Automatic Detection of Temporal Information in Ukrainian General-language Texts

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Abstract. Temporal information provides important and precise indications on facts and events. Yet, when automatically processing unstructured documents, it may be complicated to extract temporality-related information. Besides, such tools are not available for many languages. We propose to adapt an existing tool for the automatic detection and annotation of temporal information in Ukrainian. The tool is rule-based. It permits to detects temporal expressions, be they absolute or relative, and to normalize them. We test the adapted tool on two corpora from different genres and evaluate the results.

Keywords: Natural Language Processing, Temporality, Information Extraction

1   Introduction

Unstructured documents are the most common source of information, and they may represent the majority of information available on a particular question and domain. For instance, in the biomedical area, several documents are unstructured, such as clinical discharge summaries, scientific literature, patient brochures, informed consents, or clinical trial protocols. The situation is similar in other areas (law, energy, economics, politics, history, etc.). Hence, when working with unstructured narrative texts, the process is very demanding on automatic methods for detecting, extracting, formalizing and organizing information contained in these documents. Information extraction (IE), which is part of Natural Language Processing (NLP), proposes such methods and aims at detecting and extracting relevant pieces of information from textual data. Different types of information can be searched, such as (1) entities and events, which are traditionally detected thanks to the exploitation of terminological resources and thesauri, when available. The process is dedicated to the recognition of terms and is a very challenging issue related to the computing of variants of these terms in documents [14, 12, 2, 16, 6]; (2) or detection and extraction of contextual information, such as temporality related to the concepts. If the detection of entities and events provides factual information, extraction of contextual data permits to de-

scribe these facts with more detail. For instance, examples (1) to (7) below contain precise contextual temporal information on various events. Temporal information is important for several tasks and areas, as it allows to structure the entities and events according to their chronological occurrence. This is important in several situations. For instance, in historical studies, the events are usually ordered and then taught and studied in this order; in medical area, events related to a given patient may be ordered and thus provide a clearer view of his disease and its evolution. As a matter of fact, temporality has become an important research field in the NLP domain and several challenges addressed this task up to now, such as: ACE [1], SemEval [23, 24, 22], I2B2 2012 [21].

In our work, we propose to contribute to this research and to concentrate on the description of temporal information and on its automatic detection and annotation in Ukrainian. This implies that we have to design suitable methods, resources and tools for this language.

In what follows, we first present some related work (Sec. 2). We then precise our objectives (Sec. 3), introduce the material used (Sec. 4) and the proposed method (Sec. 5). Our results and their discussion are presented in Section 6. Finally, we conclude with some directions for future work (Sec. 7).

2   Related Work

Work on temporal information relies on three important steps when processing unstructured narrative documents: identification of linguistic expressions that are indicative of the temporality and their normalization [23, 5, 19, 10], and modeling and chaining of temporal information [3, 13, 15, 21, 7]. Identification of temporal expressions, which corresponds to the first step, provides basic knowledge for further tasks aiming at the processing of the temporality. The existing available automatic systems such as HeidelTime [19] or SUTIME [5] exploit rule-based approaches, which makes them adaptable to new data, areas, and languages. Such tools usually encode temporal information with the TimeML standard.

TimeML[1][15] is an annotation standard for temporal expressions proposed in 2010. Since then, it has became the reference for encoding temporal information in different languages. For instance, it has been used in several contexts: for encoding temporal data in challenge corpora such as TempEval [24, 22, 4] and I2B2 [21], for preparing corpora[2] annotated with temporal expressions such as TimeBank, TempEval, I2B2 and Clinical TempEval corpora.

TimeML offers the possibility to encode several types of temporal information and expressions (i.e. TIMEX3 tags):

1. Expressions of dates, time, durations or sets (attribute types). Dates and time are represented according to the ISO-8601 norm. Examples below present these types of temporal information:

   (1)   *Корабель Аполлон-11 стартував 16 липня 1969 о 13 годині 32 хвилини за*

Грінвічем. (The Apollo-11 ship took off at <u>1:32 pm GMT</u> on 7/16/1969.) (date and time)

(2) *Протягом <u>трьох годин</u>, поки налагоджували зв'язок із Москвою, Гагарін давав інтерв'ю і фотографувався. (<u>During three hours</u>, while establishing communication with Moscow, Gagarin was interviewed and photographed.)* (duration)

(3) *Корейська війна – збройний конфлікт між Корейською Народно-Демократичною Республікою та Південною Кореєю, який тривав з <u>25 червня 1950 року</u> до <u>27 липня 1953 р</u>. (Korean war is an armed conflict between Democratic People's Republic of Korea and South Korea, which lasted from <u>25th of June 1950</u> up to <u>27th of July 1953</u>.)* (duration)

(4) *В екваторіальному та тропічному поясі приплими і відпливи здебільшого повторюються <u>двічі на добу</u>. (In the equatorial and tropical areas, high and low tides mostly occur <u>twice a day</u>.)* (set)

(5) *Тривали <u>118 років</u>, з примиренням. (Lasted for <u>118 years</u>, including armistices.)* (duration)

(6) *До <u>середини 260-х до н.е.</u> Римська республіка остаточно підпорядкувала собі Апеннінський півострів. (By <u>the mid of 260 BC</u>, the Roman Republic had gained control of the Italian peninsula.)* (date)

(7) *Основним джерелом з історії греко-перських воєн є «Історія» Геродота, що містить опис подій до <u>478 до н.е. включно</u>. ("The Histories" by Herodotus, which contains description of events up to 478 BC, is the main source on history of the Greco-Persian Wars.)* (date)

2. ISO-normalized forms of the expressions (attribute value), such as in (from examples above):

— *16 липня 1969* о *13 годині 32 хвилини* ⇒ 1969-07-16T 13:32:00
— *трьох годин* ⇒ P3H
— *двічі на добу* ⇒ P1D

3. Quantity and frequency of the set expressions (attributes quant or freq), such as in this expression of frequency:

— *двічі на добу* ⇒ 2X

4. Begin and end anchors for durations (beginpoint and endpoint attributes). For instance, in Example (3), the begin anchor is *25th of June 1950* and the end anchor is *27th of July 1953*. The implicit duration is 3 years, 1 month and 2 days, which is normalized in P3Y1M2D.

5. Temporal modifiers, which have been introduced in order to annotate changed or clarified temporal expressions. For instance, in Example (6), the date *260 до н.е.* is changed by *середини*, which is the date modifier attribute MID.

In addition to the annotation of temporal expressions, TimeML also allows to describe events as well as relations between temporal expressions and/or events. In this paper, we only focus on the annotation of temporal expressions (TIMEX3) related to dates and durations. Description and detection of other temporal information will addressed in later work.

3   Objectives

The purpose of our work is to automatically detect and annotate temporal expressions in corpora in Ukrainian language. We aim particularly at the description of dates and durations, such as in Examples (1)-(3) and (5)-(7). During a preliminary study, we tested several existing systems for identification of temporal expressions and found out that HeidelTime [19] has the best combination of performance and adaptability. We propose to exploit this automatic system, to adapt it and to test it on general-language texts in Ukrainian.

4   Material

We use two types of texts from two different genres: newspaper and encyclopedic articles. Both of them have the potential to contain temporal information.

4.1   Newspaper articles

Newspaper articles are obtained from the online news journal from Ukraine Україн-ська правда[3] (*Ukrainian truth*). This journal covers any news related to the events which happen in Ukraine and also to the events which happen in other places but which may be important to Ukraine. The journal has been founded in 2010 and shows good popularity and objectivity. The main interest in using this type of articles is that they typically contain dates associated to events. We use 40 articles (over 31,000 word occurrences) for the development of the system and 40 articles (over 35,000 word occurrences) for its tests and evaluation.

4.2   Encyclopedic articles

Encyclopedic articles are obtained from the Wikipedia resource[4], which is a free and collaborative resource. This encyclopedia contains information on a great variety of topics. We have chosen to work with the articles related to wars, as part of the Wiki-Wars corpus[5] [11]. This corpus is a collection of texts issued from Wikipedia articles. These texts describe the course of the most famous wars in history, including the biggest wars that happened in the 20th century. The corpus contains 22 articles (such as WW1, WW2, Vietnamese war, Russo-Japanese war, or Punic wars). The main interest in working with these articles is that they contain several dates, as they are typically associated with battles, meetings, armistices, etc. The initial project contains articles in English. It has been extended to three other languages (German, Vietnamese and Croatian) [18, 9]. For our work, we compiled the corpus with the corresponding articles in Ukrainian (66,474 word occurrences). The articles have been collected similarly to the building of the original WikiWars corpus. Hence, we use these 22

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[3] https://www.pravda.com.ua/news/
[4] https://uk.wikipedia.org
[5] http://timexportal.wikidot.com/wikiwars

articles (66,479 word occurrences) for the evaluation of the automatic system.

5   Methods

The methods are composed of several steps: pre-processing of texts, adaptation of *HeidelTime* to Ukrainian, and evaluation of the automatic annotations.

5.1   Pre-processing

All source documents are in the *html* format because they are obtained from online resources. The documents are converted in the text format. The characters are encoded with the UTF-8 characterset.

5.2   Adaptation of *HeidelTime*

HeidelTime is a cross-domain temporal tagger that extracts temporal expressions from documents and normalizes them according to the TIMEX3 annotation standard, which is part of the markup language TimeML [15]. This is a rule-based system. Because the source code and the resources (patterns, normalization information, and rules) are strictly separated, it is possible to develop and implement resources for additional languages and areas using *HeidelTime* rule syntax. *HeidelTime* is provided with modules for processing documents in several languages (English, French, Italian, Spanish...). Recently, an attempt has been made to extend it to over 200 other languages using existing multilingual resources [20], and more particularly Wiktionary[6], which provides data for 170 languages. Ukrainian is part of the languages which has been added to the system. Exploitation of this automatically built system produced no results when applied to the Ukrainian data: fully automatic collection of suitable resources is a complicated task. Even if it permits to go faster, it still requires human processing for the validation, disambiguation and enrichment of the resources, as well as the setting of the normalization process.

Hence, adaptation of the *HeidelTime* resources to Ukrainian is the main step of the current work. The detection and normalization of temporal information by *HeidelTime* relies on three kinds of resources:

— linguistic patterns, which describe linguistic elements of the temporality (days of the week, months, numbers, etc.). This type of resources is used for the detection of temporality in texts;
— normalization resources, which are created to permit the normalization of the detected elements. In this way, all the detected units are normalized. Thanks to these resources, normalization can be performed for absolute (Example (8)) and relative (Example (9)) dates, durations and sets. Thus, the normalized values of Examples (8) and (9) are 2015-05-07 and 2017-05-09, respectively if we consider that these two dates are related;
— rules for composing more sophisticated detection of temporality, such as periods,

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[6] https://www.wiktionary.org/

intervals and specific expressions.

(8) *7 травня 2015 року. (May 7th, 2015.)*
(9) *Через два дні. (Two days later.)*

5.3   Evaluation of automatic annotation

A subset of the corpus (22 newspaper articles) is used for the development and tuning of *HeidelTime*. The rest of the corpus is used for the evaluation. For all the processed document, we used the default parameters, namely no postagger and the type of document are considered as narrative which leads to solve relative dates regarding the previous absolute date. The results generated are evaluated manually with two classical evaluation measures [17]: true positives *TP*: number of correctly extracted or normalized temporal expressions; precision *P*: percentage of the relevant temporal expressions extracted and normalized divided by the total number of the temporal expressions extracted and normalized.

6   Results and Discussion

Table 1. Precision (*P*) for the detection and normalization of temporal expressions obtained on development and test sets in the two processed corpora (newspaper and encyclopedia). *TP* is the number of date correctly identified or normalized.

| | Development | | | | Test | | | | |
| | | Detection | | Normalization | | | Detection | | Normalization | |
	total	*TP*	*P*	*TP*	*P*	*total*	*TP*	*P*	*TP*	*P*
Newspaper	655	598	91.30	571	87.18	703	635	90.33	622	88.48
Encyclopedia	-	-	-	-	-	2.226	1.918	86.16	1.745	78.39

In Table 1, we present the evaluation results obtained on the two processed corpora. The results are indicated in terms of true positives *TP* and precision *P*. We also indicate the total number of temporal expressions occurring in each corpus (*total*).

The system was adapted to Ukrainian on a subset of newspaper articles. We can see that the results obtained on the two subsets of newspaper corpus are comparable and close to 90% precision. This is a very good performance for the first version of the system. Besides, when working with newspaper articles, both detection and normalization show good results. Transposition of the system on another genre, encyclopedia articles, permits to test the same system on different data. As we can see, the results are slightly lower, especially for the normalization. For the detection, we keep the precision values high (86%), while the normalization process is more complicated: it shows 78% precision. By comparison with similar work in other languages [8], we obtain higher results in French (0.90-0.95 precision) and lower in English (0.80-0.85 precision). We will illustrate below typical cases of success and failure of the system.

Examples below illustrate successful annotation of temporal values and of their normalization. In these examples, the TIMEX3 values are annotated in the XML for-

mat, which is the native format of *HeidelTime*. We present here examples for dates and durations and explain them. Our main interest is to show the results obtained when normalizing relative, ambiguous or imprecise expressions:

— *<TIMEX3 type = "DATE" value = "2017-03-01"> 1 березня 2017 </TIMEX3> ... У <TIMEX3 type = "DATE" value = "2016-09"> вересні </TIMEX3> керівник Спеціалізованої антикорупційної прокуратури Назар Холодницький заявив, що Чаус перебуває в анексованому Росією Криму...<TIMEX3 type = "DATE" value = "2016-11-11"> 11 листопада </TIMEX3> Інтерпол оголосив Чауса в міжнародний розшук.* In this example, the starting date 2017-03-01 is first recorded by the system. Then, the next two dates (2016-09 and 2016-11-11) are positioned during the previous year, which is correct. This example illustrates the possibility of the system to disambiguate the chronology of event seven if the year soft he events are not indicated precisely.

— *S&P прогнозує зростання ВВП Українина 1,9% <TIMEX3 type = "DATE" value = "2017"> цього року </TIMEX3>.* Similarly to previous example, the system records that the current year is 2017 and can disambiguate expression *цього року* (*this year*) through its correct normalization.

— *<TIMEX3 type = "DATE" value = "XXXX-XX-XX"> Середа </TIMEX3>, <TIMEX3 type = "DATE" value = "2017-03-08"> 8 березня 2017 </TIMEX3>. ...Про це повідомив генпрокурор Юрій Луценко у <TIMEX3 type = "DATE" value = "2017-03-08"> середу </TIMEX3> в Facebook.* In this example, the system can normalize the date by referring it to the day of week *Середа* (*Wednesday*).

— *S&P: за <TIMEX3 type = "DURATION" value = "P3Y"> три роки </TIMEX3> Україна повинна віддати 20 мільярдів доларів боргів.* This sentence provides an example of the detection and normalization of durations.

— *запобіжний захід у вигляді арешту на <TIMEX3 type = "DURATION" value = "P60D"> 60 діб </TIMEX3>.* This is another example of the detection and normalization of durations.

We have also found several cases in which the system is not successful, such as those presented below:

— *радник президента США з національної безпеки Майкл Флінн подав у відставку <TIMEX3 type = "TIME" value = "2017-02-24TEV"> ввечері </TIMEX3> <TIMEX3 type = "DATE" value = "2017-02-13"> 13 лютого </TIMEX3>.* This is a typical example of temporal expressions in which the normalization process may fail. Here, the right normalization value is 2017-02-13. Yet, for the normalization of the first part of the expression *ввечері* (*in the evening*), the systems exploits the last date recorded, which is 2017-02-24. Such temporal expressions are very frequent in the encyclopedia corpus since several military actions are happening in the evening. For mending this kind of errors, more sophisticated patterns and rules will be created.

— *У <TIMEX3 type = "TIME" value = "1776-12-07TNI"> ніч </TIMEX3> з 25 на <TIMEX3 type = "DATE" value = "1776-12-26"> 26 грудня </TIMEX3> крадькома перетнув Делавер I розбив британський загін у битві біля Трентона, захопивши майже 1000 здивованих I неукріплених гессенських найманців.* This example is similar to the previous example, but the situation is

more complicated because we have in addition the interval of dates *з 25 на 26 грудня* (*from December 25th to 26th*). As we can see, currently we did not fit the system to the detection of intervals and usually only the last date is detected. This is the main source of current errors as the intervals are very frequent in presentation of historical and political information. They frequently occur in both corpora processed. Description and encoding of intervals will be added to the system in future.

— *Уряд планує додати до пенсій від 200 до <TIMEX3 type = "DATE" value = "1000"> 1000 </TIMEX3> гривень.* Here, the system detects wrong information because of the preposition *до* (*up to*), which can also have temporal meaning, followed by numbers *1000*, yet not related to the temporality. This kind of errors can be reduced with the creation of specific exception patterns and rules.

— *У спробах полегшити тиск з <TIMEX3 type = "TIME" value = "1967-06-12T 24:00"> півночі </TIMEX3>, <TIMEX3 type = "DATE" value = "1967-08-09"> 9 серпня </TIMEX3> мобільна бригада армії Біафри у складі 3000 осіб за підтримки артилерії та бронемашин переправилася на західний берег Нігера.* In this example, we can see that the word *півночі* is ambiguous as it can mean *midnight* and *north*. This temporality marker causes several errors in the processed corpora. Its disambiguation will need additional analysis of texts, as pre-processing or post-processing step.

These are certainly the main detection and normalization errors which we can find in the corpora processed. Another difficulty which we currently face is related to very specific temporal expressions. The system does not take them into account, which causes several silences (false negatives) in the output. They will be described and encoded in our future work. Here are some example:

— Relative temporal expressions like *в той же день, цього ж дня (the same day, that day)*;
— Specific temporal expressions like *За минулий з тих пір місяць (during the month that passed since)*;
— Specific forms for expressing the temporality (combination of numbers and characters) like *21-го століття, на початку 1990-х років (XXI century, at the beginning of 1990s)*;
— Specific calendars like the one introduced during the French revolution. *На вимогу Робесп'єра 14 фрімера другого року (<TIMEX3 type = "DATE" value ="1793-12-04"> 4 грудня 1793 </TIMEX3>) був організований уряд із винятковими повноваженнями.* In this example, the system correctly detects and normalizes *4 грудня 1793*, but is not sensible to *14 фрімера другого року (14 of Frimaire of the second year)*. For such cases, additional resources must be created, so that their detection, conversion and normalization become possible.

7   Conclusion and Future Work

We presented our work on creation of automatic system for the detection and normalization of temporal information in Ukrainian. In information extraction applications, temporal information is indeed important. For performing this task, we pro-

posed to use an existing tool *HeidelTime*. This system has undergone automatic adaptation of its resources to Ukrainian but this showed to be not efficient: the system produced no results with these resources. Hence, the main purpose of our work was to create the suitable resources.

We used two corpora from two genres (newspaper and encyclopedia). 22 newspaper articles were used to develop the system. The rest of our data was used for the tests. Encyclopedia articles correspond to the WikiWars project. The Ukrainian WikiWars corpus has been compiled for our study. The evaluation of the system shows that up to 90% of temporal units in newspaper articles are detected and normalized correctly. In encyclopedia articles, the detection shows 86% precision and the normalization 78% precision. We also present and discuss some examples of the current failures of the system.

In future, the system will be further developed and fitted to Ukrainian, so that it detects and normalizes other temporal expressions. It will be made freely available to the research community. Besides, the two used corpora will be fully annotated with temporal expressions and also made freely available to the research community.

References

1. ACE challenge: The ACE 2004 evaluation plan. evaluation of the recognition of ace entities, ace relations and ace events. Tech. rep., ACE challenge (2004), http://www.itl.nist.gov/iad/mig/tests/ace/2004
2. Bashyam, V., Taira, R.K.: Indexing anatomical phrases in neuro-radiology reports to the UMLS 2005aa. In: Ann Symp Am Med Inform Assoc (AMIA). pp. 26-30 (2006)
3. Batal, I., Sacchi, L., Bellazzi, R., Hauskrecht, M.: A temporal abstraction framework for classifying clinical temporal data. In: Ann Symp Am Med Inform Assoc (AMIA). pp. 29-33(2009)
4. Bethard, S., Savova, G., Palmer, M., Pustejovsky, J.: Semeval-2017 task 12: Clinical tempeval. In: Int Workshop on Semantic Evaluation (SemEval-2017). pp. 565-572. Association for Computational Linguistics, Vancouver, Canada (August2017)
5. Chang, A.X., Manning, C.D.: SUTIME: A library for recognizing and normalizing time expressions. In: LREC. pp. 3735-3740(2012)
6. Davis, N., Harlema, H., Gaizauskas, R., Guo, Y., Ghanem, M., Barnwell, T., Guo, Y., Ratcliffe, J.: Three approaches to GO-tagging biomedical abstracts. In: Hahn, U., Poprat, M. (eds.) SMBM. pp. 21-28. Jena, Germany(2006)
7. Grouin, C., Grabar, N., Hamon, T., Rosset, S., Tannier, X., Zweigenbaum, P.: Hybrid approaches to represent the clinical patient's timeline. J Am Med Inform Assoc 20(5), 820-7(2013)
8. Hamon, T., Grabar, N.: Tuning heideltime for identifying time expressions in clinical texts in english and french. In: EACL Workshop Louhi on HealthText Mining and Inform Analysis. pp. 101-105. Goteborg, Sweden (2014)
9. Jeong, Y.S., Joo, W.T., Do, H.W., Lim, C.G., Choi, K.S., Choi, H.J.: Korean timeml and Korean timebank. In:Chair), N.C.C., Choukri,K., Declerck, T., Goggi, S., Grobelnik, M., Maegaard, B., Mariani, J., Mazo, H., Moreno, A., Odijk, J., Piperidis, S.(eds.) Proceedings of the Tenth International Conference on Language Resources and Evaluation (LREC 2016). European Language

Resources Association (ELRA), Paris, France (may 2016)

10. Kessler, R., Tannier, X., Hagege, C., Moriceau, V., Bittar, A.: Finding salient dates for building thematic timelines. In: Annual Meeting of the Association for Computational Linguistics. pp. 730-739 (2012)

11. Mazur, P., Dale, R.: WikiWars: A new corpus for research on temporal expressions. In: Int Conf on Empirical Methods in Natural Language Processing. pp. 913-922 (2010)

12. Mercer, R.E., Di Marco, C.: A design methodology for a biomedical literature indexing tool using the rhetoric of science. In: HLT-NAACL 2004, Workshop Biolink. pp. 77-84 (2004)

13. Moskovitch, R., Shahar, Y.: Medical temporal-knowledge discovery via temporal abstraction. In: Ann Symp Am Med Inform Assoc (AMIA). pp. 452-456 (2009)

14. Nadkarni, P., Chen, R., Brandt, C.: Umls concept indexing for production databases: a feasibility study. J Am Med Inform Assoc 8(1), 80-91 (2001)

15. Pustejovsky, J., Lee, K., Bunt, H., Romary, L.: ISO-TimeML: An international standard for semantic annotation. In: Chair), N.C.C., Choukri, K., Maegaard, B., Mariani, J., Odijk, J., Piperidis, S., Rosner, M., Tapias, D. (eds.) Int Conf Language Resources and Evaluation (LREC'10). European Language Resources Association (ELRA), Valletta, Malta (may 2010)

16. Schulz, S., Hahn, U.: Morpheme-based, cross-lingual indexing for medical document retrieval. Int J Med Inform 58-59, 87-99 (2000)

17. Sebastiani, F.: Machine learning in automated text categorization. ACM Computing Surveys 34(1), 1-47(2002)

18. Strötgen, J., Gertz, M.: Wikiwarsde: A german corpus of narratives annotated with temporal expressions. In: Conf of the German Society for Comp Linguistics and Language Technology (GSCL 2011). pp. 129-134. Hamburg, Germany (September 2011)

19. Strötgen, J., Gertz, M.: Temporal tagging on different domains: Challenges, strategies, and gold standards. In: Int Conf on Language Resources and Evaluation. pp. 374-3753. ELRA (2012)

20. Strötgen, J., Gertz, M.: A baseline temporal tagger for all languages. In: Int Conf on Empirical Methods in Natural Language Processing. pp. 541-547. ACL (2015)

21. Sun, W., Rumshisky, A., Uzuner, Ö.: Evaluating temporal relations in clinical text: 2012 i2b2 challenge. JAMIA 20(5), 806-813 (2013)

22. UzZaman, N., Llorens, H., Derczynski, L., Allen, J., Verhagen, M., Pustejovsky, J.: Semeval-2013 task 1: Tempeval-3: Evaluating time expressions, events, and temporal relations. In: Int Workshop on Semantic Evaluation (SemEval2013). pp. 1-9. Atlanta, Georgia, USA (June 2013), http://www.aclweb.org/anthology/ S13-2001

23. Verhagen, M., Gaizauskas, R., Schilder, F., Hepple, M., Katz, G., Pustejovsky, J.: Semeval-2007 task 15: Tempeval temporal relation identification. In: Int Workshop on Semantic Evaluations (SemEval-2007). pp. 7580. Prague, Czech Republic (June 2007), http://www.aclweb.org/anthology/S/S07/S07-1014

24. Verhagen, M., Sauri, R., Caselli, T., Pustejovsky, J.: Semeval-2010 task 13: Tempeval-2. In: Int Workshop on Semantic Evaluation. pp. 57-62. Uppsala, Sweden (July 2010), http://www.aclweb.org/anthology/S10-1010