Elaboration of Psychological Ontology that Integrates the Problem of Human Frailty in COVID-19 Context

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Abstract: In terms of mental health, COVID-19 has a great impact on people's psychology. It can cause a certain degree of fear, worry, boredom, depression, eating disorders, loneliness and sometimes self-aggression or suicidal behaviour. The purpose of this article is to explore the psychological consequences of health problems related to COVID-19. During this period, some literature appears to analyze the psychological behaviour of individuals. However, in the sense of domain ontology, there is a lack of knowledge about modelling specific knowledge in the field of psychology and to have formal semantics. Through this article, we present a psychology-based method to analyze human behaviour and frailty during COVID-19. We chose IR (Information Research) based on TOR (Termino-Ontology Resources) as the method to construct the resulting ontology modelling the state of mental health in a COVID-19 context, an ontology that avoids ambiguities in the concepts that model the domain in question. The result of our research is the ontology described in Fig. 5, 6, 7, 8 and 9. The concepts that make up our ontology are derived from the results of the calculation of scores through Eq. 6, which consists of calculating the Score (C_{ij}), then the CI(c) through the calculation of P(c) which is 0.18 in the term t_i= anxiety, and therefore (-log (0.25)) for the calculation of CI(c). These results concern the term "anxiety" in our ontology, following the same logic for the other terms. The lack of a psychological ontology modelling the concepts, those correspond to the fragility of people's mental health during the COVID-19 pandemic, so we thought about developing an ontology that would fill this gap.

Keywords: COVID-19, Psychology, Domain ontology, Disambiguation, SKOS.

1. Introduction

There is no doubt that the COVID-19 pandemic will remain engraved in the memory of everyone, regardless of their country, lifestyle or socio-economic status, they will all be affected by this crisis. Psychologically, the confinement situation has brought us a new way of life, and its impact is significant. Anxiety, fear, depression, irritability, anger, confusion, social isolation, drug addiction, or drug-related behaviours, insomnia, aggressive behaviour and violence, etc. are generally the psychological and behavioural consequences of midlife. This unique environment can sometimes reveal the worst of human nature.

In this unprecedented situation everyone is asking a lot of questions. For example: how will our work be affected? What is the current psychological state of the family members of the deceased who were buried anonymously? What will happen tomorrow? What are the consequences for our mental health? Etc. In fact, not everyone has the same ability to adapt to this situation. The COVID-19 epidemic has made visible the weaknesses in the mental health of the general population, whether or not they suffer from psychiatric illnesses.

Several works have addressed mental health during the pandemic in the year 2020. [1] Have saying that "Coronavirus is a big challenge for a human being. People must be given a deep and thorough understanding of the deadly pandemic. They must be prepared for their current as well as prolonged post-pandemic effects on their lives and livings. Decisions of some countries are, to some extent, in the right direction. Restricted and extended

lock down is not the solution to this drastic scenario because it has proved to be economically disastrous. The revival of social and economic activities is undeniable. Still, along with that, people should be aware of how they need to play their part and keep the balance in their outdoor activities and life-saving measures to protect themselves and their community. In that respect, the media and governing bodies are bound to do their duties honestly and vigilantly in the welfare of human beings and humanities."

According to [2], "COVID-19 has had a profound effect on our thoughts, emotions, and behavior. Understandably, it has generated much fear and panic globally. Mental health correlates to the pandemic have been widespread and varied in presentation, related to vulnerability and pre-morbid functioning, with social and economic factors contributing heavily. Commenting on national survey data during COVID-19, the United Nations (2020) raised concern after studies showed distress prevalence ranging from 35% to 60%. A recent population-based survey found that 54% of South Africans viewed themselves as moderate to high risk for contracting the virus, suggesting some level of anxiety about their current situation [3]. Another community survey of over 12,000 respondents noted significant negative emotions including 33% of adults depressed and 45% fearful, with fear, stress, and depression more prevalent in those fewer than 40 years of age than older people [4]. More worrying, however, is that the increased mental health service needs are surfacing during a time of reduced mental health service provision due to the risks associated with in-person consultations. In attempts to limit the spread of infection, large numbers of mental health service providers have opted to offer virtual consultations. The extent to which, this mode of consultation is meeting the needs of all concerned in the current situation, is yet to be determined, considering the diversity of those in need, especially in terms of age, educational level, technological sophistication, financial resources and numerous other variables – all an indication of just how egalitarian the virus is."

According To [26] "Beyond behaviour change, health psychology also has a role in understanding how people might respond to and cope with the threat of a global pandemic and changes to their lives that are made in an effort to reduce that threat".

Through the articles of the authors cited in the two preceding paragraphs, we have been able to deduce that the research carried out in the context of covid-19 is rich in detailed information on psychology and mental health.

At the level of ontological modeling, several works have been developed in the Covid-19 period.

These works concern the modeling of data related to Covid-19 for the valorization and the improvement of the statistics as in [27]. As well as work on the development of ontology related to the analysis of disease data in the context of Covid-19 such in [28].

Cependant, il y'a un vrai manque au niveau de la modélisation de l'ontologie intégrante du problème de la fragilité de la santé mentale des personnes pendant la pandémie. C'est pourquoi notre travail consistera à créer une ontologie qui sera la base d'une application de soutien psychologique qui sera réalisée par les auteurs de ce document. Therefore, the acquisition of knowledge in the field of psychology related to the COVID-19 pandemic is always reserved for individual users (researchers, psychiatry students, health professionals, people with COVID-19, family members of people with COVID-19, teachers, parents, educators, etc.). Therefore, there is a need for a more powerful search tool that allows users to easily and quickly find relevant information that meets their needs. Our research will focus on the creation of a psychological ontology based on IR (information retrieval) "OntoPsy-COVID-19" based on the reuse of TOR (Termino-Ontological Resources).

Nevertheless, although many semantic resources have been developed in the medical field, there is still a need to cover specific areas such as the psychological field, where knowledge of the field is regularly updated. Access to knowledge in this field remains an important issue for researchers and practitioners today. Such modeling can be done through domain ontology [5]. However, it should be noted that the construction of domain ontology remains a fastidious and costly task, which requires an elaborate methodology to lighten the process. No standard approach exists as it is the case in the field of databases [6].

To build the proposed ontology, we chose to work with the method of ontology acquisition from texts and TOR, by proceeding as follows; First, we were able to extract concepts from documents (texts, articles, ontology, books and dictionaries) automatically using a concordance and using queries to which our ontology will respond. We were interested in identifying representative concepts in textual corpora, in their disambiguation, in their weighting, and then in identifying the relations between these concepts.

To justify our choice for the above-mentioned method, we are obliged to point out that few research groups propose methodologies for the construction of ontology. However, ontological engineering consists in the study of methods; each working group uses its own methodology [6]. In this paragraph, we have

based ourselves on the article in [29] to present the most important methodologies for ontology construction. From the previous work, we were able to extract four main categories of approaches: 1- approaches for building ontology from scratch, 2- approaches for building ontology from texts, 3- approaches based on the reuse of existing TORs, 4- approaches based on crowd sourcing. The choice of one methodology or another is based on the use we want to make of our ontology and also on the resources available for the construction of our ontology.

Approach 1 is a manual approach used by ontology experts, in the work of [30] and [31]. Then, more detailed methodologies such as Meth-ontology [29] and the more recent work of Sure and colleagues [32] appeared [6]. In these methodologies, the sources of knowledge are generally constructed by humans, including experts in the field of application [6]. Specific knowledge acquisition techniques (brainstorming meetings, interviews with experts, etc.) are necessary, but note that there is no guarantee that the knowledge described is exhaustive [6]. Approach 2 is an approach very often used in recent years, the disadvantage of this approach lies in the corpus of text used, since it forms the basis of ontology construction, it must therefore be rich and tied together. The analysis and processing of textual documents thus becomes simpler [6]. What motivates the development of methodologies for ontology construction from texts is that texts are considered to be good sources of knowledge. These approaches often combine linguistic, statistical and/or machine learning techniques to extract ontological knowledge from texts [33]. Depending on our resources, we have adopted this second approach combined with approach 3, which is the approach based on the reuse of existing TOR. To simplify the task of constructing the proposed ontology, we advocated the reuse of existing TORs [34]. These approaches focus on the exploitation of all or part of the information contained in these often informal sources for the development of new ontology or the enrichment of existing ontology [6]. They often seek to capture the implicit knowledge contained in these resources, generally represented in informal languages [35], to describe them in a formal model [6] and this is the objective of this paper. We cannot close this section without mentioning the crowd sourcing approach, which is a complementary approach to classical construction methodologies by allowing lightening certain tasks [6].

They exist Several methods of semantic information retrieval are generally based on keyword representation, also called word-bag representation; documents and queries are described by a set of words (or even n-grams) they contain; the correspondence between a document and a query is based on the number of words they share [6]. In addition to disregarding the order of words (technical communication vs. communication technique) and relying on a purely lexical matching (1:1 matching between words), they are thus affected by two main limitations: ambiguity (polysemy and homonymy) of words and synonymy. A term can be ambiguous (have several meanings) and its meaning depends in this case on its context of use [6].

Many are the statistical techniques most commonly used in IR to overcome the limitations related to term ambiguity and synonymy, such as LSA which uses algebraic techniques based on the frequency and co-occurrence of words in documents to construct "concepts". The advantage of this approach is that it does not require external knowledge. Consequently, it remains independent and applicable in any field. Moreover, associations between terms (synonymy, polysemy) are partially taken into account, but it remains limited for the treatment of large collections of documents since it depends on the SVD which is computationally heavy. In addition, updating indexes is difficult when new documents are added.

The approach of disambiguation that we adopt in this paper is inspired by the work of [14]. The advantage of this approach lies in its principle which consists, for each ambiguous term, in retrieving all the concepts it denotes and in finding the concept closest semantically to the other concepts in its context [6]. According to [8] "To estimate this proximity, some methods rely on semantic relations extracted from a knowledge source while others rely on more advanced similarity computation techniques". The disambiguation approach we use is inspired by the work of [8] and we have integrated a weight to measure the importance (for disambiguation) of each term in the context of the ambiguous term. The methodology used in this paper is described in more detail in Section 2.

The major argument justifying the choice of the SKOS language for the formalization of the proposed ontology is that SKOS is a data model intended to support TORs. And since we base our ontology construction on TORs, we are consequently required to adopt the SKOS language.

In the remainder of this document, the research methodology used is first presented in section II, then the construction of our OntoPsy-COVID-19 ontology in section III, followed by the formalization of the ontology in section IV. Then, presentation of the

results and discussion in section V. Finally, conclusion in section VI.

2. Research methodology

2.1 Why an ontology?

Ontology have today a major place in the representation and modeling of knowledge [6]. They are used to formalize the knowledge of a domain and add a semantic layer to computer systems and applications [6]. Ontology is used to explicitly represent domain knowledge using a formal language so that it can be automatically manipulated and easily shared [6]. They are widely used in various research areas such as knowledge representation, IR [8] and data integration [12].

The notion of ontology has been redefined in the course of the debates it has been the subject of. We will retain the following definition [16]: "ontology is a standardized specification representing the classes of objects recognized as existing in a domain." While having a meaning for humans, computers must be able to use ontology to define the concept of domain in a standardized and consensual way, while meeting the needs of expected applications. The role of ontology in information retrieval lies in the link between knowledge and its expression in language: it must not only support research work, but also define resource files for annotation metadata. Some works such as [16] mention the need to associate independent dictionaries with ontology to mark concepts and relationships, all of which form ontology with lexical components.

2.2 Type of ontology ?

There are different typologies that have been proposed to distinguish the multiple existing ontology: according to their coverage, according to their granularity or according to their level of formalisation. At the same time, the craze generated by the multiple functionalities offered by ontology has resulted in a very rapid development of "derived" resources that do not exactly comply with the definition and mode of use of ontology, particularly in the medical field [17].

Proposed ontology "OntoPsy-COVID-19" is a domain ontology, which allows expressing the knowledge of a specific "Psychological Domain", and it can be reused through applications in this domain. It is the most common type of ontology in ontology engineering [6].

2.3 Methodology for the construction of 'OntoPsy-COVID-19'

The method used to build the proposed ontology is IR (information retrieval) based on the reuse of TOR (Termino-Ontological Resources) [11]. TOR reuse approach: This approach focuses on the exploitation of all or part of the information contained in these often informal sources for the development of new ontology or the enrichment of existing ones. They often seek to capture the implicit knowledge contained in these resources, usually represented in informal languages [14] describe it in a formal model.

2.3.1.   The construction of document base

In this part, we use the IR method based on domain ontology using the knowledge contained in semantic resources. In order to be able to answer the various questions that constitute the field of "psychology" related to the COVID-19 pandemic.

2.3.2.   Extraction of candidate terms

All collected documents that form the basis of the text are processed and analyzed using the "AntConc" concordance. This tool allows users to make queries in the form of regular expressions in the text database and displays all databases containing the expression Part, to enrich the body during inspection.

2.3.3.   Disambiguation of terms

This step allows, for each ambiguous term, to find the adequate concept corresponding to its context of use [6]. The approach of disambiguation with which we have worked is inspired by the work of [13] and we have integrated a weight allowing us to measure the importance (for disambiguation) of each term in the context of the ambiguous term. The principle of this method is, for each ambiguous term, to retrieve all the concepts it denotes and to find the concept that is semantically closest to the other concepts of its context [6]. This context is defined as an arbitrarily fixed text window and can be a sentence, a paragraph or even the whole document [6]. Thus, for each concept associated with the ambiguous term, its similarity score is estimated as the sum of the degree of similarity of this concept with each of the other concepts in its context [6]. For any other ambiguous term in the context, only its associated concept closest semantically to the target concept (i.e., having the highest degree of similarity with the latter) is considered instead of all the concepts it denotes [6]. At the end of this computation, the concept with the highest score is retained and assigned to the term.

The formula used by McInnes and Pedersen is described in more detail in [14]. The similarity between a concept denoted by a term to be

disambiguated and the other concepts in its context is weighted by a coefficient indicating the importance of their associated terms in the disambiguation [14]. This weight, for a given term, is defined as the inverse of the number of concepts associated with it [14]. We consider that the less polysemic a term in the context, the more important it is for the disambiguation of ambiguous terms. Thus, for unambiguous terms, this weight is maximal *(w(t_i) = 1)*.

Formally, F is the context of an ambiguous term t_i associated with n concepts $C_i = \{C_{i1}, ..., C_{in}\}$ and T is the set of terms of F extracted using the concordance.

The score of each C_{ij} concept with $J \in \{1, ..., n\}$ is defined by the following equation:

$$Score\ (c_{ij}) = \sum_{\substack{k=1 \\ k \neq i}}^{|T|} \max_{l \in [1,...,|CK|]} (Sim_{Lin}(c_{ij}, c_{kl})) \times w(ti) \quad (1)$$

$Sim_{Lin}(C_{ij}, C_{kl})$ = the semantic similarity between the concepts C_{ij} and C_{kl} defined in [14].

$W(ti)$ = a weight to indicate the importance of the concepts associated with the term t_i in disambiguation, it is calculated by :

$$w(ti) = \frac{1}{nbconcept(ti)} \quad (2)$$

Such that **nbconcept(t_i)** = the number of concepts associated with t_i.

In this way, we have developed a clear set of concepts that can be used to index the processed documents.

3. Construction of proposed ontology "OntoPsy-COVID-19"

In this section, we build the ONTOPSY-COVID-19 ontology in a clear, efficient and relevant way. As mentioned in the introduction of this article, our ontology will be based on information retrieval (IR) based on the reuse of TOR. The principle of IR is based on the following steps: 1) Users express their needs through requests (free text or forms). 2) The request is analyzed, processed and represented by a series of concepts in the documents that form the basis of our text.

Mental health information for the public can have a huge psychological impact. However, there are still some gaps in the strategies used to convey this information and the public does not benefit from psychological knowledge. The conceptual accessibility of information is the ability to find, understand and interpret psychological information in the context of COVID-19. People want to understand the mental state related to COVID-19, and they seek information about the mental health of people with the same experience and symptoms, as their behaviour may be similar to that of others in some cases. However, the mass dissemination of this information on the Internet may satisfy the needs of a few people.

3.1 Starting postulate

The initial hypothesis of text selection is knowledge, and therefore the concept of human frailty can be simulated in a covid-19 context, included in the text representing the field. As proof, Bachimont's work [16] adopted this point of view: "The work of modeling must be extracted from documents proven in practice and gathered in a corpus" [16].

Our choice of text is based on the following assumptions:- Since our aim was to highlight aspects of the functioning of terms in the field of psychology in relation to the COVID-19 pandemic, this choice of text should also be a choice of specialized texts, using terms. We consider the text as the material substrate carrying both semantic and pragmatic content. - The use of the proposed ontology should improve the understanding of the psychological state of people during the Covid-19 pandemic by a more efficient management of the information and documentary resources of the domain.

3.2 The construction of the text base

We used two types of documents obtained from the Internet: documents on the psychological field and the mental health of individuals related to COVID-19, and other documents related to general psychology.

Sources of documents used: According to [18], useful sources should have three properties: they represent related fields, they contain current information, and finally the relationship with the associated fields should be clear.

Depending on the quality described in the previous paragraph, the website or web page used to extract the documents that make up our text database is selected. For COVID-19, Google is used as a search engine to generate documents related to psychology. Several queries were launched to retrieve the desired documents, For documents concerning psychology in a covid-19 context; -

Table 1. Text features	
Texts by researchers in the field of psychology related to the pandemic COVID-19	**Texts related to the field of psychology**
Number of documents= 85 Number of words= 982868	Number of documents =15 Number of words = 491434

Table 2. Candidate terms collected

ID	Term	Frequency
1	Addiction	22
2	Aggressiveness	109
3	Worry	287
4	Background	31
5	Anticipation	37
6	Antidepressants	19
7	Anxiety	516
8	Abdominal Anxiety	1
9	Increased anxiety	4
10	Generalized anxiety	3
11	Wellness	442
12	character	461
13	Containment	825
14	COVID-19	3430
15	Depression	297
16	Drugs	56
17	Emotion	133
18	emotional	182
19	Psychosocial intervention	4
20	Insulation	47
21	Sick	764
22	Mental illness	15
23	Negativism	10
24	Personality	306
25	Patient	892
26	Health Care Providers	65
27	Psychoanalysts	24
28	psychological	1098
29	Psychologists	120
30	Psychotraumatology	21
31	Quality of life	131
32	Reintegration	4
33	Relaxation	37
34	Resilience	157
35	Mental Health	1877
36	post-traumatic stress	61
37	Suicide	143
38	Tele-consultation	27
39	Trouble	109
40	Emotional Disorder	2
41	Eating Disorder	3
42	Person	8
43	Bipolar disorder	4
44	Acute Stress Disorder	3
45	Eating Disorder	4
46	Trouble sleeping	4
47	Neurotic disorder	2
48	Panic Disorder	3
49	Psychic disorder	8

Mental health related to the COVID-19 pandemic. - Impact of COVID-19 on the mental health of individuals. -Pandemic and mental health. - Psychological disorders related to covid-19. -The psychology of individuals during the course of the corona virus. Concerning documents related to psychology; -Psychology. -The mental health of persons. - Ontology of psychology. -Dictionary of psychology.

The documents that appear at the top, i.e., the most frequently referenced and popular documents, always meet the following standards: representativeness of the field, target audience (public health or mental health professionals), author of the page (mental health professional or not). These standards allow us to collect and sort the most appropriate documents to provide the terms that make up our ontology.

The source of our collected documents is not only documents, but rather ontology of psychology such as the Oxford Dictionary of Psychology and many other dictionaries of psychology. We have collected 100 documents in ENGLISH.

Table 1 contains functionalities related to the two types of text related to our search (the numbers provided in the table below do not take into account lists of non-alphanumeric characters or empty words).

3.3 Extraction of candidate terms

The step of term extraction is according to [19] "the task of automatically detecting, from a textual base, lexical units that designate concepts in restricted thematic areas" [19].

After constructing the document (this is the starting hypothesis of ontology), we found that the extracted expressions and lists of terms contained a lot of noise. Therefore, we use the AntConc concordance to select and identify candidate terms specific to the field of psychology.

Once we have imported the files that make up our text into the concordance, we can extract a set of terms and a series of words from the documents that make up the text. We were able to collect the following candidate terms in table 2:

3.4 Disambiguation of terms

So we moved on to the concept disambiguation stage, in which we tried to find the right concept that corresponds to the COVID-19 context. After using the concordance, we were able to deduce the

candidate terms, but there are still polysemic terms. This is why we resorted to the disambiguation technique based on the semantic similarity between the collected candidate terms. We consider that the less polysemic a term in the context is, the more important it is for the disambiguation of ambiguous terms.

We applied McInnes and Pedersen's formula as follows:

We take the case of the Formal context F= *increased anxiety* an ambiguous term t_i= *anxiety* associated with n=4 concepts C_i={C_{i1}= *Anxiété*, C_{i2}= *Anxiété abdominales*, C_{i3}= *anxiety accrue*, C_{i4}= *generalized anxiety* } and **T=49** all the terms that appear in Table 1, collected by the concordance software used 'AntConc'.

To calculate the score for each concept C_{ij} with **J** ∈ **{1, … , 4}** which is defined by the following equation :

$$Score\ (c_{ij})$$
$$= \sum_{\substack{k=1 \\ k \neq i}}^{|T|} \max_{l \in [1,...,|CK|]} (Sim_{Lin}(c_{ij},c_{kl})) \qquad (3)$$
$$\times w(ti)$$

With $Sim_{Lin}(C_{ij},C_{kl})$ = the semantic similarity between the concepts defined above C_{ij} and concepts C_{kl} Knowing that the C_{kl} are the concepts that make up the *T*. So the K={1,...,49} and the l ∈{1,..., 49}.

And **W(t_i)** = a weight to indicate the importance of the concepts associated with the term t_i in disambiguation, it is calculated by :

$$w(ti) = \frac{1}{nbconcept(ti)} \qquad (4)$$

In our case the weight w(ti) :

$$w(ti) = \frac{1}{4} \qquad (5)$$

Such as **nbconcept(t_i)** = the number of concepts associated with t_i =4.

By replacing the values obtained in the equation to calculate the score (Cij) :

$$Score\ (c_{ij})$$
$$= \sum_{\substack{k=1 \\ k \neq i}}^{|49|} \max_{l \in [1,...,|45|]} (Sim_{Lin}(c_{ij},c_{kl})) \qquad (6)$$
$$\times \frac{1}{4}$$

To have the value of the score, we still have to detect the value of $Sim_{Lin}(C_{ij},C_{kl})$.

To study the similarity of the C_{ij} of ti concepts with the C_{kl} de T concepts, we have used again the Resnik method introduced by Resnik in 1995 in [29], this method is clarified in [27].

The notion of informational content (IC) was first introduced by Resnik in [20]. It uses both ontology and corpus [21]. The informational content of a concept reflects the relevance of a concept in the corpus by taking into account its specificity or generality [21]. A general concept is said to subsume a more specific concept [21]. The frequency of concepts in the corpus is calculated in order to find the information content [21].

This frequency groups together the frequency of appearance of the concept itself as well as the concepts it subsume [21]. The formula is as follows:

$$CI(c) = -log\ (P(c)) \qquad (7)$$

With $P(c)$ = the probability of finding an instance of the concept c. These probabilities are calculated by: frequency $(c)/N$ where N is the total number of concepts, according to **Lin** in [27].
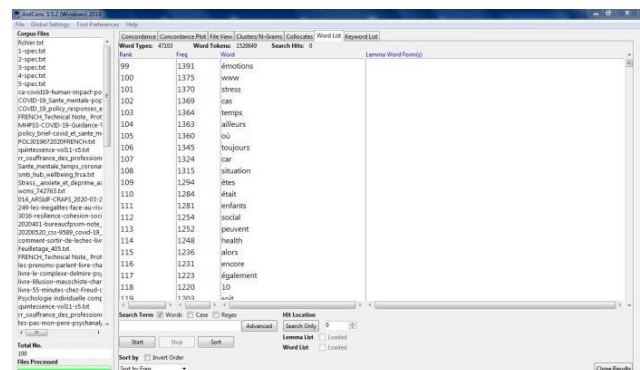

Figure. 1 Example of term search in the 'AntConc' concordance

Figure. 1 Example of term search in the 'AntConc' concordance

Table 3. Result of adopted Method

Term	Calcul du P(c) =(c)/N	Calcul CI(c) = (-log(P(c))
Addiction	1,18	-0,071
Aggressiveness	4,19	-0,62
Anxiety	0,18	0,74
Background	1,19	-0,07
Anticipation	1,42	-0,15
Antidepressants	0,73	0,13
Wellness	17	-1,23
Character	17,73	-1,24
Containment	31,73	-1,50
COVID-19	131,42	-2,11
Depression	11,42	-1,05
Emotion	5,11	-0,70
Patient	34,30	-1,53
Mental illness	0,57	0,24
Personality	11,76	-1,07
Person	0,30	0,52
Psychoanalysts	0,92	0,03
psychological	42,23	-0,62
Psychologists	4,61	-0,66
Quality of life	5,03	-0,70
Relaxation	1,42	-0,15
Resilience	6,03	-0,78
Mental Health	72,19	-1 ,85
post-traumatic stress	2,34	-0,36
Suicide	5,5	-0,74
Tele-consultation	1,03	-0,01
Trouble	4,19	-0,62

We have calculated the $P(c) = 0.18$ in our case So:

$$CI(c) = -log(0.18) \tag{8}$$

Resnik in [16] defines the semantic similarity between two concepts by the amount of information they share. This shared information is equal to the information content of the smallest generalizer (PPG) the most specific concept that subsume both concepts in ontology [21].

$$Sim\ (c1, c2)\ =\ CI\ (ppg(c1, c2)) \tag{9}$$

We have therefore been able to deduce the formula for calculating the similarity $Sim_{Lin}(C_{ij}, C_{kl})$:
Where:

$$Sim_{Lin}(C_{ij}, C_{kl}) = CI\ (ppg(C_{ij}, C_{kl})) \tag{10}$$

We then take the CI of the smallest generalize between the concepts, we thus obtain the value of

$Sim Lin(Cij, Ckl)$ and we replace it in our equation of calculation of the score for disambiguation. And the concept with the highest score is retained and assigned to the term.

Through this method, a set of unambiguous concepts is deduced. Each concept is defined by a term and usually an intention or extension in table 3.

4. Formalization of "OntoPsy-COVID-19"

The final step is to use formal and expressive language to describe the ontology derived from the previous steps. For this, the SKOS reference language is used. SKOS (Simple Knowledge Organisation System) is a representation language of concept schemas, which covers documentaries languages such as thesauri, classifications, subject heading lists, taxonomies, folksonomies, etc [22]. Its name has been chosen to highlight the very objective of this language: to propose a system allowing the expression and management of machine-interpretable models in the semantic web perspective [22]. This model is defined as "simple" as opposed to other models, such as OWL (Ontologic Web Language), which are more capable of representing richer semantic structures such as ontology, but also more complex to use [22].

4.1 Identification of relations between concepts

To identify the relations between the concepts that make up our ontology, we have used the ACF formal concept analysis method, which consists of using the syntactic analysis of the sentences automatically obtained by the concordance to construct the formal context by removing the nouns and verbs from the analysis. The object in the formal context is the noun that appears as the direct subject or complement of the object. The attributes of the formal context are the verbs of the sentence in question, and they end with the suffix -ABLE when they come from the direct object complement (COD).

Definition of Formal Context: A formal context is a triplet

$$K\ =\ (G, M, I) \tag{11}$$

Where G is a set of objects, M is a set of attributes and I is a binary relation between G and M called K's incidence relation and checking

$$I\ \subseteq\ G\ \times\ M \tag{12}$$

A pair

$$(g, m)\ \in\ I \tag{13}$$

(Also denoted gIm) means that the object

$$g \in G \qquad (14)$$

Has the attribute [23].

$$m \in M \qquad (15)$$

A formal context can be represented in the form of a table where the rows correspond to objects and the columns correspond to attributes [23]. The cells of the table are filled as follows: if the ith object g is in relation I to the jth object, then the cell intersection of row i and column j contains "×", otherwise the cell is empty [23].

By applying this method, we were able to deduce the formal concepts of our ontology in Table 4.

Table 4. Formal Context of the Proposed Ontology

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Person	×				×		×																			
Patient	×					×		×					×													
Covid-19		×															×									
Mental Health			×																							
Back				×																						
Personality						×																				
Psychologists										×	×								×						×	
Psychoanalysts										×	×								×						×	
Trouble								×							×		×					×				
Mental illness								×							×		×					×				
Agony								×							×							×				
Anxiety								×							×							×				
Aggressiveness								×							×							×				
Addiction								×							×											
Depression								×							×								×			
Antidepressant												×														

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Tele-consultation											×														
Wellbeing														×											
Character				×																					
Quality of life														×											
Suicide																×									
Anticipation																		×							
Relaxation																				×					
Stress-paustrauma						×																	×		
Resilience																						×			
Containment																×									
Emotion																									×

Figure. 4 OntoPsy-COVID-19 Conceptual Lattice for Ontological Interpretation

Identification of the numbers listed in Table 4:

1. Reach
2. Reach -ABLE
3. Repose
4. Repose -ABLE
5. Possess
6. Possess -ABLE
7. Suffer
8. Suffer -ABLE
9. Consult
10. Consult -ABLE
11. Prescribe
12. Prescribe -ABLE
13. Participate
14. Participate -ABLE
15. Paralyze

16. Paralyze -ABLE
17. Driving
18. Driving -ABLE
19. Encourage
20. Encourage -ABLE
21. Attenuate
22. Attenuate -ABLE
23. Getting rid of
24. Getting rid of -ABLE
25. Observe
26. Observe –ABLE

4.2 Visualization of relations between concepts through the lattice

The lattice of formal concepts can be represented visually in a Hasse diagram [24]. Each node of this diagram represents a formal concept; each arc represents a subsumption relation [24]. To improve the readability of the lattice it is possible to represent it in a reduced form, which consists in transferring the labels of the intentions to the most general concept possible in the lattice and the labels of the extensions to the most specific concept [24].

To trace the lattice that concerns our ontology, we chose to use ConExp as a tool that allowed us to trace the terminology to be interpreted by the SKOS in the following section. We chose ConExp because it offers a compact and modular representation of the lattice.

In order to use ConExp, we started by entering the above table in the 'context Editor' part, in order to conceptualize the latice line diagram through the calculation of the concepts (Fig. 5).

● Concept formel « standard »
◑ Concept formel avec extension propre
◒ Concept formel avec intension propre
○ Concept formel « blanc »

4.3 Model SKOS

Recommended by the W3C since August 2009, SKOS is a data model designed to support TORs, such as terminologies, thesaurus or taxonomies [25].

We have chosen to use SKOS in this article because we want to describe in detail the level of vocabulary that constitutes the concept of the proposed ontology "OntoPsy-COVID-19". SKOS provides a simple mechanism to support the representation. Structured vocabulary. Each concept is defined as an RDFS class with a set of attributes. A concept has a URI for its identification, a preferred term (or one per language in the case of multilingual resources), possible synonyms (or alternative terms) and one or more definitions. The term (or label) is a

string. These concepts are linked by generalization / specialization (skos:broader and skos:narrower) and by association (skos:related). Fig. 5, 6, 7, 8 and 9 shows the concepts of the proposed ontology 'OntoPsy-COVID-19' in SKOS.

5. Result and Discussion

The terminology and ontology levels are not differentiated. We are inspired by several works and in particular the ontology of psychology APAONTO, but we wish to go further in this study and manipulate this ontology model in SKOS through a psychological support application that will be realized soon.

Ontology assessment is always an open research question. As part of this work, the ontology is being verified in practice. Different aspects will be evaluated: the relevance of the ontology for the target application, its coverage in the field, etc. In fact, the generated ontology will soon be refined and verified by experts in the field, and will be evaluated in practical applications (in progress).


```
Onto:Person  rdf:type       skos:Concept ;
             skos:prefLabel "Persons"@fr ;
             skos:altLabel   "personality"@fr;
             skos:narrower  onto:patient;
             skos:narrower  onto:Psychoanalyst;
             skos:narrower  onto:Psychologist;
             skos:related   onto:COVID-19;
             skos:related   onto:MentalHealth;
             skos:related   onto:trouble;
             skos:related   onto:Addiction;
             skos:related   onto:character;

Onto:Patient  rdf:type       skos:Concept ;
              skos:prefLabel "Patients"@fr ;
              skos:broader   onto:Person;
              skos:related   onto:COVID-19;
              skos:related   onto:MentalHealth;
              skos:related   onto:trouble;
              skos:related   onto:Psychoanalyst;
              skos:related   onto:Psychologist;
              skos:related   onto:Addiction;

Onto:COVID-19  rdf:type       skos:Concept ;
               skos:prefLabel "covid19"@fr ;
               skos:prefLabel "coronavirus"@fr;
               skos:related   onto:Person;
               skos:related   onto:patient;

Onto:MentalHealth rdf:type       skos:Concept ;
                  skos:prefLabel "MentalHealth"@fr ;
                  skos:prefLabel  "troublemental"@fr;
                  skos:narrower  onto:anguish;
                  skos:narrower  onto:aggressiveness;
                  skos:narrower  onto:Anxiety;
                  skos:narrower  onto:depression;
                  skos:narrower  onto:stress-paustrauma;
                  skos:related   onto:Person;
                  skos:related   onto:patient;
                  skos:related   onto:santementale;
                  skos:related   onto:Addiction;
```

Figure. 5 Presentation of ontology 'OntoPsy-COVID-19

```
Onto:Psychologist  rdf:type          skos:Concept ;
        skos:prefLabel   "Psychologists"@fr ;
        skos:broader    onto:Person;
        skos:related    onto:patient;
        skos:related    onto:Antidepressant;
        skos:related    onto:teleconsultation;
        skos:related    onto:Emotion;


Onto:Psychoanalyst  rdf:type          skos:Concept ;
        skos:prefLabel   "Psychoanalysts"@fr ;
        skos:broader    onto:Person;
        skos:related    onto:patient;
        skos:related    onto:Antidepressant;
        skos:related    onto:teleconsultation;
        skos:related    onto:Emotion;


Onto:trouble  rdf:type          skos:Concept ;
        skos:prefLabel   "troubles"@fr ;
        skos:altLabel    "psychologicaldisorder"@fr;
        skos:altLabel    "troublesommeil"@fr;
        skos:altLabel    "psychologicaldisorder"@fr;
        skos:broader    onto:mentalillnesses;
        skos:related    onto:patient;
        skos:related    onto:Suicide;
        skos:related    onto:relaxation;


Onto:Antidepressant  rdf:type          skos:Concept ;
        skos:prefLabel   "Antidepressant"@fr ;
        skos:related    onto:Psychoanalyst;
        skos:related    onto:Psychologist;
        skos:related    onto:Patient;
```

Figure. 6 Presentation of ontology 'OntoPsy-COVID-19'

```
Onto:teleconsultation  rdf:type          skos:Concept ;
        skos:prefLabel   "teleconsultations"@fr ;
        skos:related    onto:Psychoanalyst;
        skos:related    onto:Psychologist;
        skos:related    onto:Patient;


Onto:character  rdf:type          skos:Concept ;
        skos:prefLabel   "character"@fr ;
        skos:related    onto:Person;
        skos:related    onto:Patient;


Onto:well-being  rdf:type          skos:Concept ;
        skos:related    onto:Addiction;
        skos:related    onto:Qualityoflife;
        skos:related    onto:Person;
        skos:related    onto:Patient;


Onto:Qualityoflife  rdf:type          skos:Concept ;
        skos:related    onto:trouble;
        skos:related    onto:mentalillnesses;
        skos:related    onto:Person;
        skos:related    onto:Patient;


Onto:Suicide  rdf:type          skos:Concept ;
        skos:related    onto:trouble;
        skos:related    onto:mentalillnesses;
        skos:related    onto:Person;
        skos:related    onto:Patient;


Onto:stress-paustrauma  rdf:type          skos:Concept ;
        skos:related    onto:resilience;
        skos:related    onto:Person;
        skos:related    onto:Patient;
```

Figure. 7 Presentation of ontology 'OntoPsy-COVID-19'

```
Onto:containment  rdf:type          skos:Concept ;
        skos:altLabel    "quarantine"@fr ;
        skos:altLabel    "isolation"@fr;
        skos:related    onto:Person;
        skos:related    onto:Patient;
        skos:related    onto:COVID-19;


Onto:Emotion  rdf:type          skos:Concept ;
        skos:altLabel    "Positive"@fr ;
        skos:altLabel    "negative"@fr;
        skos:related    onto:Person;
        skos:related    onto:Patient;
        skos:related    onto:Psychoanalyst;
        skos:related    onto:Psychologist;


Onto:resilience  rdf:type          skos:Concept ;
        skos:related    onto:Patient;
        skos:related    onto:stress-paustrauma;
        skos:related    onto:MentalHealth;
        skos:related    onto:trouble;


Onto:Addiction  rdf:type          skos:Concept ;
        skos:related    onto:bien-etre;
        skos:related    onto:patient;
        skos:related    onto:Person;


Onto:mentalhealth  rdf:type          skos:Concept ;
        skos:related    onto:Back;
        skos:related    onto:MentalHealth;
        skos:related    onto:trouble;
        skos:related    onto:patient;
        skos:related    onto:Person;
```

Figure. 8 Presentation of ontology 'OntoPsy-COVID-19'

```
Onto:Back  rdf:type          skos:Concept ;
        skos:altLabel    "environmental"@fr ;
        skos:altLabel    "Social"@fr;
        skos:related    onto:mentalhealth;
        skos:related    onto:patient;
        skos:related    onto:Person;


Onto:relaxation  rdf:type          skos:Concept ;
        skos:related    onto:trouble;
        skos:related    onto:MentalHealth;
        skos:related    onto:stress-paustrauma;
        skos:related    onto:patient;
```

Figure. 9 Presentation of ontology 'OntoPsy-COVID-19'

The objective is to validate the following points: The ontology adequately covers the knowledge of the domain. It takes into account the diversity of users and their professional level. The ontology provides portal users with quick and easy access to documents that meet their information needs.

Discussed the limitations encountered in this study and the mechanisms used to reduce its impact. Unfortunately, due to a lack of time and resources, we cannot overcome them: - Basic text used: the text is the starting point of our work, however, we have to be careful with some restrictions: To collect terms used by professionals in the field of psychology, we use a database of Google Texts and Google Scholar
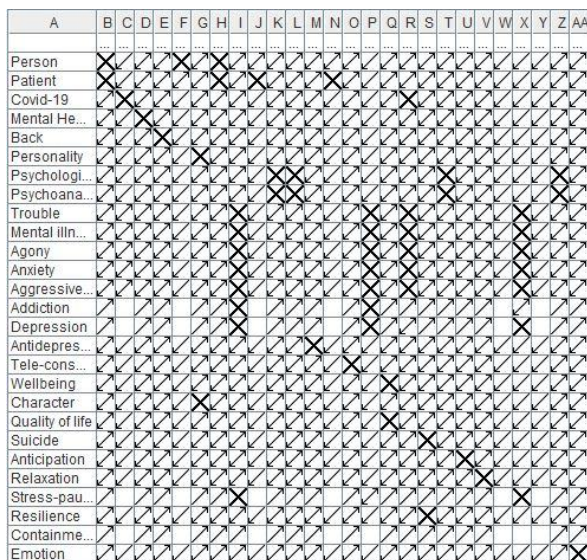
Figure. 10 Relations between the concepts of proposed ontology

articles published in 2020. Therefore, the authors of the articles we target are professionals in the field. The selection of profiles is based on the importance of their knowledge. - Text size varies and it seems difficult to give an accurate indication of the optimal number of words. In general, the text of articles related to the COVID-19 pandemic exceeds the text of the psychological literature.

The originality of our ontology lies in its idea of combining extracted term-candidates with the concordance and disambiguate with the method based on semantic similarity and ACF. This is in contrast to work that does not rely on a combined and structured method to guide the user in the construction of the ontology [23].

The value of our work is that the proposed approach has therefore made it possible to construct a psychological domain ontology in English relating to the state of people's mental health during the Fig. 10 presents a projection of relations between the concepts. COVID-19 pandemic, containing 24. These concepts are structured via 702 transversal relationships.

6. Conclusion

Throughout this article, we try to develop a domain ontology called "OntoPsy-COVID-19" through IR and terminology research. We begin by studying the salient elements of the text that form the basis of the text, which can be used to construct the ontology, based on the two hypotheses we specified at the beginning. Subsequently, we used methods adapted to our research to extract candidate words, remove ambiguity and define possible connections between them.

The motivation for developing this ontology was the lack of sufficient research in the sense of domain ontology, which modeled concepts related to the mental health of individuals during the COVID-19 pandemic. Therefore, our ontology fills this gap and describes the formal knowledge related to this domain ontology.

The purpose of this article is to describe the knowledge through the proposed ontology and using the SKOS language. Following this work, we intend to query this data and manipulate it through the SPARQL language, which uses graph patterns to determine the triplets that meet the conditions of the request, and which will be manipulated by the JEE language for the operations. The data is provided by SKOS and will be used as a platform to provide people with psychological support during the COVID-19 pandemic.

Conflicts of Interest

The authors declare that we do not have any circumstances or interest that may affect the results discussed in this manuscript.

Author Contributions

The paper conceptualization, methodology, software, and validation, have been done by 1st author. Formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review, editing, and visualization, have been done by 1st and 2nd authors. The supervision, and project administration, has been done by 3thd and 4thd author.

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