY IS AN OBJECT, MEMORY IS A PERSON, and MEMORY IS CHANGE. However, the container metaphor is proportionally more present in the computer memory corpus than in the quantum computer corpus and the three other conceptual metaphors more present in the quantum computer corpus than in the computer memory corpus. This observation is a first indicator that memory is conceptualized slightly differently between the corpora.

77 The similarity analyses about the word "memory" run on each corpus enabled us to look beyond these "basic" conceptual metaphors of memory to observe lexical items closely related to it in the corpora (i.e., present in the same segments). These analyses gave us a better understanding of how memory works in regular computers and quantum computers and led to the discoveries of other metaphors and most importantly new types of mapping and migration patterns. We were able to identify 5 cases based on the examples provided above:

- An initial mapping from one domain to computer science, followed by a migration to quantum computing with a slightly different conceptualization. e.g., A COMPUTER IS A PERSON (mapping from biology to computer science) >> A QUANTUM computer is a superhero (migration from computer science to quantum computing with "enhanced" conceptualization);

- A two-way or reverse mapping (Kövecses [2010]), that is an initial mapping from one domain (biology) to another (computer science) is mapped "back". In other words, the target domain becomes the source domain of the reverse mapping. e.g., a computer is a person >> a person is a computer;
- Nomadism from regular computers to quantum computers which gives rise to new metaphors evolving in swarms (Prandi [2010], [2012]). e.g., computer information is a bit >> quantum computer information is a qubit >> quantum computer information is a qudit >> quantum computer information is a qutrit (the migration of bit into quantum computing led to the emergence of a metaphorical swarm containing qubits, qudits, qutrits, etc.);
- Circular nomadism: metaphors undergoing multiple migrations from one domain to another circle back to the source domain where the initial mapping took place. e.g., a computer is a person (mapping from biology to computer science) >> a quantum computer is a supernatural person (migration of personification from computer science to quantum computing) >> a person is a quantum computer (migration of metaphor back to biology in the domain of quantum cognition);
- Metaphors mapped from the source domain of quantum mechanics to quantum computing have started to or will likely migrate to other domains. e.g., quantum chemistry, quantum engineering.

78 Additionally, these cases confirm the validity of the parameters conditioning interdomanial nomadism stated by Rossi [2015: 70-71]. First, metaphors about memory and (quantum) computers are frequently personified through several conceptual metaphors, such as MEMORY IS A PERSON, A COMPUTER IS A PERSON, A QUANTUM COMPUTER IS A SUPERHERO, etc. These numerous cases of personification can indeed be explained by the high availability of humans and their biological characteristics as a conceptual source domain. Second, the nomadic shifts from computer science to quantum computing have led to a change of conceptualization shaping quantum computers, emphasizing the heuristic function of metaphors as a parameter for their nomadism. Finally, quantum computing could not have been described without relying on general principles and metaphors borrowed from computer science, opening many opportunities for metaphors to travel from computer science to quantum computing.

Conclusion

79 This paper aimed at analyzing the metaphors of memory in regular computers and quantum computers to seek potential nomadic migrations of these metaphors (Rossi [2015]) from computing science to quantum science. Two corpora were built in these scientific domains from texts collected in the *Scientific American*: one corpus was made about the memory of regular computers (to have a basis for the analysis of metaphors related to memory instead of other computer aspects or components), while a second corpus was compiled about quantum computers.

80 Keywords in common with a minimum frequency of five in both corpora were extracted in Sketch Engine (Kilgarriff *et al*. [2014]) and similarity analyses of the word "memory" were run in Iramuteq (Loubère & Ratinaud [2008]) to have a larger perspective of the lexical items situated in its close context. The MIPVU (Steen *et al*. [2010]) was used to identify metaphor-related words (MRWs) in both corpora. The identification method was slightly adapted to fit to a concordancer window environment. The identification figures corroborate those of another study using this same modified version of the method (Meyers [2021]).

81 In total, 30 MRWs were coded as part of a conceptual metaphor related to memory in the computer memory corpus as opposed to 17 in the quantum computer corpus. Not

only do our results stress that basic conceptual metaphors such as MEMORY IS A CONTAINER, MEMORY IS AN OBJECT, MEMORY IS A PERSON, and MEMORY IS CHANGE have indeed migrated from computer science to quantum computing, but also that memory is conceptualized slightly differently in the two scientific domains. Memory is proportionally more often conceptualized as a container in the computer memory corpus while it is more often conceptualized as an object, a person or change in the quantum computer corpus.

82 Finally, on the basis of examples found by examining the lexical items surrounding the word "memory" in the similarity analyses, we were able to isolate five cases of nomadic moves which are all in agreement with the conditional parameters of interdomanial nomadism stated by Rossi [2015: 70-71]: (1) enhanced or adapted conceptualization, (2) reverse mapping, (3) a nomadic shift leading to the coinage of new metaphors evolving in swarms, (4) circular nomadism where metaphors come back to their "starting-point scientific domain", and finally (5) new nomadic moves from the target scientific domain towards other scientific domains. This categorization of shifts could be useful for studying metaphorical nomadism in other scientific fields and extend this first attempt at providing an overview of different types of nomadic shifts of metaphors.

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Notes

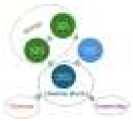
1 By default, Sketch Engine uses as a reference corpus the biggest corpus available in the same language as the corpus under analysis.

2 The software was asked to render “maximum spanning tree”. In graph theory, this means that words displayed in the graph have the highest possible edge weights. See Moreno *et al.* [2017: 55-56] for the use of this specific function in Iramuteq.

3 Original citation : « le cerveau n’est ni plus ni moins qu’un ordinateur manipulant syntaxiquement des symboles » (Vandaele [2007: 131]).

4 Original citation : « Deux cœurs qui ont interagi dans le passé ne peuvent plus être considérés de la même manière que s’ils ne s’étaient jamais rencontrés. Marqués à jamais par leur rencontre, ils forment un tout inséparable. » (Klein [1991])

List of illustrations

	File	image/png, 40k
	**Title**	Figure 10. Schrödinger’s cat experiment
	Caption	Dhatfield, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons
	URL	http://journals.openedition.org/lexis/docannexe/image/9355/img-10.png
	File	image/png, 273k
	**Title**	Figure 11. Metaphorical nomadism coming full circle
	URL	http://journals.openedition.org/lexis/docannexe/image/9355/img-11.png
	File	image/png, 95k

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Charlène Meyers, “The conceptual metaphors of memory: Cases of interdomanial nomadism from computer science to quantum computing”, *Lexis* [Online], Words about #1 | 2025, Online since 12 May 2025, connection on 12 May 2025. URL: http://journals.openedition.org/lexis/9355

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