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A Quantitative Study on English Polyfunctional Words

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Abstract

This paper reports quantitative research on the parts of speech of English words using the data from British National Corpus. Most of the part-of-speech investigations focus on the rank-frequency distribution. However, in English and many other languages, we can find that partd of speech can be ambiguous. For example, *hope* can be a noun and a verb. Such words are called polyfunctional words, while other words, which belong to only one part of speech, are called monofunctional words. The number of parts of speech that a word belongs to is referred to as polyfunctionality. First, we study polyfunctionality distribution of English words and find that the Shenton-Skees-geometric and the Waring distributions capture the data very well. Then, we group words according to their part of speech, e.g., monofunctional nouns, like *Saturday*, and polyfunctional nouns, like *hope* (noun, verb) compose noun group, and try to work out a general model for all the groups. The result is that the extended positive binomial distribution captures all the groups except the article group, because of the sparsity of the data. Last, we study the diversification variants. Since there are polyfunctional words in each group – e.g., in a noun group, a polyfunctional noun may also be a verb, we consider the “verb” function as a diversification variant and try to model the rank-frequency distribution of variants with the Popescu-Altmann function, as used in the previous investigation. The results show very good fit for all groups exzept conjunction group.

Keywords: *polyfunctionality, polyfunctional words, parts of speech, BNC.*

1. Introduction

There is a phenomenon in English, as well as in many other languages, that the same word may have several different grammatical functions. For example, in the sentence *A canner can can a can*, the first *can* is a modal verb which means “be able to”, the second *can* is a verb which means “to preserve food by putting it in a can”, the last *can* is a noun which means “a metal container”. Linguists call this class cleavage (Bloomfield, 1933), multiple class membership (Bloomfield, 1933; Allerton, 1979; Biber, 1999; Hudson & Hudson, 2007; Jackson & Amvela, 2007; Jackson, 1988; Nida, 1948), multifunctionality (Harris, 1946; Braun, 2009), decategorization (Hopper & Thompson, 1984), intercategorial polysemy (Zawada, 2005), zero-derivation (Kastovsky, 2005), transcategorization (Halliday & Matthiessen, 2006), heterosemy (Enfield, 2006), conversion (Balteiro, 2007), word class expansion (Fan & Altmann, 2008) and polyfunctionality (Wang, 2016). In this paper, we follow the terminology from Wang (2016): words that have more than one part of speech are called polyfunctional words, while words with only one part of speech are called monofunctional words; the number of parts of speech they have is referred to as polyfunctionality (PF). Polyfunctionality is different from polysemy, because all the meanings of a polysemous word may belong to one part of speech. The word is monofunctional, with PF = 1. Only when the meanings belong to different parts of speech, the word is also polyfunctional, such as *can* in the abovementioned sentence, PF = 2. The present

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paper attempts to study the polyfunctionality distribution of English words.

We can group words according to their parts of speech, e.g., monofunctional nouns, like *Saturday*, and polyfunctional nouns, like *hope* (noun, verb) compose the noun group; monofunctional verbs, like *rely*, and polyfunctional verbs, like *hope* (verb, noun) compose the verb group; monofunctional adjectives, like *fantastic*, and polyfunctional adjectives, like *mean* (adjective, noun, verb) compose the adjective group, etc. Thus, each group forms a polyfunctionality distribution. We try to analyse the polyfunctionality distributions and find a general model to capture all the groups.

If a word group includes polyfunctional words, the part(s) of speech other than the shared one are variants. Consider the above-mentioned five words as a small corpus: the noun group includes *Saturday*, *hope* and *mean*, where the part of speech "verb" from *hope* and *mean* and the part of speech "adjective" from *mean* are variants. Similarly, in the verb group (*rely*, *hope*, *mean*), the parts of speech "noun" and "adjective" are variants; in the adjective group (fantastic, mean), the part of speech "noun" and "verb" are variants. We focus on the variants and their rank-frequency distribution of each group and test if all the groups abide by the same model.

2. Data

Our data is extracted from British National Corpus[4] (BNC), which contains over 100 million words. The whole corpus is tagged with the Constituent Likelihood Automatic Word-tagging System[2] (CLAWS) according to C5 tagset[3]. This tagset contains over 60 tags, in which 53 denote parts of speech, such as NN0 refers to common noun, neutral for number; NN1 refers to singular common noun; NN2 refers to plural common noun; NP0 refers to proper noun. In analogy to these noun tags, most of the 53 tags are subcategories. However, it is not our aim to distinguish sub-classes of a part of speech, so we merge them to their corresponding part of speech (POS) – adjective, article, adverb, conjunction, numerals, pronoun, interjection, noun, preposition and verb – ten classes in total as shown in Table 1.

Within BNC there is 3.3% part-of-speech ambiguity[5]. The word *round* in the following sentence is an example: its tag PRP-AVP means preposition or adverb particle.

*James Rogers is 23 and needs **<w PRP-AVP>round** the clock medical attention.*

Since those ambiguity tags[6] increase the error rate[7] of BNC part-of-speech tagging, they are excluded from the present study. Thus, the error rate reduces to 0.7%, which we consider acceptable. We also exclude word combinations, words with hyphens, words with Arabic numerals, incorrect spellings and non-English words as shown in the following sentences. Words are not lemmatized, since a previous study (Wang and Guo, 2018) adopts English dictionary data (i.e. lemmas). In this study we focus on word forms in running texts. Finally, we obtain 278,966 word types, case insensitive.

[4] https://ota.bodleian.ox.ac.uk/repository/xmlui/handle/20.500.12024/2554
[5] http://ucrel.lancs.ac.uk/claws/
[6] http://ucrel.lancs.ac.uk/claws5tags.html
[7] http://ucrel.lancs.ac.uk/bnc2/bnc2error.htm

*Ours was an **<w AJ0>ad hoc** group.*

*Pound was a bohemian figure, despite his Quaker origins, who espoused an **<w AJ0>anti-credit** economic philosophy which thrust him into **<w NN1>anti-Semitism**.*

*Times to beat from last year are Kevin Brown's **<w CRD>1:07:21** and Chris Buckley's **<w CRD>1:24:25** in the women's race.*

***<w AT0>Thc** effort of the natives to be heard by the Greeks was evidently encouraged by the curiosity of the Greeks about the natives and, generally speaking, corresponded to the political situation.*

*From **<w AT0>de** lift to **<w AT0>de** balcony.*

Table 1.
BNC tags and parts of speech

BNC tags	**Description**	**POS**
AJ0	Adjective (general or positive) (e.g. *good, old*)	Adjective (adj.)
AJC	Comparative adjective (e.g. *better, older*)	
AJS	Superlative adjective (e.g. *best, oldest*)	
AT0	Article (e.g. *the, a, an, no*)	Article (art.)
AV0	General adverb: an adverb not subclassified as AVP or AVQ (e.g. *often, furthest*)	Adverb (adv.)
AVP	Adverb particle (e.g. *up, out*)	
AVQ	Wh-adverb (e.g. *when, how*)	
EX0	Existential *there*, i.e. *there* occurring in the “*there is ...*” or “*there are ...*” construction	
XX0	The negative particle “*not*” or “*n't*”	
CJC	Coordinating conjunction (e.g. *and, or*)	Conjunction (conj.)
CJS	Subordinating conjunction (e.g. *although, when*)	
CJT	The subordinating conjunction “*that*”	
CRD	Cardinal number (e.g. *one, 3, fifty-five, 3609*)	numerals (num.)
ORD	Ordinal numeral (e.g. *first, sixth, 77th, last*).	
DPS	Possessive determiner-pronoun (e.g. *your, their, his*)	Pronoun (pron.)
DT0	General determiner-pronoun: i.e. a determiner-pronoun which is not a DTQ or an AT0.	
DTQ	Wh-determiner-pronoun (e.g. *which, what, whose, whichever*)	
PNI	Indefinite pronoun (e.g. *none, one [as pronoun]*)	
PNP	Personal pronoun (e.g. *I, them*)	
PNQ	Wh-pronoun (e.g. *who, whoever*)	

PNX	Reflexive pronoun (e.g. *myself, ourselves*)	
ITJ	Interjection or other isolate (e.g. *oh, yes, mhm, wow*)	Interjection (interj.)
NN0	Common noun, neutral for number (e.g. *aircraft, data*)	Noun (n.)
NN1	Singular common noun (e.g. *pencil, goose*)	
NN2	Plural common noun (e.g. *pencils, geese*)	
NP0	Proper noun (e.g. *London, IBM*)	
PRF	The preposition "*of*"	Preposition (prep.)
PRP	Preposition (except for "*of*") (e.g. *at, in*)	
VBB	The present tense forms of the verb *BE*, except for *is, 's*: i.e. *am, are, 'm, 're* and *be* [subjunctive or imperative]	Verb (v.)
VBD	The past tense forms of the verb *BE*: *was* and *were*	
VBG	The -ing form of the verb *BE*: *being*	
VBI	The infinitive form of the verb *BE*: *be*	
VBN	The past participle form of the verb *BE*: *been*	
VBZ	The -s form of the verb BE: *is, 's*	
VDB	The finite base form of the verb *BE*: *do*	
VDD	The past tense form of the verb *DO*: *did*	
VDG	The -ing form of the verb *DO*: *doing*	
VDI	The infinitive form of the verb *DO*: *do*	
VDN	The past participle form of the verb *DO*: *done*	
VDZ	The -s form of the verb *DO*: *does, 's*	
VHB	The finite base form of the verb *HAVE*: *have, 've*	
VHD	The past tense form of the verb *HAVE*: *had, 'd*	
VHG	The -ing form of the verb *HAVE*: *having*	
VHI	The infinitive form of the verb *HAVE*: *have*	
VHN	The past participle form of the verb *HAVE*: *had*	
VHZ	The -s form of the verb *HAVE*: *has, 's*	
VM0	Modal auxiliary verb (e.g. *will, could*)	
VVB	The finite base form of lexical verbs (e.g. *forget, send*) [Including the imperative and present subjunctive]	
VVD	The past tense form of lexical verbs (e.g. *forgot, sent*)	
VVG	The -ing form of lexical verbs (e.g. *forgetting, sending*)	

VVI	The infinitive form of lexical verbs (e.g. *forget, send*)	
VVN	The past participle form of lexical verbs (e.g. *forgotten, sent*)	
VVZ	The -s form of lexical verbs (e.g. *forgets, sends*)	

3. Discussion

3.1 Polyfunctionality distribution

We find that 27,592 out of the total 278,966 words in the BNC data are polyfunctional accounting for 9.89%, and 251,374 words are monofunctional accounting for 90.11%. Polyfunctionality arranges from 1 to 6 as shown in Table 2. The word *like* extends to six parts of speech as shown in the following sentences.

*Corridors that twisted upwards **<prep.>like** corkscrews.*

*In the woman's eyes he saw a **<adj.>like** recognition and knew his senses did not deceive him.*

*Pull out the magazine schemes that appeal most to you and stick them in a file; mark the pages you **<v.>like** in books.*

*What I'd like is just a few regulars, that'd come by appointment, **<adv.>like**, so I could stay at home.*

*He knew full well: by Acts of Parliament, voted by landlords to benefit their **<n.>like**.*

*They'll miss him, **<conj.>like** they missed many of their first team players who're saving themselves for a vital league game next week.*

Fan & Altmann (2008) found that the Shenton-Skees geometric distribution is an excellent model for their 165-English-word data:

$$P_x = pq^{x-1}\left[1 + a\left(x - \frac{1}{p}\right)\right],$$

where x stands for PF ($x = 1, 2, 3, \ldots$); p, q and a are parameters ($0 < p < 1$, $q = 1-p$, $0 < a < \frac{1}{q-1}$). Later studies on the polyfunctionality distribution model include Wang (2016), which adopts the Modern Chinese Dictionary (the 5th edition), and Wang & Guo (2018), which adopts CELEX dictionary data (Baayen et al., 1995) from German, Dutch, and English. The results show the Waring distribution –

$$P_x = \frac{b}{b+n} * \frac{n^{(x)}}{(b+n+1)^{(x)}}$$

$$x = 0, 1, 2, \ldots \ (b > 0, n \geq 0)$$

where x stands for PF (x = 0, 1, 2, …); b and n are parameters ($b > 0$, $n \geq 0$); $n^{(x)} = n(n+1)(n+2)\ldots(n+x-1)$ – can fit the data of all these four languages better than Shenton-Skees geometric distribution. In the present study, both models are fitted as shown in Table 2. C and R^2 values indicate goodness-of-fit. C is the coefficient of discrepancy. The fit is considered to be acceptable, when $C \leq 0.02$. R^2 is the coefficient of determination, originally applied to linear models, but also used to evaluate non-linear models, if they obtain a sufficiently high R^2 value:

$R^2 > 0.9$ is considered to be a good fit and $R^2 > 0.8$ an acceptable fit. (Macŭtek & Wimmer, 2013).

Table 2.
Fitting Waring and Shenton-Skees geometric distributions to the polyfunctionality data

x[i]	f[i]	Waring	Shenton-Skees-geometric
1	251374	251800.7	251323.8
2	25191	24519.98	25309.55
3	2308	2387.72	2151
4	84	232.51	168.15
5	8	22.64	12.5
6	1	2.44	0.97
		$b = 77730601.38$ $n = 8385897.13$	$p = 0.9391$ $a = 0.6265$
		$C = 0.0005$ $R^2 > 0.999$	$C = 0.0002$ $R^2 > 0.999$

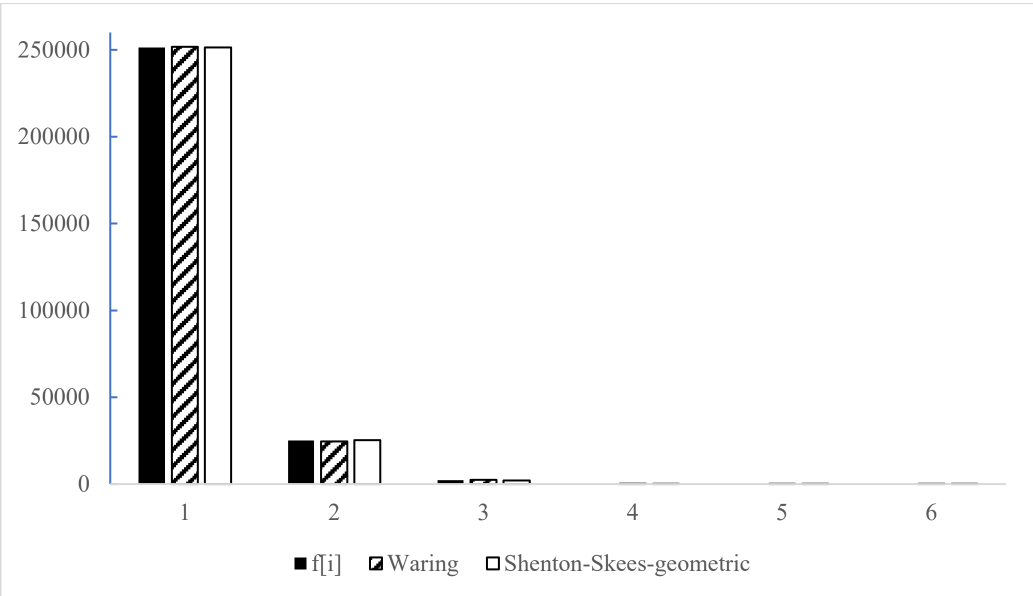


Figure 1. Fitting Waring and Shenton-Skees geometric distributions to polyfunctionality of BNC data

3.2 Polyfunctionality distribution of word groups

The polyfunctionality distribution of each group is demonstrated in Table 3. The data for verb, preposition and conjunction groups show bell-shaped forms. The data for noun, adjective adverb, pronoun, numerals and interjection groups are monotonically decreasing. The data of these nine groups abide by the extended positive binomial distribution

$$P_x = \begin{cases} 1-\alpha, & x = 0 \\ \dfrac{\alpha \binom{n}{x} p^x (1-p)^{n-x}}{1-(1-p)^n}, & x = 1, 2, 3, \ldots \end{cases}$$

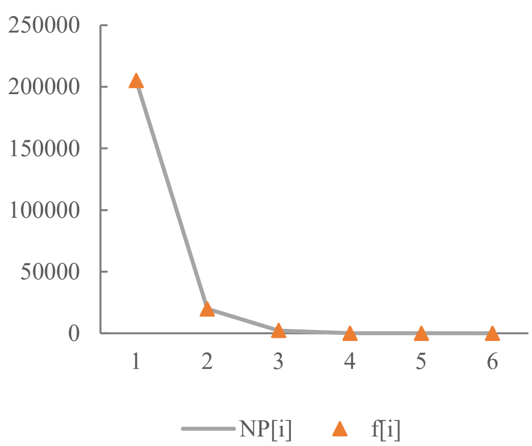
where x stands for PF; n, p and α are parameters, $n = 1, 2, 3, \ldots, 0 \le p \le 1, 0 \le \alpha \le 1$. Since the article group consists of only three data points (Table 4), it is insufficient to fit a three-parameter model like extended positive binomial distribution. We tried other models with fewer parameters, such as the binomial distribution, because the extended positive binomial belongs to the binomial family, and Shenton-Skees-geometric and Waring, which are reported to capture polyfunctionality distributions by Fan and Altmann (2008) and Wang (2016) respectively. For such a small data set, we use the χ^2-test and its p-value instead of the discrepancy coefficient C, which is applied only when the sample is large and χ^2-test loses its reliability (Macůtek & Wimmer, 2013). The results show that, the p-values of binomial, Shenton-Skees-geometric and Waring are 0.4645, 0.4625 and 0.7438 respectivley, all greater than 0.05, thus indicating the models are acceptable. Caution is required because the article data set with only five words and three data points is quite small, therefore the results are questionable. However, they are still worth reporting to provide information for further studies.

Table 3.
Fitting extended positive binomial distribution to the polyfunctional data of word groups

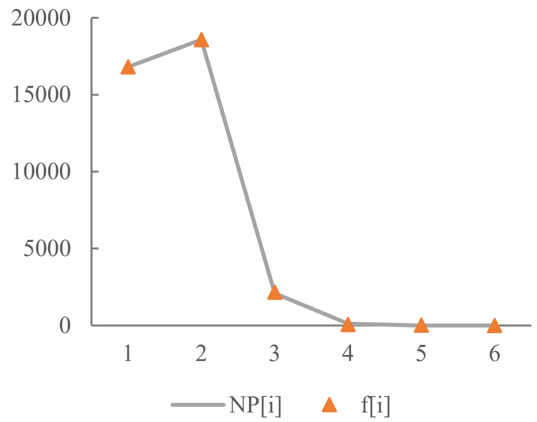
PF	**n.**		**v.**		**adj.**		**adv.**	
x[i]	f[i]	NP[i]	f[i]	NP[i]	f[i]	NP[i]	f[i]	NP[i]
1	205222	205222	16811	16811	23019	23019	5612	5612
2	19904	19910.57	18575	18580.81	11018	11067.13	548	508.74
3	2279	2230.91	2156	2103.7	2221	2050.88	161	224.19
4	78	124.98	67	119.09	71	190.03	71	49.4
5	8	3.5	8	3.37	6	8.8	7	5.44
6	1	0.04	1	0.04	1	0.16	1	0.24
	n = 5 p = 0.0531 α = 0.0979		n = 5 p = 0.0536 α = 0.5531		n = 5 p = 0.0848 α = 0.3665		n = 5 p = 0.1806 α = 0.1231	
	C = 0.0001 $R^2 > 0.999$		C = 0.0009 $R^2 > 0.999$		C = 0.0025 $R^2 = 0.9999$		C = 0.0049 $R^2 = 0.9998$	

PF	**prep.**		**conj.**		**pron.**		**num.**		**interj.**		**art.**
x[i]	f[i]	NP[i]	f[i]	NP[i]	f[i]	NP[i]	f[i]	NP[i]	f[i]	NP[i]	f[i]
1	32	32	18	18	123	123	309	309	226	226	2
2	51	48.75	23	21.75	54	54.51	45	42.78	162	154.08	2
3	39	44.47	14	16.18	22	21.04	12	15.55	20	31.04	0

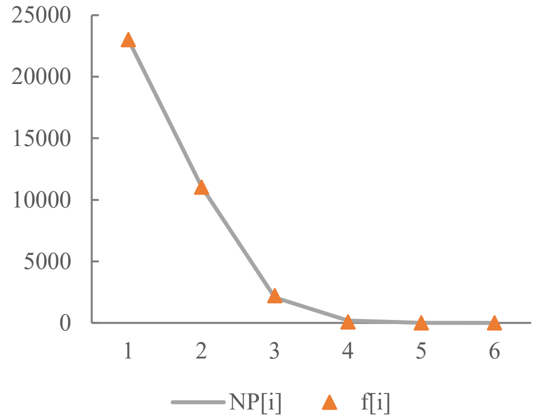
4	27	22.54	8	7.29	5	5.31	3	2.51	5	2.78	1
5	6	6.86	2	2.22	1	1.14	1	0.15	1	0.09	
6	1	1.38	1	0.57							
	$n = 7$ $p = 0.2332$ $\alpha = 0.7949$		$n = 12$ $p = 0.1191$ $\alpha = 0.7273$		$n = 51$ $p = 0.0152$ $\alpha = 0.4$		$n = 4$ $p = 0.1951$ $\alpha = 0.1649$		$n = 4$ $p = 0.1184$ $\alpha = 0.4541$		
	$C = 0.012$ $R^2 = 0.9724$		$C = 0.0068$ $R^2 = 0.9833$		$C = 0.0004$ $R^2 = 0.9999$		$C = 0.0043$ $R^2 = 0.9997$		$C = 0.0187$ $R^2 = 0.9958$		



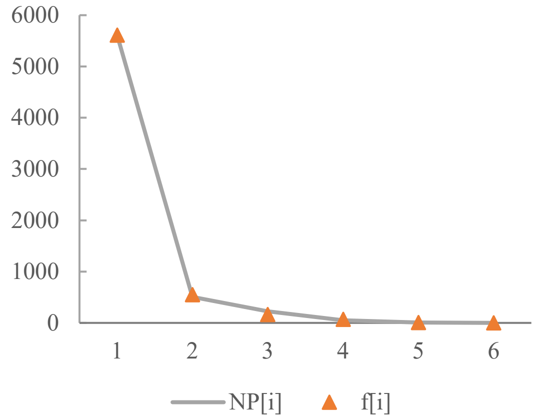
(1) nouns



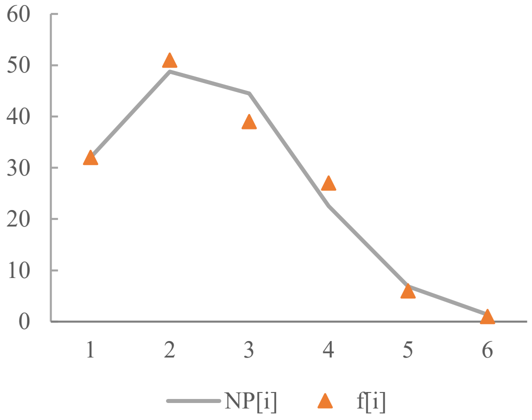
(2) verbs



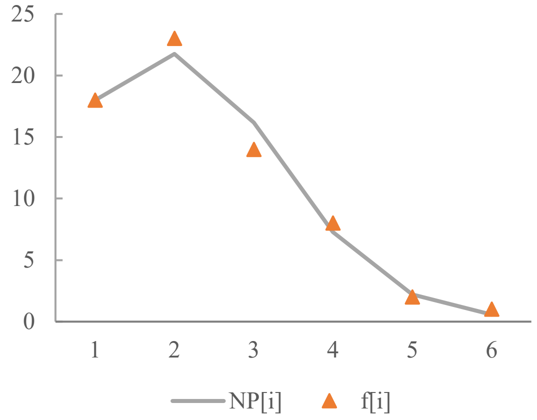
(3) adjectives



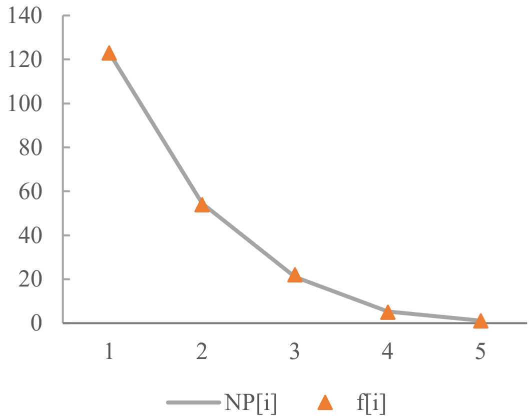
(4) adverbs



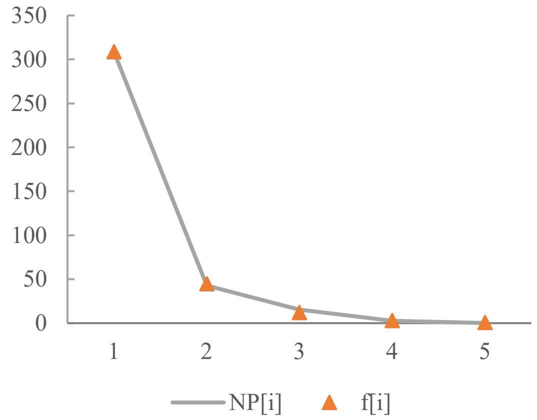
(5) prepositions



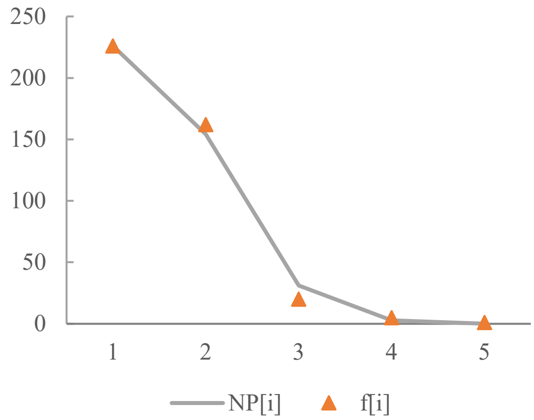
(6) conjunctions



(7) pronouns



(8) numerals



(9) interjections

Table 4.
Article group

Words	POS	PF	Examples
every	art.	1	*It should have been no surprise: Johnson scored two of the goals in last season's play-off final against Brighton and was booed **<art.>every** time he touched the ball by home fans with good memories.*
the	art.	1	*But **<art.>the** Greeks were seldom in a position to check what the natives told them: they did not know the languages.*
a	art. n.	2	*It is delighted **<art.>a** college preparatory school headed by Dr Norman **<n.>A** Palmer.*
an	art. n.	2	*As early as the 17th minute, Johnson sold McCarthy **<art.>an** extravagant dummy and hit a 20-yard shot that just cleared Digweed's crossbar.* *A mile to the west of Loch Gorm the road to Gruinart cuts through a settlement at **<n.>An** Sithern of about a dozen round houses which were constructed in the late Bronze Age and which a cursory examination has shown that they were used at least three times.*
no	art. adv. interj. n.	4	*Nevertheless **<art.>no** reader takes the passage like that.* *But there is **<adv.>no** doing so unless we accept that the literal writer has an imagination.* *Oh **<interj.>no**!* *Fact **<n.>no** 11, Income Support for residential and nursing homes, has been updated.*

3.3 Diversification variants

We have observed that each group includes polyfunctional words. Take the article group as an example – the words *a, an* and *no* are polyfunctional words, in that all the three have the noun function besides the article function. The part of speech "noun" is considered as a variant with three observations. In the same way, the parts of speech "adverb" and "interjection" from the word *no* are variants, each obtaining one observation. Thus, the rank-frequency distribution is obtained and shown in Table 5. These variants are generated by part-of-speech diversification processes such as conversion. According to diversification studies (Köhler & Altmann, 2009), if an entity diversifies, the frequency of individual elements abides by a regular distribution or a function. Here, we choose Popescu-Altmann's function (Popescu, Altmann & Köhler, 2009):

$$y = 1 + ae^{-bx} ,$$

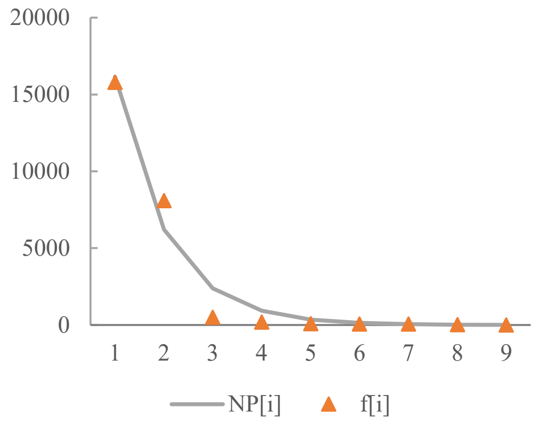
which is proved to be the best model for diversification variants in Wang (2016). The fitting results are shown in Table 5 and Figure 3, mostly acceptable except the conjunction group obtaining $R^2 = 0.6578$.

Table 5.
Fitting Popescu-Altmann's function to rank-frequency distribution of part-of-speech variants

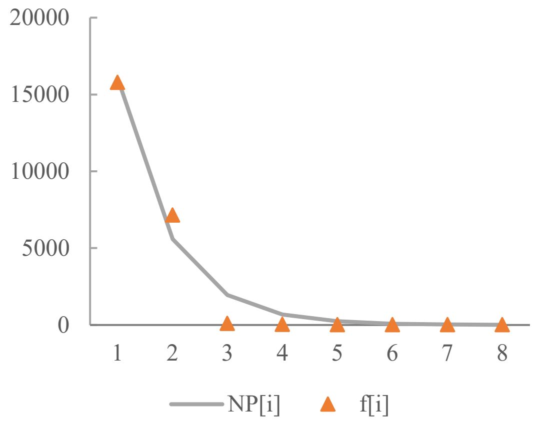
	n.			**v.**			**adv.**		
x[i]	variants	f[i]	NP[i]	variants	f[i]	NP[i]	variants	f[i]	NP[i]
1	v.	15773	16160.30	n.	15773	16061.20	n.	490	528.38
2	adj.	8083	6216.70	adj.	7147	5588.55	adj.	410	291.37
3	adv.	490	2391.88	adv.	96	1944.98	v.	96	160.88
4	interj.	177	920.66	prep.	42	677.34	prep.	63	89.03
5	prep.	71	354.75	interj.	22	236.31	pron.	25	49.47
6	num.	59	137.07	pron.	19	82.87	conj.	22	27.69
7	pron.	55	53.34	conj.	18	29.48	interj.	7	15.69
8	conj.	22	21.13	num.	8	10.91	num.	2	9.09
9	art.	3	8.74				art.	1	5.45
	a = 42010.1968 b = 0.9554 R^2 = 0.968			a = 46161.3184 b = 1.0558 R^2 = 0.9726			a = 957.8383 b = 0.5967 R^2 = 0.9254		

	adj.			**pron.**			**prep.**		
x[i]	variants	f[i]	NP[i]	variants	f[i]	NP[i]	variants	f[i]	NP[i]
1	n.	8083	8872.82	n.	55	54.28	n.	71	77.53
2	v.	7147	4362.20	adv.	25	28.18	adv.	63	55.37
3	adv.	410	2144.87	v.	19	14.87	v.	42	39.63
4	prep.	37	1054.88	adj.	7	8.08	adj.	37	28.44
5	interj.	10	519.07	num.	4	4.61	conj.	21	20.49
6	pron.	7	255.67	interj.	3	2.84	num.	3	14.85
7	num.	5	126.19	prep.	2	1.94	pron.	2	10.84
8	conj.	3	62.54	conj.	2	1.48			
	a = 18047.6134 b = 0.7101 R^2 = 0.8512			a = 104.4288 b = 0.6729 R^2 = 0.9876			a = 107.7328 b = 0.3419 R^2 = 0.9102		

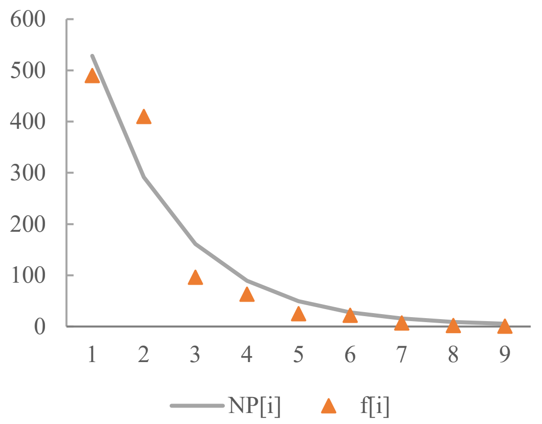
	num.			**interj.**			**conj.**			**art.**		
x[i]	variants	f[i]	NP[i]	variants	f[i]	NP[i]	variants	f[i]	NP[i]	variants	f[i]	NP[i]
1	n.	59	58.93	n.	177	176.87	n.	22	25.80	n.	3	2.99
2	v.	8	8.98	v.	22	23.87	adv.	22	19.95	interj.	1	1
3	adj.	5	2.10	adj.	10	3.97	prep.	21	15.49	adv.	1	1
4	pron.	4	1.15	adv.	7	1.39	v.	18	12.07			
5	prep.	3	1.02	pron.	3	1.05	adj.	3	9.46			
6	adv.	2	1.00	num.	1	1.01	pron.	2	7.47			
7	interj.	1	1.00	art.	1	1.00						
	$a = 420.2848$ $b = 1.9817$ $R^2 = 0.9915$			$a = 1352.518$ $b = 2.0399$ $R^2 = 0.997$			$a = 32.4507$ $b = 0.2688$ $R^2 = 0.6578$			$a = 18305.8794$ $b = 9.1218$ $R^2 > 0.999$		

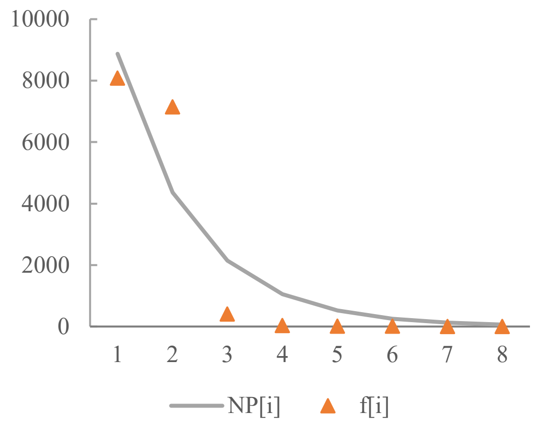


(1) noun group

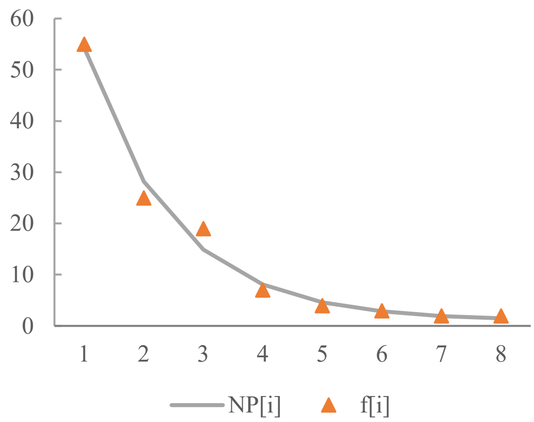


(2) verb group

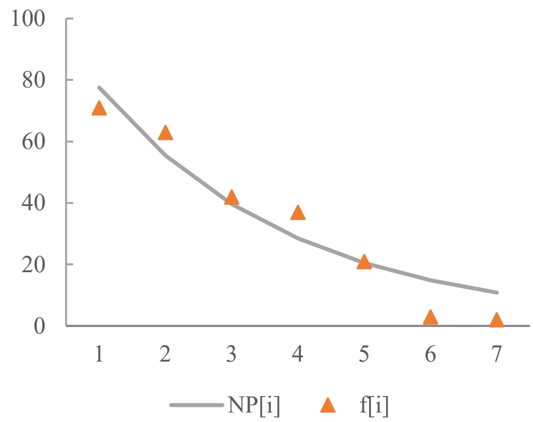




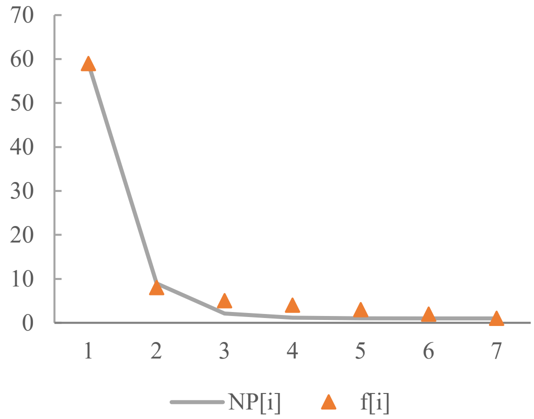
(3) adverbs



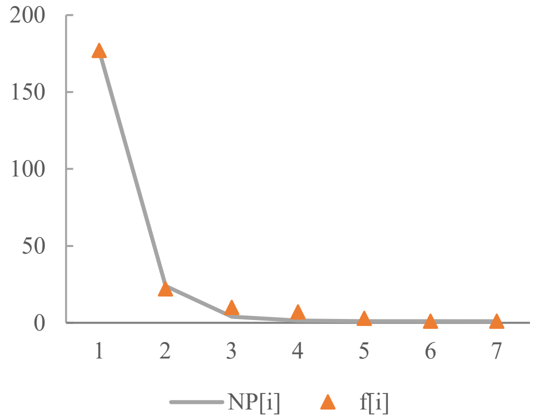
(4) adjectives



(5) pronouns

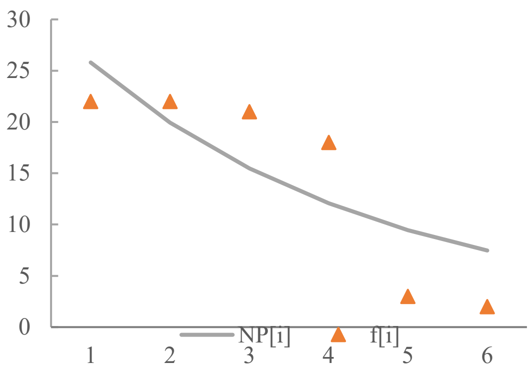


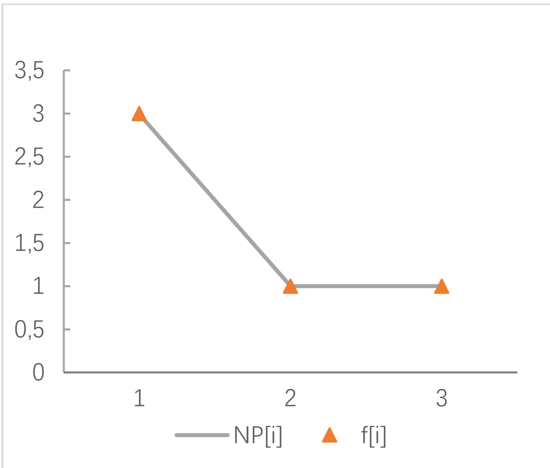
(6) prepositions



(7) numerals

(8) interjections





(9) conjunctions

(10) articles

Figure 3. Fitting Popescu-Altmann's function to rank-frequency distribution of part-of-speech

4. Discussion and Conclusion

The present paper shows the results of investigating polyfunctional English words based on data exzracted from the BNC. The polyfunctionality data are shown to abide by Shenton-Skees-geometric and Waring distributions. Further, the polyfunctionality data of the word groups that classified according to part of speech were analysed. Extended positive binomial distribution captures nine groups perfectly. The article group, too small for this model, obtains good fitting results from binomial, Shenton-Skees-geometric and Waring distributions, but it should be noted that, the reliability of fitting such a small data set is doubtful. The rank-frequency distribution of diversification variants of the word groups abide by Popescu-Altmann function.

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