Investigation of indeterminacy of temporal information in clinical narratives based on linguistic features

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Introduction

Despite the importance, making use of temporal information in the biomedical informatics field is highly limited because of the indeterminacy of temporal expressions. Suppose a sentence such as *"she suffered from a migraine a week ago."* Even though the patient could have had a migraine exactly seven days ago, it is also very likely that the patient suffered six or eight days ago. In other words, temporal expressions rarely guarantee to correspond to the exact time points they refer to. This study aims to investigate how indeterminacy of temporal information varies depending on linguistic features – event class, part of speech of event expressions, time granularity and relation type between event and time. The indeterminacy of temporal information was measured in terms of interval, which is the range of dates when the event could have occurred, and fuzziness, which measures the possibility of the event at the endpoints of the range.

Methods

EXTRACT SENTENCES WITH TEMPORAL EXPRESSIONS AND ANNOTATE WITH LINGUISTIC FEATURES

Using the MIMIC-III (v1.4) database[1], 42,329 sentences from clinical records with temporal expressions (day, week, and month) were extracted. With TARSQI Toolkit[2], each sentence was annotated with event class, part of speech (POS) of words that describe medical events, granularity of temporal expression and relation type between event and time. For simplicity's sake, we extracted 566 sentences where only one time, event and relation type are marked. Finally, 38 sentences with unique events were selected as stimuli. Examples of stimuli are provided in **Table 1**.

Sentences	Event class	POS	Granularity	Relation_Type
Low lung volumes are **stable** since **four days ago**.	STATE	JJ	day	BEGUN_BY
Former tobacco **use** until **2 months ago**.	OCCURRENCE	NN	month	ENDED_BY
She recently **assaulted** about **3 weeks ago** per records	OCCURRENCE	VBN	week	IS_INCLUDED
He was **asymptomatic** until **last week**.	STATE	JJ	week	ENDED_BY

Table 1. Examples of stimuli and their annotated features. The event and time expressions are italicized.

BEHAVIORAL EXPERIMENT WITH CLINICIANS

Four clinicians participated in the task. Given an interface (**Figure 1.**), participants were asked to adjust interval slider so as to indicate a range of dates in which the event could have occurred and to adjust fuzziness slider so as to indicate the possibility of the event at the endpoints of the range. 19 sentences were given to each participant. The scope of interval ranged from 2 to 60 days without the one of fuzziness ranged from 0 to 100 at an interval of 10.

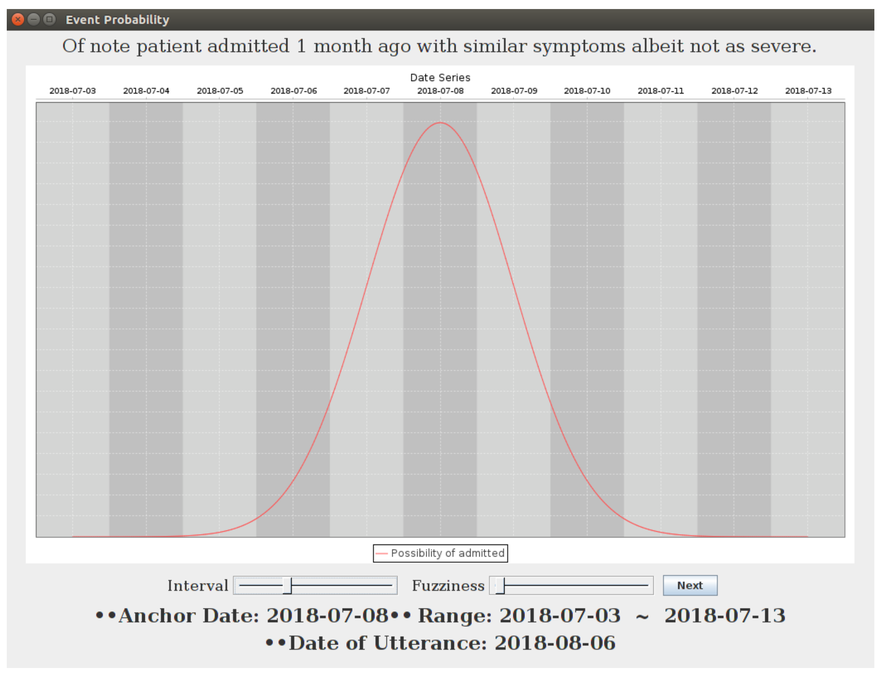

Figure 1. Experimental interface with which participants are provided to measure interval and fuzziness

STATISTICAL ANALYSIS

To see whether the indeterminacy values differ among types of linguistic features, descriptive analysis and inferential analysis (multiple one-way ANOVAs) were conducted.

Results

DESCRIPTIVE ANALYSIS

Mean values of interval and fuzziness of temporal expressions were compared by types of each feature. The result is provided in **Table 2.**

	EVENT_CLASS				
	OCCURR-ENCE	I_ACTION	STATE	ASPECTUAL	PERCEP-TION
INTERVAL	14.24	7	5.5	22.57	7
FUZZINESS	26.8	20	25	34.28	40

	PART_OF_SPEECH						
	JJ	NN	VBD	VBG	VBN	VBP	VBZ
INTERVAL	5.5	20	16.54	13	11.46	27	24
FUZZINESS	25	22	33.85	20	30.77	0	0

	GRANULARITY		
	MONTH	WEEK	DAY
INTERVAL	34.1	9	4.7
FUZZINESS	43	30.56	9

	RELATION_TYPE		
	IS_INCLUDED	BEGUN_BY	ENDED_BY
INTERVAL	15.3	5.75	30..33
FUZZINESS	32.22	15	26.67

Table 2. Values of interval and fuzziness in each type of linguistic features

INFERENTIAL ANALYSIS

Time granularity had significant effects on interval ($F(2, 54 = 30.48)$, $p < 0.001$) and fuzziness ($F(2, 54) = 12.55$, $p < 0.001$). Relation type of event and time also had significant effects on interval ($F(2, 54) = 4.643$, $p < 0.05$) and fuzziness ($F(2, 54) = 3.537$, $p < 0.05$). Event class and part-of-speech(POS) of words describing events showed no effects both on interval and on fuzziness.

Conclusion

The result shows that indeterminacy of temporal expressions, which is measured in terms of interval and fuzziness, varies a lot depending on types of linguistic features. This implies that linguistic features could be important factors which can predict the degree of indeterminacy of temporal expression in clinical narratives, facilitating the use of temporal information in Biomedical Informatics.

References

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