# An exploration of the relatedness problem between arguments: combining the generative lexicon with inference

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# An Exploration of the Relatedness Problem between Arguments: Combining the Generative Lexicon with Lexical Inference

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**Abstract.** Given a controversial issue, argument mining from natural language texts is extremely challenging: domain knowledge is often required together with appropriate forms of inferences. This contribution explores the use of the Generative Lexicon viewed as both a lexicon and a domain knowledge representation.

## 1 Aims and Challenges of Argument Mining

### 1.1 Aims of argument mining

The main goal of argumentation is to convince someone or an audience of a certain state of affairs. In most texts, argumentation is often associated with explanation whose goal is to give new information to someone, in order to provide new information or possibly to contradict common beliefs. Although argumentation and explanation serve different purposes, the boundaries between them is subtle and very context-dependent.

The main goal of argumentation is to convince someone or an audience of a certain state of affairs. One of the main goals of argument mining is, given a controversial issue, to search for arguments for or against that issue in various types of texts. The arguments are supports, attacks, contrasts or concessions of the issue at stake. Arguments may also attack or support each other. An argumentation is represented by a graph where nodes are arguments and arcs are supports and attacks.

Arguments are difficult to identify and to characterize from a linguistic point of view. They are standard natural language statements which get the status of arguments because of the specific relations they have with a controversial issue. For example, the statement from the Indian Press: *we now see long lines of your girls with school bags along the roads* could be just factual, but if the issue (e.g. article title) at stake is: *the situation of women has improved in India*, then, the first statement becomes an argument supporting this title. It is often difficult to identify whether a statement is a support or an attack of a controversial issue, and what it precisely attacks or supports. In the above example, 'school bags' means education: it is a means to improve women's condition because it leads to jobs and more independence. Relating a controversial issue with arguments therefore requires knowledge, lexical semantics data, and appropriate inferential patterns. Finally, arguments are often not adjacent to the controversial issue they are related to, but in general they are referentially clearly identified.

This paper is exploratory: it is essentially, at this stage, a linguistic and conceptual analysis that shows how lexical and domain knowledge can be used to identify and interpret arguments found in various documents in relation with a controversial issue. Once these elements get stable and developed, the goal is to develop the domain knowledge facte of argument mining which is a crucial corner stone to extract relevant arguments.

### 1.2 Challenges of ongoing research in Argument Mining

Argument mining is an emerging research area with new challenges that requires the combination of linguistic analysis and language processing with artificial intelligence. Argument mining is at the moment applied mainly to written texts, e.g. (Mochales Palau et al., 2009), (Kirschner, C. et ali., 2015), opinion analysis, e.g. (Villalba et al., 2012) dialogue analysis, e.g. (Budzynska, et ali. 2014), (Swanson et ali., 2015). Annotated corpora are being made available, such as the AIFDB dialogue corpora at Dundee university and (Walker et ali., 2012). These corpora are very useful to identify argumentative discourse units (ADUs), linguistic cues, as in e.g. (Nguyen et al., 2015), and argumentation strategies, in a more concrete way than abstract argumentation schemes, as shown in e.g. (Feng et al., 2011).

The goal of argument mining is, given a controversial issue, to identify in a set of texts, statements which can be interpreted as supports or attacks. Argument mining applies to many areas and has many applications. In opinion analysis, the benefits are not only to identify the customer satisfaction level, but also why customers are happy or unhappy. Abstracting over arguments allows to construct summaries and to define customer value systems (e.g. low fares are preferred to localization or quality of welcome for some categories of hotel customers). In controversial dialogs, it is of much interest to identify arguments and how speakers challenge each other. A result can be the synthesis of the Pros and Cons and the conclusions of the discussion.

Argument mining from full natural language texts is extremely challenging: since arguments can seldom be identified from linguistic marks, domain knowledge is often required together with appropriate forms of inferences. Then, given a controversial issue, the identification of the relations between arguments and that issue is often more complex than just the bipolar support or attack view. For example, given the issue *Vaccination against Ebola is necessary*, and an argument: *There are almost no cases of Ebola in Europe*: is this argument a support, an attack or something else, such as e.g. a concession ? Identifying the 'conceptual chain' between a controversial issue and an argument is of much importance to have a clear analysis of the role of each argument in an argumentation graph.

### 1.3 Research Questions and Paper structure

Among the large number of complex natural language processing problems raised by argument mining, this paper addresses the following challenges related to language resources and how they are paired with knowledge and reasoning:

– The identification of the linguistic cues that may be relevant to identify arguments in texts,

- The identification of the types of knowledge and inferences which are needed in conjunction with linguistic cues,
- The analysis of the relations between linguistic data (mainly lexical) and knowlege in this context,
- The identification of relatedness factors between a controversial issue and a statement, in particular which aspects or facets of the issue are involved in an argument,
- The investigation of the exact nature of the relations between an issue and an argument. Besides supports and attacks, other types of relations such as various types of causality, concessions and supports must be taken into account. This investigation also includes analysing the strength of the argument and its the persuasion effect(s),
- Finally, the analysis of the re-usability or scalability of an argument mining system that includes knowledge.

In this paper, we first develop a corpus analysis to characterize these challenges. Then, via two case studies from this corpus, we show that the Generative Lexicon (GL) (Pustejovsky, 1995) paired with a few generic inferential patterns is a useful approach to argument mining. The GL provides both language resources and the knowledge that is required in a large number of cases to deal with the above questions. This contribution is essentially exploratory at this stage.

In the next section, we briefly present the GL. The next two sections develop the two use cases and the inferences that are involved. We conclude this article by an analysis of the scalability of this approach in order to develop large-scale argument mining systems.

## 2 Linguistic and Conceptual background

In this section, we introduce the main concepts in linguistics, conceptual analysis and knowledge representation which will serve as a basis for our investigation.

### 2.1 Lexical semantics and lexical features

**Lexical types** Words are in general linguistic realizations of concepts. Concepts realized as nouns or verbs are structured into networks of ontologies where words are language realization instances. Nouns are often structured as a terminology parallel to a corresponding ontology. Nouns are in general typed by one or more semantic label, e.g. *bread* is typed as 'food' or 'edible stuff'. Labels are relatively empirical and domain dependent. A number of nouns and almost all verbs are relational and predicative. Verbs sub-categorize for arguments (agents, themes, locations, etc.) which are typed by means of semantic labels. Those types correspond to the standard and most direct uses of the verbs. Metaphors, metonymies and other forms of sense variations are not included in these types. For example, *eat* expects a human subject and an edible and solid object. Other categories such as prepositions are relational, adjectives and adverbs are often higher-order predicative, e.g. when they have scope over formulas.

General purpose types are relatively well-known and widely used in large repositories of lexical resources such as WordNet. However, more accurate types may be needed to deal with more complex linguistic and conceptual situations. The analysis of arguments requires the development of accurate semantic types such as the polarity (negative, neutral, positive) of a word, in general or in a given context.

**Lexical semantics relations** In Computational Linguistics, ontologies are often limited to the 'isa' (type-subtype) hierarchy, but there are many other, hierarchical or non-hierarchical, relations which contribute to structure lexical knowledge and entity property management. For example, the various part-of and the antonymy relations structure lexical knowledge in a powerful manner (Cruse, 1986). These are developed in e.g. WordNet but they not extensively used in applications.

The part-of relations structure lexical items in terms of e.g. physical or functional parts of a more generic entity. There is no downward inheritance of properties as fo rthe isa relation, but a weak form of upwards inheritance, e.g. a car inherits of the color of its trunck. Since argument orientation analysis is largely based on notions such as polarity, lexical semantics relations such as antonyms, non-branching proportional series, or scales of positive/negative terms turn out to be a useful resource. Scales and series structure terms according to a certain property on the basis of a partial ordering. For example, a simple scale related to cost is: expensive - (reasonable, acceptable) - cheap - free. Such scales are useful to identify the orientation of an argument.

**Verb and noun semantic classes** Most nouns and verbs can be grouped into classes which share a number of common properties. For example, large classes of verbs of communication, of consumption, of body care are proposed in various resources. The role of these classes is to help to describe lexical knowledge in an homogeneous and principled way. For example, verbs of oral communication, such as: *report, ask, order, request* have all a subject of type human, an object of type abstract contents and an indirect object of type human (X orders something to Z). Their syntactic behavior as well as their conceptual representation have a lot in common.

Verbs are particularly interesting since most of them have a rich semantic structure. Of interest in this paper is the presupposition structure, which is often shared by large verb semantic classes.

**Domain knowledge and Conceptual representations** In a number of areas such as argument mining, lexical knowledge is a major resource. It must however frequently be paired with domain knowledge to allow the development of specific inferences. These inferences allow the identification and the characterization of arguments w.r.t. a controversial issue. As shall be seen below, these inferences are in general relatively recurrent and stable. Domain knowledge also plays a role in e.g. disambiguation or semantic interpretation.

Most of the semantic representations given in this article are based on a direct translation of concepts into constants and predicates. This is a superficial semantic representation which turn out to be sufficient for our purpose. However, semantic representations based on systems of primitives allow much more accurate semantic analysis. Systems such as the Lexical Conceptual Structure (LCS, REF) has shown its efficiency in e.g. machine translation based on interlingua. Resources such as VerbNet make an extensive use of a small set of primitives to describe verbs in an abstract way. Using systems of primitives allow more abstract and homogeneous representations of statements, of inferences and of resulting states and events.

The Generative Lexicon (GL) presented below, on which our argument mining analysis is essentially based, capture several aspects of the elements presented above. In terms of semantic representations, the GL adopts a rather superficial analysis based on predicates and constants. However, these could be reformulated on the basis of a system of primitives if needed.

## 2.2 An introduction to the Generative Lexicon

The Generative Lexicon (GL) (Pustejovsky, 1995) emerged from Aristotle's notion of modes of explanation, developed later by (Moravcsik, 1975). The GL is an attempt to structure lexical semantics knowledge in conjunction with domain knowledge from several perspectives. It allows to explain a number of language phenomena such as various types of metonymies via a decompositional view of lexical meaning. Various forms of so-called 'generative aspects of lexical combinations' have been characterized via the operation of type shifting, where the original type that is expected has been coerced to another type, allowing metaphors such as 'to devour books' or various forms of sense variations, which are frequent in language.

The GL develops some original forms of semantic typing, such as dotted types, that allow to account for the different facets of an entity (e.g. the physical and contents facets of a book), the development of a specific argument structure with semantic types, lexical paradigms (lcp), an event structure and the Qualia structure, which is the structure that is considered in our investigations.

Very briefly, the Qualia structure of an entity is a kind of template on which from which various operations can be applied. The Qualia structure is composed of four fields called roles:
- the constitutive role describes the various parts of the entity and its physical properties, it may include subfields such as material, parts and components,
- the formal role describes what distinguishes the entity from other objects, i.e. the entity in its environment, in particular the entities which are more generic. It may also be structured into several subroles such as shape, dimensions, position, etc.
- the telic role describes the entity functions, uses, roles and purposes,
- the agentive role describes the origin of the entity, how it was created or produced.

These definitions are relatively vague and empirical. Roles are composed of predicates, which are related to the the argument structure and the event structure, which is not presented here. The predicates used in the different roles are a priori defined from a domain ontology or from a general purpose ontology. From the examples are given in the two next sections, it is clear that analysis and description methods are necessary to further develop Qualia structures of the GL on a wide range.

A simple and well-known example is the case of *novel(X)*:
Novel(X):

$$\begin{bmatrix} \text{CONSTITUTIVE:} \begin{bmatrix} \text{PHYSICAL OBJECT: PAGES, COVER,} \\ \text{CONTENTS: CHAPTERS, STORY, CHARACTERS, ETC.} \end{bmatrix}, \\ \text{TELIC:} \left[\text{CONTENTS: READ(Y,X), COMMENT(Y,X), ETC.}\right], \\ \text{FORMAL:} \left[\text{BOOK}\right], \\ \text{AGENTIVE :} \left[\text{WRITE(T,X), PUBLISH(P,X), SELL(P,X), ETC.}\right] \end{bmatrix}$$

In this informal Qualia structure, variables are in capital letters. X is the novel, Y, a reader, T, the author, P, the publisher and P, the retailer. The predicates in each role can be quite diverse. In the constitutive, we show how two facets of novel can be encoded: the physical object and the contents. In the telic role, the main predicate is read, but others such as comment, criticize, illustrate, etc. are possible for the contents facet. The physical facet, not represented here may contain predicates such as print, bind, etc. The same remark holds for the agentive role, where, besides the authors that writes the novel, this novel is then published and sold by other actors.

Another interesting example is the case of cake(X):
Cake(X):

$$\begin{bmatrix} \text{CONSTITUTIVE:} \begin{bmatrix} \text{Y: INGREDIENTS THE CAKE IS MADE OF:} \\ \text{EGGS, FLOUR, SUGAR, MILK, ETC.} \end{bmatrix}, \\ \text{TELIC:} \left[\text{EAT(E2, Z, X), FEED(X, Z), ENJOY(Z, X), ETC.}\right], \\ \text{FORMAL:} \left[\text{FOOD, ARTEFACT}\right], \\ \text{AGENTIVE :} \left[\text{BAKE(E1, W, Y), ETC.}\right] \end{bmatrix}$$

In this example, the set Y of ingredients instantiates the third argument of bake (to indicate that all the ingredients are considered in the bake act). Note also the event variables E1 and E2, with the constraint: E1 $\leqslant$ E2. The predicates in the telic role of this example are related to different roles of a cake, similarly to the distinction physical object / contents of novel. Some predicates are also more prototyical than others. Adding such details into Qualia role may be difficult but, on the other hand, adds a lot of valuable information to the system.

As discussed above, the roles of a Qualia contain predicative expressions. These remain relatively superficial compared to e.g. a conceptual semantics. However, it seems that this level of expressivity is sufficient for our purpose. Another important issue is the fact that some axioms can be defined to characterize the properties of the Qualia roles. We give below, for Argument A2, an axiom that manages the relations between the agentive and telic roles, informally: *by definition, the agentive role is pre-telic: the events it describes occur before the functions or events given in the telic role. They lead to the creation or coming into being of the concept. There are a priori no causal relations between these two sets of events besides this notion of creation.*

The GL has remained a relatively theoretical view of language. Relatively few resources have been produced to validate the approach, except for the EEC SIMPLE project, carried out about two decades ago. However, as will be seen below, the GL

is a very relevant means to structure lexical knowledge to characterize some forms of language production. In particular, the Qualia structure was designed to account for the large diversity of sense variation phenomena, which is formally modeled by the type coercion operation. Other formal operations include selective binding and co-composition (mutual influence of a predicate and one of its arguments).

With respect to other well-known resources, the constitutive role is close to the part-of relation and the formal is close the the isa relation frequently found in ontologies and in WordNet. However, the constitutive role has a more precise informational structure since the different types of constituents can be specified in dedicated sub-roles. The argument structure of the GL and its semantic typing is different from FrameNet which basically develops semantic roles, which are not present in the GL. Finally, VerbNet basically describes the structure of verbs, from WordNet and semantic classification. VerbNet also provides a conceptual representation of verbs based on a smalls et of primitives. The GL does not offer this level of detail, and it is, in fact, not very efficient to describe verbs. However, as shall be seen below, the main interest of the GL for argument mining are the telic and the agentive roles, which are very productive and an useful compromise to deal with lexical and domain knowledge.

## 3 Corpus Construction and Analysis

We constructed four corpora from four independent controversial issues. These corpora are relatively small, they are designed to explore the problem, not to design a comprehensive argument mining system. The first task was to annotate statements in each of these corpora. Annotations mainly include: text span involved, polarity of argument, direct or indirect relation with the issue (i.e. knowledge is needed or not to identify the argument), main concepts involved in the indirect case to relate the argument with the issue, strength of argument. The corpus is characterized as follows:

| Controversial issue | Corpus size (short texts) | nb. of annotated arguments (no overlap) |
|---|---|---|
| Ebola vaccination | 16 texts, 4300 words | 50 |
| Women's condition in India | 9 texts, 3600 words | 24 |
| Development of nuclear plants | 7 texts, 2800 words | 31 |
| Organic agriculture is the future | 19 texts, 3800 words | 17 |
| Total | 51 texts, 14500 words | 122 |

Table 1. Four controversial issues.

From a manual analysis, the following argument distribution is observed over the 122 annotated arguments:

| Attacks | Supports | Concessions | Contrasts | Ambiguous |
|---|---|---|---|---|
| 51 | 32 | 17 | 18 | 4 |

Table 2. Polarity distribution.

The corpus shows a tendency to argue against an issue rather than to support it (attacks and contrasts = 57%, supports and concessions = 40%).

Let us now consider the direct vs. indirect character of the relation between the issue and the argument, and the number and nature of concepts a priori involved in the indirect case from our manual analysis:

| Controversial issue | Indirect cases (rate) | total number of concepts for this corpus (estimate) |
|---|---|---|
| Ebola vaccination | 29 (58%) | 47 |
| Women's condition in India | 18 (75%) | 22 |
| Development of nuclear plants | 14 (45%) | 19 |
| Organic agriculture is the future | 12 (70%) | 26 |
| Total | 73 (60%) | 114 |

Table 3. Number of indirect cases and estimate of number of concepts involved.

These figures, although limited to a small experiment, show that in about 60% of the cases, knowledge is involved to establish an argumentative relation between a statement and an issue. An important result is that the number of concepts involved is not very large: 114 concepts for 73 arguments. More concepts may be needed to mine arguments on a larger scale, however, the number of arguments found per issue shows a relatively good coverage of each issue. This is an important observation for the scalability issue.

annotation: quels attributs (polarit, concepts concerns dans issue par arg, etc.)

stats sur ce qui est concern, arg direct/indirect, connaissances utiles (dans corpus dev.).

nb of concepts/words involved (about), nbre arguments pas identifs sans connaissances ?

Case 1: number of arguments, experiments,

Other cases: how many, size, themes, diversity, make a chart ?

## 4 Case study A: *Should I get vaccinated against Ebola ?*

Given a controversial issue and text spans, potential arguments for or against this issue, this case study explores the different types of lexical and domain knowledge which are required and the types of inferences that are needed to determined where these text spans are arguments. The use of the GL contributes to characterize the role of these arguments.

The text fragments which are investigated below are extracts from various sources where the vaccination against Ebola is discussed, in particular: newspapers articles and blogs from associations for or against vaccination. These are documents accessible to a large public, with no complex medical consideration. These text fragments are in French and have been translated into English for a better readability. These are in general short sentences. About 50 text fragments, potential arguments, have been extracted from 16 sources. We investigate in this case study six text fragments which are representative of this set. More details about this corpus are given in section 5 dedicated to scalability issues.

### 4.1 Features and analysis of the controversial issue

Let us consider the controversial issue:
*The vaccine against Ebola is necessary*.
This statement means (1) that the vaccine must be developed and (2) that people must be vaccinated. The Qualia structure of the head term of this statement, vaccine, is represented as follows:

Vaccine(X):

$$\begin{bmatrix} \text{CONSTITUTIVE: } \left[\text{ACTIVE\_PRINCIPLE, ADJUVANT}\right], \\ \text{TELIC: } \begin{bmatrix} \text{MAIN: PROTECT\_FROM(X,Y,D)} \Rightarrow \text{AVOID(X,DISSEMINATION(D))}, \\ \text{MEANS: INJECT(Z,X,Y)}, \end{bmatrix}, \\ \text{FORMAL: } \left[\text{MEDICINE, ARTEFACT}\right], \\ \text{AGENTIVE : } \left[\text{DEVELOP(T,X), TEST(T,X), SELL(T,X)}\right] \end{bmatrix}$$

X is the variable that represents the vaccine, Y is the person that is vaccinated, T is the biologist or company that develops the vaccine, Z is the doctor that makes the injection, and D is the disease associated with the vaccine. The agentive role develops the way the vaccine is created while the telic role develops its functions and roles. Note the typing in this role: main functions (protect, avoid dissemination) and the means: how these functions are realized (via an injection). This Qualia representation can be further organized, in particular to develop causal and temporal chains. For example, the predicates in the agentive and telic roles could be structured into formulas as follows, using event-denoting variables $E_i$, as developed in the GL at the level of its event structure:
*develop(E1,T,X)* $\wedge$ *test(E2,T,X)* $\wedge$ *sell(E3,T,X)* $\wedge$ *E1* $\leqslant$ *E2* $\leqslant$ *E3*.
Similarly, a causal chain can be developed in the telic role:
*inject(E1,Z,X,Y)* $\Rightarrow$ *protect_from(E2,X,Y,D)* $\Rightarrow$ *avoid(X,dissemination(E3,D))*.
with a kind of partial overlap between E2 and E3. This causal chain is more informative: it says that the injection is the prerequisite to or a means for a protection of the patient and a prevention from any dissemination.

Next, the Qualia structure of Ebola (and more generally, of a virus) can be defined as follows:
Ebola:

$$\begin{bmatrix} \text{FORMAL: } \left[\text{VIRUS, DISEASE}\right], \\ \text{TELIC: } \left[\text{INFECT(E1,EBOLA, P)} \Rightarrow \text{GET\_SICK(E2,P)} \Rightarrow \Diamond\ \text{DIE(E3,P)} \wedge \text{E1} \leqslant \text{E2} \leqslant \text{E3.}\right] \end{bmatrix}$$

P represents here the patient that gets the disease. The purpose of Ebola is to infect people (P) who get sick and may die. There is no agentive role since there is no volition in the Ebola virus. Ebola is a constant in this representation.

The meaning of the controversial issue (people must be vaccinated, sense (2) above) has the following semantic representation:
$\Box$*(*$\forall$ *Y, patient(Y),* $\exists$ *Z, X, doctor(Z), vaccine_against(X,ebola)* $\wedge$ *inject(Z,X,Y))*.
where 'vaccine against Ebola' in the controversial issue is treated as a kind of metonymy

for 'inject vaccine against Ebola'. The metonymy is reconstructed from the predicate 'inject' in the telic role of 'vaccine'. This controversial issue has a positive orientation due to the predicate 'protect_from' in the telic of vaccine. The positive orientation is further reinforced by the modal 'necessary'.

### 4.2 Argument A1: *The Ebola adjuvant is toxic for humans*

The constitutive role of *vaccine(X)* tells us that the adjuvant is part of the vaccine. The role of the adjuvant is specified in its Qualia entry: where 'adjuvant' is relational: adjuvant(Y,X1):

$$\text{Adjuvant(Y,X1):} \begin{bmatrix} \text{FORMAL} : \left[\text{VACCINE, MEDICINE, CHEMICALS}\right], \\ \text{TELIC:} \left[\text{DILUTE(Y,X1), ALLOW(INJECT(X1,P))}\right] \end{bmatrix}$$

where Y is the adjuvant of X1, which is the active principle of the vaccine X. The role of an adjuvant is to dilute X1, and to allow to inject it to patients P. Let us now investigate whether this argument attacks or supports the controversial issue and how.

(1) The informal semantics of dilute(Y,X1) is that Y and X1 are mixed together and form a single entity: the vaccine X.

(2) *upwards inheritance of a property in a part-of relation*: this inference rule says that:
if a constitutive part K1 of an object K has a property P (i.e. toxic), then (probably) the entire object K has P (is toxic for humans):
$has\_property(K1,P) \wedge part\_of(K1,K) \Rightarrow has\_property(K,P)$.

(3) since Y and X1 are parts of X, the statement says that Y is toxic for humans, then X is toxic for humans. Therefore, argument A1 has a negative orientation, due to the lexical property of *toxic*.

As a side-effect, from this conclusion, a general purpose rule such as 'humans must not ingest toxic products' can be induced. The concept 'ingest' refers to a class of verbs that includes, e.g. *eat, drink, inject, inhale*. This rule can be represented by:
$\forall X, P, human(X), product(P) \wedge has\_property(P,toxic) \Rightarrow \neg(inject(X,P))$

The global statement *The Ebola adjuvant is toxic for humans* **attacks the controversial issue**. This statement may also be interpreted as a **contrast to the controversial issue**: 'the vaccine is necessary BUT it is toxic'. According to the semantics of a contrast (e.g. (Winterstein 2012)), the second part of the contrast, Q, in: 'P but Q', wins without being in full contradiction with the controversial issue P.

### 4.3 Argument A2: *Seven persons died during the Ebola vaccine tests*

This statement reports deaths that occurred during tests. The 'die' events are related to the event 'test'. 'Die' has obviously a negative polarity. If we consider again the GL structure of vaccine(X), the 'test' activity is related to the agentive role. A readable axiomatization of the GL structure says:
*by definition, the agentive role is pre-telic: the events it describes occur before the functions or events given in the telic role. They lead to the creation or coming into*

*being of the concept. There are a priori no causal relations between these two sets of events besides this notion of creation.*
In more formal terms, where P and Q are predicates, and E event variables:
$\forall$ *P(E)* $\in$ *agentive-role,* $\forall$ *Q(E1)* $\in$ *telic-role, E* $\leqslant$ *E1* $\wedge$ $\neg$*(P* $\Rightarrow$ *Q).*
From that point of view, the statement A2 about tests does not say anything about the vaccine roles, functions and consequences once it has been fully tested and approved.

From an argumentation point of view, strictly speaking, Argument2 is **irrelevant or neutral w.r.t. the controversial issue** since tests fully precede injection. However, due to its very negative orientation it may be possible to say that it very weakly attacks (concession) the first interpretation of the issue: the vaccine must be developed, BUT tests are dangerous.

### 4.4 Argument A3: *Vaccine is important to avoid Ebola epidemic*

The main concept in this statement that motivates the vaccine is 'epidemic', its Qualia structure can be defined as follows, where X is the disease (Ebola in our example):
Epidemic(X):

$$\begin{bmatrix} \text{AGENTIVE: } \left[\text{CAUSE: LOW\_PREVENTION\_AGAINST(X)}\right], \\ \text{TELIC: } \left[\text{CONSEQUENCE: } (\textit{several}\ \text{Z, HUMAN(Z)} \wedge \text{INFECT(X, Z)} \Rightarrow \text{DISSEMINATION(X)})\right] \end{bmatrix}$$

Where X refers to ebola. Since epidemic is an event-denoting noun which is not volitional, the agentive role describes the cause of the epidemic. The functions in the telic role describe the related consequences. The typing given here allows to refine the functions of each of these roles.

If we consider that 'important' is a relational adjective whose arguments can be entities or events, then, roughly, argument A3 is represented by:
*important(vaccine(ebola), avoid(ebola epidemic)).*

To have an accurate representation, an informal quantification, 'several', has been added to the usual Qualia representation. Let us now analyze argument A3 from the Epidemic and Ebola Qualia representations:
(1) From epidemic, consequences are: $several$ *Z, human(Z)* $\wedge$ *infect(ebola, Z)*
(2) from Ebola, the predicate *infect(ebola, Z)* can be expanded using the causal chain given in the Ebola telic role:
$several$ *Z, human(Z)* $\wedge$ *infect(E1,ebola, Z)* $\Rightarrow$ $several$ *Z, human(Z)* $\wedge$ *get_sick(E2,Z)* $\Rightarrow$ $several$ *Z, human(Z)* $\wedge$ $\Diamond$ *die(E3,Z)* $\wedge$ *E1* $\leqslant$ *E2* $\leqslant$ *E3.*
(3) therefore, from the statement 'Ebola epidemic', *several Z, human(Z)* $\wedge$ $\Diamond$ *die(E3,Z)* is inferred. The conclusion is negative, derived from a lexical property of the verb 'die'.
(4) *avoid(Event)* reverses the orientation of the statement: *avoid(die(E3,Z))* is positively oriented,
(5) finally, the adjective 'important', applied to 'avoid' reinforces the strength of the orientation. It establishes the relation between the vaccine and its consequence:
*avoid(ebola epidemic).*
To conclude, from the statement structure and the polarity of its different elements, it follows that **Argument A3 is a strong support** to the event of vaccination, and therefore to the controversial issue. This example shows how the polarity of the argument is

gradually elaborated, compositionally, from the meaning of its components, following the syntactic structure of the sentence.

Argument A1 is also an attack of Argument A3: 'the ebola vaccine is important to avoid epidemic, BUT it is toxic for humans'.

### 4.5 Argument A4: *No one is infected by Ebola in Europe*

The representation of this statement is the following:
$\forall$ *Z, human(Z), in(Z,europe)* $\Rightarrow \neg$ *infect(E,ebola,Z)* .
(1) This representation is in contradiction with the initial predicate in the telic role of epidemic(ebola): *infect(E1,ebola,Z)*. It therefore does not entail the purposes or goals of epidemic(ebola) given in its telic role.
(2) Therefore, since there is no one infected by Ebola in Europe, from the telic role of epidemic, it follows that there is no dissemination at the moment and therefore, from the telic of vaccine, no need of this vaccine.
(3) Therefore, Argument A4 is an attack of the controversial issue, but with several restrictions: it is valid only in Europe and it relates a fact that occurs at the present time, which may be different in the future (this temporal consideration is difficult to express in the Qualia).
(4) Therefore, argument A4 only partially attacks the controversial issue, it is analyzed as a **contrast:** *vaccine is indeed necessary as a general principle, BUT since there are no cases in Europe at the moment it may not be necessary in Europe*.

### 4.6 Argument A5: *The vaccine is not always efficient: 3 vaccinated people died in Monrovia*

The higher-order adjective 'efficient' applies to the predicates in the telic role of vaccine:
*protect_from(X,Y,ebola)* $\Rightarrow$ *avoid(X, dissemination(X,ebola))*.
(1) Argument A5 means that among the patients Y that got vaccinated, a few of them got sick and died:
$\exists$ *Y, patient(Y), (inject(E1,X,vaccine(ebola),Y)* $\wedge$ *get_sick(E2,Y)* $\wedge$ *die(E3,Y))*.
(2) Then, the following proposition is inferred, from the semantics of protect:
$\neg$*(protect_from(X,Y,ebola)*.
which contradicts the purpose of vaccine(X).
(3) Argument A5 weakly attacks the controversial issue, which says that vaccines protect the population (with no exception). However, since the number of non protection cases is very limited, this statement is preferably **interpreted as a concession**:
*Vaccine protects the population HOWEVER there are a few cases where it does not work*.
The concession basically supports the controversial issue, but adds some restrictions that weaken the strength of the support.

### 4.7 Argument A6: *The vaccine is (too) expensive*

This last argument refers to a property of a vaccine: its cost. This property is defined in the constitutive role of artifacts. Argument A6 is represented for example as follows,

assuming the predicates *has_property* and *has_value*:
$vaccine(X) \wedge has\_property(X, cost) \wedge has\_value(cost, high)$.
Let us now investigate the orientation of A6 w.r.t. the controversial issue:
(1) A general purpose rule says that 'an object X that is expensive is not accessible to everyone':
$has\_property(X, cost) \wedge has\_value(cost, high) \Rightarrow \neg (\forall Y, human(Y) \wedge accessible\_to(X,Y))$.
(2) the controversial issue says that the vaccine is necessary. This is represented in 3.1. The predicate *inject(Z,X,Y)* presupposes that the vaccine is accessible, so that it can be injected, the modal 'necessary' presupposes that it is accessible to everyone:
$\forall X, vaccine(X) \Box (inject(Z,X,Y)) \Rightarrow \forall Y, human(Y) \wedge accessible\_to(X,Y)$.
(3) the representation in (1) is in contradiction with the presupposition in (2), therefore, argument A6 **attacks the controversial issue**. One may consider that argument A6 does not fully attack the controversial issue, but that the necessity that is evoked is difficult to realize: in that case it can be analyzed as a contrast. It would be a more clear attack with the adverb 'too' that indicates that the vaccination is difficult to be carried out.

### 4.8 Other arguments

the vaccine protects the future generations,

COMPOSITIONALITY issues to define orientation, scope, etc.

### 4.9 Summing up

The above examples have revealed various types of relations between arguments and the controversial issue, and between arguments:

- attack: arguments A1, A6
- support: argument A3,
- neutral or irrelevant: argument A2 (even if the topic is addressed)
- contrast: arguments A1, A4, A6
- concession: argument A5
- relations between arguments, e.g.: A1 attacks A3.

The analyses that are provided show that the boundaries between attacks, neutral, concession, contrasts and support are not very clearcut, and that there is a kind of continuum between them. They also show that attacks and supports may only concern some facets of the controversial issue.

The other main interest of this analysis is that, given a set of independent statements, coming from different origins, it is possible to precisely relate them (or not) to the main issue and to identify, for each of them, how they are related, their argumentative orientation and strength. This is realized by means of three main knowledge and reasoning sources:

- lexical knowledge: semantic features for lexical items, in particular polarity, e.g. for verbs (avoid), intensifiers (for adverbs), scales, etc.,

– domain knowledge: encoded via the formalism of the Generative Lexicon, via the Qualia structure, including event structures and causal chains that make the set of predicates in the roles more structured,
– reasoning: several types of inferences have been identified:
  1. inferences related to the semantics of the Qualia roles in the GL structure, e.g. agentive events occur before telic events and do not form a priori causal chains,
  2. inferences related to lexical semantics structures, e.g. the upward inheritance of properties for the part of relation, which is not as systematic than the downward one for the isa relation,
  3. inferences related to general purpose domain knowledge and to presuppositions,
  4. inferences dedicated to argumentation, that allow to compute relations and their strength between the controversial issue and the argument at stake. These are specific compositionality rules.

Finally, another challenge is to identify those strategy principles that indicate which rule or data must be triggered to analyze the relation between the potential argument at stake and the controversial issue.

## 5 Case Study B: *Has the political situation improved ?*

### 5.1 The controversial issue: *The political situation has improved.*

Let us now consider another type of situation that shows (1) the use of higher-order representations and (2) how the GL is used when relatively complex and abstract concepts are considered instead of concrete ones, as in Case Study A. The GL is clearly less efficient to represent abstract than concrete concepts, but this is a general trend for most knowledge representation systems. Nevertheless, several forms of inferences can be developed on a relatively superficial level of description.

The controversial issue is the following:
*The political situation has recently improved*.
The term 'situation' that heads the subject NP is a kind of support term, the main conceptual term of the NP is the adjective 'political'. 'Political situation' refers to the features of 'politics', which, in this statement, are said to have improved recently. The verb 'improve' is higher-order: it roughly means that the 'level of realization or satisfaction' of the properties of the telic of 'politics' have increased. This is obviously extremely difficult to measure in general.

At a coarse-grain level, political features can be summarized by the following Qualia structure, using a simplified logical form:
Politics:

$$\begin{bmatrix} \text{CONSTITUTIVE: } \begin{bmatrix} \text{POLITICAL\_PARTIES(P), EXECUTIVE\_FORCE(X),} \\ \text{LEGISLATIVE\_FORCE(Y), ...} \end{bmatrix}, \\ \text{TELIC: } \begin{bmatrix} \text{GUARANTEE(X, SAFETY\_OF(Z)), MANAGE(X,ENFORCEMENT\_OF(LAW)),} \\ \text{MANAGE(X,DEVELOPMENT\_OF(ECONOMY)), ...} \end{bmatrix}, \\ \text{AGENTIVE: } \begin{bmatrix} \text{ELECTION\_OF(Y), VOTE(Z,Y), CONFRONTATION\_BETWEEN(P)} \end{bmatrix} \end{bmatrix}.$$

In this Qualia, the agentive role describes, roughly, how a political party comes to power, the constitutive role describes the structure of power in a government while the telic role enumerates the different responsibilities a political party in power has, in other words its role or purpose. The variable Z represents the citizens. The predicates safety, enforcement and development are propositional terms to facilitate reading.

### 5.2 Argument B1: *less people get murdered every day*

The main predicate in this statement is the verb 'murder'. Let us see how verbs are represented in the Qualia:

murder(X,Y): $\begin{bmatrix} \text{AGENTIVE: } \left[\text{REASON: LACK\_OF(SAFETY\_OF(Y)), ...}\right], \\ \text{TELIC: } \begin{bmatrix} \text{PURPOSE: GET\_RID\_OF(X,Y), KILL(Y),} \\ \text{MEANS: USE(X,WEAPON), ...} \end{bmatrix} \end{bmatrix}$.

In this Qualia, the agentive role does not describe the agent of the murder but the reasons of the murder. This role may also contain e.g. presuppositions, facilitators, sources, etc. One of the reasons of 'murder' is a 'lack of safety', whatever it may cover.
(1) Let us first analyze 'people get murdered'. The causes of the murders are represented by the predicate: *lack_of(safety_of(Y))*.
(2) This predicate is in contradiction with the telic of 'politics' via the predicate: *guarantee(X,safety_of(Y))*.
Indeed, if *safety_of(Y)* is a property then *lack_of(safety_of(Y)* entails:
$for\_most$ *E,* $\neg$*(safety_of(E,Y))*.
On the other hand, *guarantee(Property)* means, roughly, 'Property satisfied to a high level: $for\_most$ *E, P(E) =* $for\_most$ *E, safety_of(E,Y)*, or, equivalently, very few instances of $\neg$*(safety_of(E, Y))*.
(3) So far, the statement is in opposition with the controversial issue because of the conflict between the predicates in the telic role,
(4) However, argument B2 says that 'less people get murdered', the quantifier 'less' applied to the proposition 'people get murdered' reverses the polarity of the expression since the number of situations of lack of safety decreases. B1 is then a **support of the controversial issue**. This example shows how the polarity of the argument is gradually elaborated, compositionally, from the meaning of its components.

### 5.3 Argument B2: *shops remain closed*

The telic role of 'politics' contains the predicate: *manage(X, development_of(economy))*.
Roughly, the telic of 'shop' is, for its 'activity' facet:
Shop(T):
$\left[\text{TELIC: } \left[\text{SELL(T,P,Y), BUY(T,P,Y), MAKE\_PROFIT(T), ...}\right]\right]$

The different predicates in the Telic of 'shop' are instances or a contribution to *development_of(economy)*. The verb 'closed', in its aspectual dimension, means that these economic activities do not occur. Therefore, B2 contradicts *development_of(economy)*.

**Then B2 attacks the controversial issue** since there is a lack of management of economy.

The argument **B3**: *corruption and favoritism have not decreased* is analyzed in a similar way, it concerns the predicate *manage(enforcement_of(law))* since corruption and favoritism are related to legal aspects, via their agentive role (what brings them about, i.e. lack of law enforcement). **B3 also attacks the controversial issue**.

### 5.4 Argument B4: *the police is less present in the streets*

This argument is more subtle. Its interpretation is ambiguous. The Qualia structure of Police is, e.g.:

Police(Z):

$$\begin{bmatrix} \text{TELIC: } \left[\text{CONTROL(Z,SAFETY\_OF(Y)), PREVENT(Z,CORRUPTION), ...}\right] \\ \text{AGENTIVE: } \left[\text{POLITICAL FORCE}\right] \end{bmatrix}$$

The statement 'less present in the streets' means that the police has a lower degree of activity concerning its telic aspects, in particular safety controls. This statement can be interpreted in two opposite ways which can be paraphrased as follows:
(1) there is less need of control, therefore, the safety situation has improved. **This interpretation supports the controversial issue**.
(2) the police is less committed and safety is less controlled, therefore the safety situation has probably worsened. **This second interpretation attacks the controversial issue**.

### 5.5 Summing Up

In this second case study, we have explored a controversial issue and a small sample of its related arguments, as found in news. Concepts which are referred to are less concrete than in the case study 1. As a result, the semantic representations in the Qualia are relatively superficial but seem to be well-tuned for our purpose. Our analysis shows different typings in the Qualia, and the orientation towards events and action of the controversial issue shows how action verbs can be represented and the limits of the system.

The arguments considered in this case study involve relatively simple inferences compared to the case study 1. Argument B4 shows a case of ambiguity leading to either a support or an attack.

## 6 Perspectives: Moving Towards Real Applications

We have presented above a linguistic analysis and a proposal for argument mining where knowledge and inference is needed to identify arguments and to characterize the way they behave w.r.t. a controversial issue. There is now a long way to develop

a system that can automatically detect and analyze these arguments from various text sources.

The major challenges include the development of lexical resources, Qualia structures, an in-depth characterization of the inferential patterns that have been advocated above and the development of processing strategies capable of efficiently selecting the appropriate data and inferential patterns.

### 6.1 Experiments on various test cases

Dbuter par le corpus: ensemble de textes, annoter (mta donnes en plus) pour montrer le problme. lister les grandes questions (voir research questions). Orienter le travail sur une base linguistique, un peu TALN, pa strop car de nombreuses questions (stratgies, faisabilit, scalability, ressources, etc.).

ensuite montrer par tude les besoins en ressources. Plus stats sur ce que l'on observe: diffrentes orientations, diff types d'args, recouvrements, etc.

In the above two case studies, relatively direct arguments have been considered. By direct we mean that they argue for against the issue itself. Most of the arguments fall in this class. However, arguments can also attack or support principles on which the issue is build. For example, for the Case study 1, we have:

- Personal decision: *everyone is free to have the vaccine injected or not (therapeutic freedom principle)*,

- temporal variability of the statement: *there are now less cases in Africa*,

- debatable character of information sources on which the statement is based: *statistics are false, efficiency is evaluated by producer*.

We constructed four corpus from four independent controversial issues. The first task was to annotate statements in each of the corpus. Annotations mainly include: text span involved, polarity of argument, direct or indirect relation with the issue (i.e. knowledge is needed or not to identify the argument), main concepts involed in the indirect case, strength of argument. The corpus is characterized as follows:

| Controversial issue | Corpus size (short texts) | number of annotated arguments (no overlap) |
|---|---|---|
| Ebola vaccination | 16 texts, 3300 words | 50 |
| Women's condition in India | 9 texts, 3600 words | 24 |
| Development of nuclear plants | 7 texts, 2800 words | 31 |
| Organic agriculture is the future | 19 texts, 3800 words | 17 |
| Total | 51 texts, 13500 words | 122 |

Table 1. Four controversial issues.

From a manual analysis, the following argument polarity distribution is observed over the 122 annotated arguments:

| Attacks | Supports | Concessions | Contrasts | Ambiguous |
|---|---|---|---|---|
| 51 | 32 | 17 | 18 | 4 |

Table 2. Polarity distribution.

The corpus is relatively modest, however it shows a tendency to argue against the issue (attacks and contrasts = 57%, supports and concessions = 40%).

annotation: quels attributs (polarit, concepts concerns dans issue par arg, etc.)

stats sur ce qui est concern, arg direct/indirect, connaissances utiles (dans corpus dev.).

nb of concepts/words involved (about), nbre arguments pas identifs sans connaissances ?

Case 1: number of arguments, experiments,

Other cases: how many, size, themes, diversity, make a chart ?

### 6.2 Lexical resources development

### 6.3 Specification and Scalability of Qualia Structures

### 6.4 Inference typology and implementation issues

## 7 Conclusions

REVOIR The experiments presented in this paper are preliminary, but they show some challenges and possible tracks to reach an efficient and expressive argument mining system. To go from the previous use-cases to a real argument mining application, several points are challenging and need to be considered in depth, among which: the definition of GL Qualia structures on a relatively large scale (scalability of knowledge and lexical data), the specification of the various types of inferences which have been presented, and, finally, strategy issues: how the Qualia structure data and the inferences are triggered. What are the principles that govern such a system?

Our preliminary investigations tend to show that the number of Qualia structures for a given domain such as vaccination is not very large, around 50 to 70 structures, which is feasible by hand given a domain ontology of predicates, functions and constants. Lexical semantics data need to be specialized for argumentation such as polarity. The most complex task is to identify, categorize and structure the different types of inferences which may occur in the argument mining process. Besides the categorization of inferences, another challenge is the definition of an adequate and generic processing strategy, as developed in TextCoop (Saint-Dizier, 2012), that is able to trigger inferences in an efficient and relevant way.

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