

Surprisal and Satisfaction: Towards an Information-theoretic Characterization of Presuppositions with a Diachronic Application

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Abstract

The paper offers a pilot study concerned with presuppositions in historical data, which are identified and annotated on the basis of six triggers, viz. three for additives, and three for factives. It brings together information extraction and annotation on (A) the satisfaction/binding and (B) information-theoretic surprisal values of presuppositions. An initial (naive) hypothesis is that the two lines of investigation converge, but this only turned out to be the case for factives in the data inspected. The work conducted relates two strands of research: information theory (Shannon 1948, Fankhauser et al. 2014, Degaetano-Ortlieb et al. 2016) and the semantic theory of presuppositions (Stalnaker 1973, Heim 1983, Schwarz 2014, 2016). Furthermore, the study begins to connect two methodological points relevant for studies concerned with the diachronic evolution of meaning and structure but not approached jointly so far: syntactically parsed data and information-theoretically calculated predictors on semantic phenomena. Using such tools, the paper offers an initial description, a discussion of methodological issues, and some empirical results such as the existence of two crystallizing major classes of triggers during the Early Modern English period, which may be indicative of the distinction between informative and run-of-the-mill presuppositions. While the focus of the paper is on the early modern period (that is, roughly, the sixteenth and the seventeenth century), a short outlook on Late Modern English (the subsequent two centuries) is offered.

1 Background

This paper reports a pilot study concerned with the extraction of information-theoretic surprisal values (Shannon, 1948, Fankhauser et al., 2014, Degaetano-Ortlieb et al., 2014, Degaetano-Ortlieb et al. 2016). We conducted the bulk of the work described in what follows on the basis of syntactic corpora such as Kroch et al. (2004), Kroch et al. (2016). Empirically, we have pursued a two-pronged metric consisting of surprisal values as well as the rate of overt textual satisfaction applied to the topic of presuppositions in a genre-balanced randomized sample of tokens of Early Modern English (Kroch et al. 2004). The context-annotation of presupposition satisfaction was manual and double-checked team-internally, thus adapting previous basic techniques (cf. Spenader 2002, Poesio & Vieira 1998, Venhuizen 2015) to the necessities of working with earlier philological traditions ('old language' and its conventions). This means, *inter alia*, that we could not rely on naive annotators in the same way that synchronic studies can. But why proceed with syntactically parsed corpora when investigating a semantic phenomenon? A benefit of using surprisal calculation on a syntactic parse in our case turned out to be, quite trivially, that the searched categories and phrases which were searched could be identified more precisely to then undergo semantic and information-theoretic scrutiny. The associates of presupposition triggers could be identified better for the calculation of surprisal values. To clarify the terminology we use, consider (1) and (2):

- (1) Sally *knows* that Abby left late.
- (2) Peter juggled, *too*.

The factive verb *know* and the additive adverb *too* are presupposition triggers. For simplicity, we call the constituents – the denotations of which help us reconstruct the presupposition – ‘associates’. For (1), that’s the clause headed by the complementizer *that* (i.e. the CP in usual syntactic terminology) *that Abby left late*. For factive predicates, we then have clauses as associates. For (2), however, an ambiguity arises – either *Peter* or *juggled* could be an associate. Pitch accent could resolve this, but we don’t have such information in most cases in the historical data. However, if the preceding context contains e.g. another predicate which is asserted of Peter (such as *danced*), then the associate must be *juggled*. The toy example already illustrates the fact that the associate can vary with respect to its syntactic category. The syntactic parse together with the contextual scanning of the discourse semantics allow us to determine it. In our data for additives, the associate varied between the following categories: adjectival phrases (AP), clausal constituents (e.g. CP/IP in one common terminology, though not much hinges on the labeling), noun phrases (NP), verb phrases (VP) and prepositional phrases (PP). The issue is obvious. Some notion of a structured tree and precise categories are needed. Determining surprisal values of an associate requires in a first step circumscribing the associate as precisely as possible. Even for factives, where hardly any such ambiguity is involved, a syntactic parse is of help to determine surprisal calculation (for details of which cf. section 3.2).

The larger goal in the background of our current endeavor is twofold: (A) to prepare the ground to get a systematic understanding of how presuppositions behave in language change (paths of other side messages, invited inferences, implicatures etc. have of course been much more studied); (B) to combine, in an initial attempt, advances in two areas of modern historical research – viz. syntactically parsed corpora and the extraction of Shannonian information density – in order to derive the effects of the well-defined notion of surprisal on linguistic change.

2 Presuppositions in Historical Data

Research on presuppositions has seen rich theoretical paradigms over the decades and it has recently gained additional momentum due to synchronic experimental studies engaging in theoretical issues (Schwarz, 2007, 2014, 2015, 2016a,b, Tiemann et al., 2011, Bade, 2014, 2016, DeVeugh-Geiss et al., 2015, Jayez & Reinecke, 2016, Tonhauser, 2016, Djärv et al., to appear). Despite the increasing body of research, corpus-based (and clearly, even less: information-theoretic) as well as the historical-developmental properties of presuppositions have only scarcely been approached (unlike studies on implicatures in semantic change, which are too numerous to mention within present confines). Diachronic studies dealing with the topic are Eckardt (2009) and Schwenter & Waltireit (2010). Upon closer inspection Schwenter & Waltireit concentrate on implicatures which can arise once a presuppositional item is already in place (e.g. interesting dialectal readings parasitic on *too*) and do not (claim to) have a corpus-based study. It is essential, however, to distinguish between presuppositions and other types of inferences as the experimental work cited above shows. Eckardt posits the APO (*Avoid Pragmatic Overload*) tendency, as a possible driving maxim of semantic change; we see large potential in APO, primarily with regard to implicatures, but we are generally of the opinion that such principles should be founded not only on the basis of interesting theoretical considerations and the analysis of individual examples, but also of wide systematic corpus studies (cf., e.g., Beck and Gergel, 2015, for a pertinent corpus-based semantic account of a presupposition trigger, though without measures of overt satisfaction or information-theoretic notions).

3 Methods

3.1 Data

The choice of data for this pilot study was guided by a selection of six potential triggers of presuppositions from the PPCEME corpus (Kroch et al., 2004). It contains three sub-periods – E1, E2, E3 – which are delimited chronologically as follows:

E1: 1500 – 1570

E2: 1570 – 1640

E3: 1640 – 1710

Furthermore, for each text the meta-information regarding its year of composition is available, so segmentation into other intervals than the ones given by the corpus three-fold division itself was possible. An interesting measure at the period is of 50-year intervals. Using unigrams as units, models are created for each 50-year interval. These allow us to track usage change over time while preserving the context information of a given unit.

The triggers themselves were chosen in such a way as to have a reasonable number of occurring tokens in the corpus. We aimed at a randomized selection of 100 tokens per trigger. To detect diachronic developments we often focused on the first and the third sub-period of Early Modern English; that is, E1 and E3. We chose three additive adverbs/particles – *too*, *also*, *even* – and three verbs – *know*, *find* and *see*. The verbs were required to have clausal complements.

3.2 Surprisal Calculation on Syntactically Parsed Data

Our primary understanding of surprisal is information-theoretic (Fankhauser et al., 2014, Degaetano-Ortlieb et al., 2016). The general definition of surprisal is the formula in (I), while the one in (II) gives the average surprisal (AvS).

$$S(\text{unit}) = -\log_2 p(\text{unit}|\text{context}) \quad (\text{I})$$

$$\text{AvS}(\text{unit}) = \frac{1}{|\text{unit}_i|} \times - \sum_i \log_2 p(\text{unit}_i|\text{context}_i) \quad (\text{II})$$

We adapted Degaetano et al.’s method to syntactically parsed corpora by calculating the mean average over the terminal nodes included in the constituents in which we were interested, i.e. the associates of the triggers. During pre-processing, the corpus files had been sliced into 50-year sections (following Degaetano et al. - other choices are possible, but we could not detect any crucial difference so far). For every 50-year slice, the AvS for every single unit (‘word’) was calculated with the context represented by the three preceding words/items. After calculating the 50-year models, the AvS values were aligned with the terminal nodes in parsed files of the PPCEME. Notice, hence, that the technology we have used did not initially hinge on the syntactic representation per se, but that such representations turned out to be advantageous in comparison with corpora that lack syntactic structures given the precise enclosure of different types of associate phrases (cf. also the discussion in section 1 above). Searches in the syntactic corpus were conducted using *CorpusSearch* (<http://sourceforge.net/projects/corpussearch/>), *CQPweb* for the surprisal-annotated corpus and we have used *R* for the calculations and plots.

3.3 Context-Based Semantic Annotation

We drew on two lines of research here. On the one hand, e.g. Beck, et al. (2009), and Gergel and Beck (2015) show that identifying the salient presuppositions in historical data is feasible and such efforts offer the prospects of ascertaining sometimes meaningful trajectories. Our historical handling of the data is similar. Additionally following Spender’s (2002) synchronic study (among others), we kept track not only of which presuppositions were salient for the extracted token-context pairs, but also

whether the presuppositions were assigned to specific types. The basic possibilities were: (i) was the presupposition in each individual case given, i.e. satisfied overtly through direct textual evidence or (ii) was it not given (and potentially to be accommodated)? A third category we took into account was (iii) that the presupposition was inferable. See below for additive adverbs and factive verbs and their respective categories – (3) & (4) for *Given*, (5) & (6) for *Inferred*, (7) & (8) for *New*. The triggers are italicized throughout and the underlined parts in (5) indicate clues for presuppositional inference - thus, while there is no directly mentioned notion of mistrust preceding the presupposition trigger, this can be inferred from the tyrant's unwillingness to be shaved by anyone. In (6) the entire sequence of operations described is intended to yield the result in the complement of the verb.

- (3) Yes, Sir, She has a Daughter by Sir Charles [...]. She has a Son *too* by her first Husband Squire Sullen, [...]; (FARQUHAR-E3-H,3.98)
- (4) The first time that his Strength was known, was by his Mothers going to a Rich Farmers House, [...] [...] so when Tom began to *know* that he had more strength then twenty Men had, he then began to be Merry with Men, and very tractable, [...]. (PENNY-E3-P1,34.198[...]/PENNY-E3-P1,35.249)
- (5) What misery was in the life of Dionyse the tyrant of Cicile ? Who knowing that his people desired his distruction , for his rauine and crueltie , wold nat be of any man shauen , but first caused his owne doughters to clippe his berde , and afterwarde he *also* mistrusted them, [...]. (ELYOT-E1-P1,157.119)
- (6) Multiply the Sine of the Latitude giuen by the total Sine, and diuide the product by the complement of $y=e$ said Latitude that done, multiply the quotient by the Sine of the sunnes declination, and diuide the product by the Sine of the complement of the declination, and the quotient thereof will shew the signe of the ascentionall difference: and by working according to this rule youshal *find* that when the Sunne is entred 3°3. into Taurus, at which time his declination is 11. degrees, 4'1. as hauebeen said before the ascentionall difference will be 15. degrees , 2'1. (BLUNDEV-E2-P1,54V.114-BLUNDEV-E2-P1,55R.119)
- (7) MISS.: Pray, Father, what do you intend to do with him, hang him?
SIR TUN: That, at least, Child.
NURSE: Ay, and it's e'en too good for him *too*. (VANBR-E3-P2,74.582)
- (8) Thus we *see*, that most Resinous Gums [...] do also, being moderately solicited by heat [...] emit steams. (BOYLE-E3-H)

4 Results

4.1 Overt Satisfaction in Context, Inferred Information, and New Information

The adverbs investigated ('additive particles') had the ratios reported in Table 1 below. Table 2 below subsequently summarizes the findings for the factive verbs *know*, *find*, and *see*. Recall that E1 and E3 are the first and the last subperiod of Early Modern English, respectively, on which we concentrated in our search for variation.

	E1 #	E1 %	E3 #	E3 %
<i>also</i>				
given	45	91.84	49	96.08
new	1	2.04	1	1.96
inferred	3	6.12	1	1.96
<i>even</i>				
given	10	25.00	24	50.00
new	29	72.50	22	45.83
inferred	1	2.50	2	4.17
<i>too</i>				
given	46	92.00	40	81.63
new	4	8.00	3	6.12
inferred	0	0.00	6	12.24

Table 1: Adverbial selection of pilot study

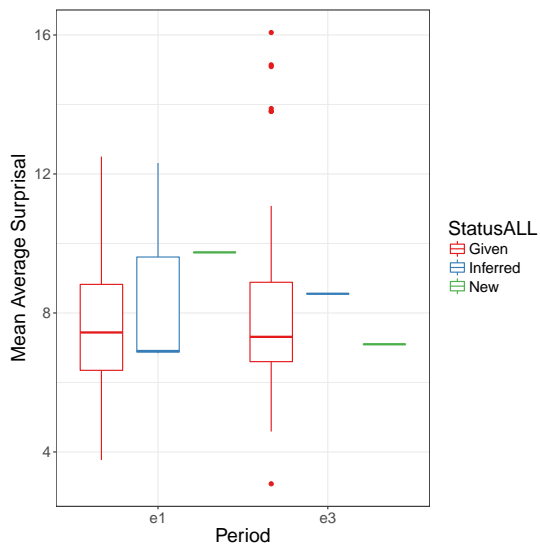
As is evident from Table 1, the additives *also* and *too* in particular display very high rates of overt satisfaction (i.e. givenness) in the corpus data. The adverbial uses of *even* are distinct as they have a more balanced division between given and new information. Table 2, by contrast, illustrates the very high - and increasing - rate of new information in the potential factive verbs during the Early Modern period:

	E1 #	E1 %	E2 #	E2 %	E3 #	E3 %
<i>know</i>						
given	9	18.75	not included		6	12.76
new	34	70.83			41	87.24
inferred	5	10.42			0	0.00
<i>find</i>						
given	0	0.00	0	0.00	1	2.44
new	3	75.00	17	80.95	39	95.12
inferred	1	25.00	4	19.05	1	2.44
<i>see</i>						
given	4	12.50	4	12.50	1	3.33
new	20	62.50	24	75.00	26	86.67
inferred	8	25.00	4	12.50	3	10.00

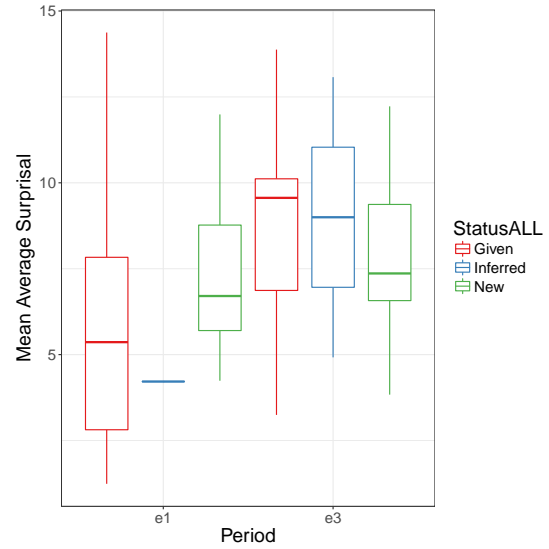
Table 2: Verbal selection of pilot study

4.2 Surprisal values

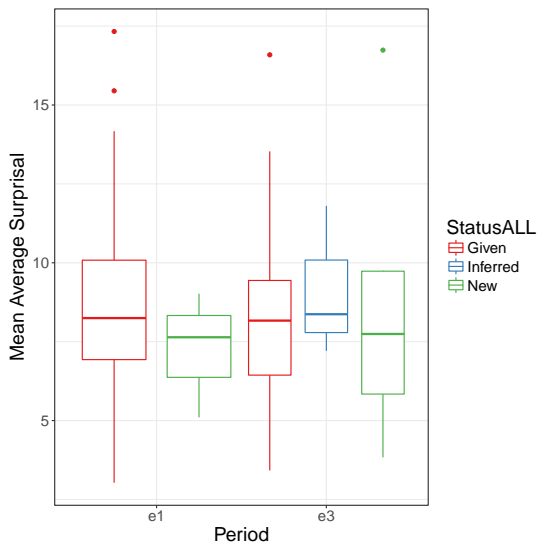
The surprisal values obtained for the six types of potential presuppositions were translated into boxplot-diagrams. We calculated such surprisal values on the basis of the methods outlined in 3.2 both for the triggers themselves and the associates. For space reasons, we reproduce the more informative figures for the associates in this short paper. Thus figure 1 (cf. below) provides insight into the distinct behaviors of both additive adverbs and factive verbs regarding the surprisal values of their associates (cf. section 5 Discussion). The temporal axis includes the period (i.e. crucially E1 vs. E3 for each individual trigger). Notice what distinguishes the two classes. While for the verbs (cf. figures 1d to 1f), we witness significantly more surprising values for the new occurrences, this is not borne out for the additive adverbs in general (cf. figures 1a to 1c).



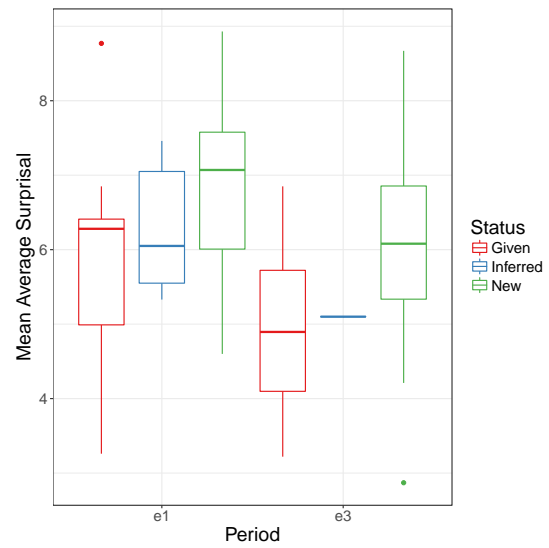
(a) also



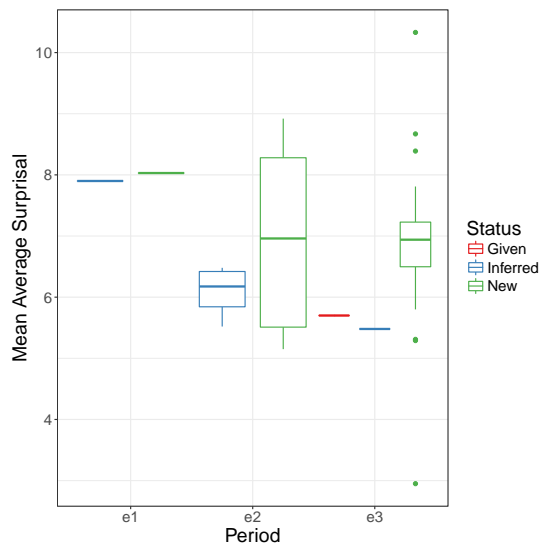
(b) even



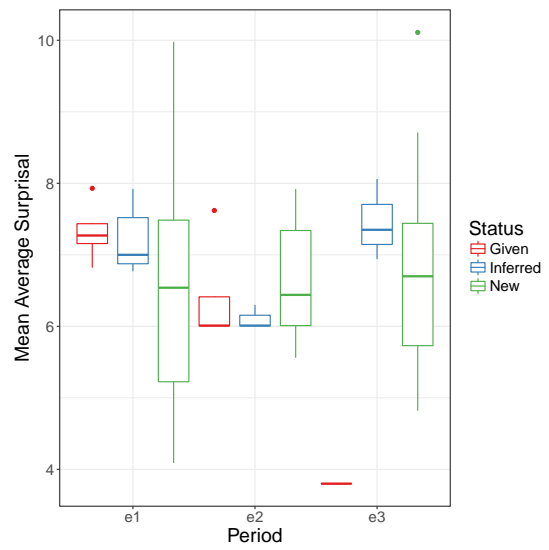
(c) too



(d) know



(e) find



(f) see

Figure 1: PSP triggers - factive verbs & additive adverbs; mean average surprisal of assoc. elements

5 Discussion

The triggers showed an interestingly distinct behavior in the two classes with respect to overt satisfaction, with the additive adverbs requiring satisfaction considerably more frequently, and in particular *too* and *also*. This is consonant with synchronic findings (Spencer 2002) made for Present-day English. The observation, then, nourishes the idea that, unlike implicatures, presuppositions partially together with their satisfaction signatures are comparatively resilient over time, pace Eckardt's (2009) theoretically interesting take. And the degree of distinctive satisfaction behavior in different classes is an indicator. Presuppositions are, however, not entirely static. First, recall that our current database only contains Early Modern English (with a brief excursus on Late Modern English explained below) and more is being done by extending the database in several respects, including on a wider span on the diachronic axis. Second, an interesting behavior can be culled from the behavior of factives in our window of observation: the territory of 'new' presupposition continuously increases during Early Modern English. This leads us to explore the idea that 'informative' presuppositions (Prince 1978, Tonhauser 2015), which arguably do not require satisfaction, may be an increasing category in English (at particular times). It will be interesting to compare the ratio of presuppositional change-of-state verbs, another candidate for so-called informative presuppositions, in a follow-up study. For space reasons, we also leave out a discussion of yet another interesting type of trigger in this short paper - viz. cleft constructions - the evolution of which we investigate in a study parallel to the one which is the focus of this short paper and for which a similar increase of the *New* category can be observed over time (cf. Gergel, Kopf-Giammanco and Watkins 2017).

While the focus of this paper has been on two trigger groups during the Early Modern English period, we mention some possible extensions and caution against too strong generalizations both across trigger classes and within groups when the timespan is extended. There are, for instance, differences between clefts and e.g. the factive verb *know* on the basis of what we have been able to see so far. While the increasing tendency for clefts to express new information seems to carry on the basis of observations reported in Gergel, Kopf-Giammanco, and Watkins (2017), a similar tendency for *know* is only observable in Early Modern English, while during Late Modern English the tendency is reversed (cf. Table 3 below).

	L1 #	L1 %	L3 #	L3 %
<i>know</i>				
given	8	16.00	13	26.00
new	32	64.00	28	56.00
inferred	10	20.00	9	18.00

Table 3: Verbal selection in extended study

And additives part way again. From an incipient inquiry into Late Modern English, we observe that *also* shows almost a mirror image of the factive verb *know*. That is, a decreasing tendency for new information first and a subsequent slight increase for it in Late Modern English; cf. Table 4 (synonymous *too* is less clear in this respect):

	L1 #	L1 %	L2 #	L2 %	L3 #	L3 %
<i>also</i>						
given	44	84.89	42	82.31	42	84.00
new	3	5.85	3	5.92	4	8.00
inferred	5	9.26	6	11.77	4	8.00
<i>too</i>						
given	34	68.00	33	67.08	33	62.50
new	10	20.00	10	20.58	8	15.74
inferred	6	12.00	6	12.33	11	21.76

Table 4: Adverbial selection in extended study

The inclusion of surprisal values is a potential additional predictor of distinct classes and a longer-term goal of such work can be to implement this more broadly, more reliably, and with improved measurements. An interesting information-theoretic asymmetry between the classes studied already emerges on the basis of the current findings from Early Modern English. While a particular tendency could be ascertained for factives in the data studied, namely that the presuppositions which are overtly satisfied (and specifically given) are less surprising than the new ones, the tendency was not visible for additives. Initial observations towards a fuller account are as follows: first, the syntax of additives is more flexible. Second, the ‘given’ part can have a higher degree of variation in the case of additives. Third, additional pragmatic inferences often arise parasitic on additive presupposition markers. Overall, however, notice that an important caveat is in order. The current notion of surprisal, while legitimate in diachronic studies and perhaps more generally due to a current lack of more suitable tools for tackling long-range dependencies (of which presuppositions are a clear case) needs to be drastically improved. On closer inspection, it may be in fact surprising that given information turns out to be less surprising for the Early Modern verbs studied in view of the type of measurement used. We do not have a better measurement tool at this point, but would like to hint at a possible direction based on the distance between trigger and its associate (in cases in which there is one); cf. Gergel, Kopf-Giammanco and Watkins (2017) for an initial testing of distance measurements.

We conclude by stressing the necessity of two objectives in the field (in our view): first, broad and systematic studies of explicit presupposition satisfaction in corpora including historical ones, towards which we take an initial step; second, the methodologically interesting possibility, which we have implemented in a first instantiation, of combining (A) information theory (e.g. via surprisal values), (B) data from syntactically parsed corpora, and (C) context-based annotation of meaning. One goal is as follows: given a group of potential trigger words (we again use the term ‘potential’ because historically you first have to test whether the trigger is genuine), find out to what extent the time-consuming philological task (C) can be approximated on the basis of combining (A) and (B) applied to that trigger group. Clearly, more (also) of the footwork of type (C) in terms of training ground needs to be done, before a reasonable answer to the general problem can be offered.

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