

coherence & proposition

measuring reference distance in :schizophrenia: threads

st. schwarz

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Chapter 1

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Hausarbeit im Seminar: *Sprache und Psychose (PHILGEIST_S_16827_25S)*

Dozent: Anatol Stefanowitsch

abgegeben von:

MtrNr:

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an: Freie Universität Berlin

1.1 Selbständigkeitserklärung

Hiermit versichere ich,

- dass ich die von mir vorgelegte Arbeit mit dem Titel

**coherence & propositions: measuring reference distance in :schizophrenia:
threads**

selbständig abgefasst habe und

- dass ich keine weiteren Hilfsmittel verwendet habe als diejenigen, die im Vorfeld explizit zugelassen und von mir angegeben wurden und
- dass ich die Stellen der Arbeit, die dem Wortlaut oder dem Sinn nach anderen Werken (dazu zählen auch Internetquellen und KI-basierte Tools) entnommen sind, unter Angabe der Quelle kenntlich gemacht habe und
- dass ich, sollte ich explizit im Vorfeld zugelassene Hilfsmittel (z.B. KI-Tools) verwendet haben, diese in einer tabellarischen Übersicht (3.7) in meiner schriftlichen Arbeit integriert habe und
- dass ich die vorliegende Arbeit noch nicht für andere Prüfungen eingereicht habe.

Mir ist außerdem bewusst,

- dass ich diese Prüfung nicht bestanden habe, wenn ich die mir bekannte Frist für die Einreichung meiner schriftlichen Arbeit versäume und
- dass ich im Falle eines Täuschungsversuchs diese Prüfung nicht bestanden habe und
- dass ich im Falle eines schwerwiegenden Täuschungsversuchs ggf. die Gesamtprüfung endgültig nicht bestanden habe und in diesem Studiengang bzw. Studienangebot nicht mehr weiter studieren darf und
- dass ich, sofern ich zur Erstellung dieser Arbeit KI-basierte Tools verwendet habe, die Verantwortung für durch die KI generierte eventuell fehlerhafte oder verzerrte (bias) Inhalte, fehlerhafte Referenzen, Verstöße gegen das Datenschutz- und Urheberrecht oder Plagiate trage.

Ich bestätige mit meiner Unterschrift die Richtigkeit dieser Angaben.

2025-11-11,

Chapter 2

15303.ha.final

2.1 abstract

In this paper we want to explore **reference marking and coherence in schizophrenia language** by measuring corpus distance of similar nouns preceded by specified determinants.

Inspired by Zimmerer et al. (2017) we are interested in observations concerning coherence and propositional statement conditions in schizophrenia language. Further Nenchev et al. (2024) consider investigating in coherence as important “linguistic aspect in psychotic language addressing the relatedness between word chunks or sentences” an approach to “capture formal thought disorders (disorganisation, tangentiality, derailment and poverty of speech) in schizophrenia” (cf. Nenchev et al. (2024), 2.1: linguistic markers of schizophrenia). As this is not a clinical but a corpus linguistics study we do not intend to concur with recent psychiatric literature but rather take the subject as welcome task to test corpus linguistics methods.

Since above mentioned linguistic marker seems to play a crucial role within target group language features (and as such can be seen as asset of thinking- or world building capacity which might deviate from standard within the range of negative symptoms) we might with our approach add to the research done concerning frequency based analyses of how typical patients language might appear and how it deviates in terms of keywords or word fields. Our interest is more dedicated to the structural layer of the language which can not be described by raw frequencies. In our opinion disturbances on that layer might be hidden and not to grasp easily such that a listener would not always be able to precisely figure out what the disturbing factor is. Missing **coherence**, which we will investigate, may be a too narrow explanation to many impressions that schizophrene language leaves the listener with. But it seems to be a good starting point to unveiling structural patterns of patients language.

2.2 definitions, terminology, assumptions

2.2.1 coherence

There are several preliminary affordances to a successful communication. One is the *coherence* of a text = way of communication, which accounts for the partner being able to follow the topic and relate subjects and objects referenced. There can be more or less *common* references and such, that need to be embedded in context to be understood. The underlying network of informations to create that context is what we call *information structure* of a text. The level of complexity of that network defines how simple it would be to gather the reference from the given information. We might have to go back many sentences or even infer reference from metaphors or such to be able to understand what is said while in the other case simply recall the subject of the last sentence to get the meaning (reference) of the pronoun in also {she} said thisandthat.... The capacity to imagine or have in mind, what concrete information is accessible to the addressee (what he actually knows or can infer) is key to a successful communication, since factors like common-ness, weltwissen and shared knowledge between addressant and addressee and informations accessible from the text itself vary depending on topic, setting, intimacy of the partners and such. So one cannot always be sure that the information provided is sufficient but the grade to which one can give a correct estimate to this sufficiency should here be the measure assuming that coherence in disturbed language is deficient which lets an utterance be more difficult to understand within the frame of given information. Now one indicator of coherence we assume is *reference distance* where according to our hypothesis a larger distance would be observed in places where the addressant overestimates¹ the ability of the partner to follow a reference. That would mean that we find a medium shorter distance between referent and reference in the reference corpus² and larger distances in the target corpus. The references we are interested in are nouns that appear as anaphors i.e. here as noun analogies. The assumption is that if a noun is repeated *and* is combined with certain preceding determiners, the speaker assumes that the addressee has some knowledge of what is talked about, depending on the strength of the determination. So e.g. this, that, those, these would be rather strong determiners requiring that the noun was introduced before.

2.2.2 premises

2.2.2.1 deictic anchoring and propositional complexity

Zimmerer et al. (2017) consider “Deictic anchoring [...] an inherent part of the process by which we make references to aspects in the world including entities, events, locations, and time.” and define propositions as being “statements about the world which can be true or false.” They mention, according to (Kuperberg 2010) “that in people with schizophrenia, cortical activity to semantic abnormalities in sentences is particularly small compared to

¹due to lack of empathy or a general self-alignment

²where the participants may show a more realistic estimation of beforementioned ability

controls if interpretation requires integration of several sentences” which can mean, that patients are not realising if their utterances are somehow disturbed on the semantics level. If “Delusions and thought disorder can be considered disruptions of propositional meaning” then the patients feeling for their stated propositions (required to the addressee) and further the estimation about what he/she can assume as familiar to the addressee can be wrong. Following Klaus Konrad (Mishara 2010) who “described the onset of a delusion as the loss of ability to transcend an experience and see it with the eyes of others” Zimmerer et al. (2017) assume that “in thought disorder, the ability to express coherent propositions can be severely impaired.” We take that as premise for our research question.

2.3 questions

Measuring the referent-reference distance which we assume as an indicator for coherence we hope to find empirical evidence for disturbed or not world building capacities within schizophrenia language. Premising that a large noun distance indicates a low reference-referent association we hypothesise that in a language/ToM setting where the speakers estimation of the audiences context understanding capacities is disturbed we will find higher medium scores for the distance under matching conditions. An environment which has potential to test our hypothesis is a reddit.com subreddit where the majority of participants describe themselves as being diagnosed with schizophrenia.³ As reference corpus we chose reddit r/unpopularopinion. The distance measured should give us information structural evidence of how strong the noun occurrences⁴ are connected, i.e. if a noun appears out of the blue mostly or if it somewhere before has been introduced to the audience and thus would be more or less legitimated to be determined by an antecedent. Our basic assumptions rely on the *taxonomy of given and new information* coined by Prince (1981). She develops a hierarchy of references⁵ with specific relations to each other, where each item is attributed in terms of *familiarity*⁶, that defines ranges of 1. givenness in the sense of predictability/recoverability, 2. givenness in the sense of saliency, 3. givenness in the sense of “shared knowledge”. (cf. Prince (1981), pp. 226) We base our hypothesis of *reference distance as indicator for coherence* on this model assuming that the reference/association strength⁷ determines the level of text coherence.

2.4 data

We built a corpus of above mentioned subreddit channel (**n =1500371 tokens**) and a reference corpus of r/unpopularopinion (**n =980731 tokens**). Both were pos-tagged using the R udpipe package (Wijffels (2023)) which tags according to the universal dependencies tagset

³to prevent stigmatisation of the subreddit users we decided to not name it here.

⁴preceded by conditioned determiners

⁵informations in a text

⁶cf. Prince: speaker assumptions about hearer familiarity = assumed familiarity

⁷which should be weaker with growing distance between reference-referent

Table 2.1: data sample of distances df

| token | upos | target | pos | prepos | url_id | range | q | det | aut_id | total_mentions | dist | embed.score | dist_rel_within | dist_rel_all | dist_rel_obs | dist_rel_ref | embed_c | dist_rel_scaled |
|--------------|------|--------|---------|--------|--------|-------|---|-----|--------|----------------|------|-------------|-----------------|--------------|--------------|--------------|---------|-----------------|
| cup | NOUN | obs | 435059 | NOUN | 671 | 5636 | a | 0 | 469 | 4 | 10 | 23.39 | 3 | 6 | 3 | 8 | -18.92 | 0.00 |
| burgers | NOUN | ref | 218584 | ADP | 1952 | 1852 | a | 0 | 5487 | 13 | 13 | 37.10 | 31 | 22 | 13 | 31 | -5.20 | 0.01 |
| pew | NOUN | obs | 162343 | DET | 319 | 1066 | d | 1 | 704 | 2 | 1 | 27.96 | 2 | 3 | 2 | 4 | -14.34 | 0.00 |
| practitioner | NOUN | obs | 797319 | NOUN | 1242 | 2322 | a | 0 | 118 | 2 | 846 | 40.80 | 693 | 1168 | 693 | 1634 | -1.51 | 0.36 |
| time | NOUN | ref | 173467 | VERB | 1929 | 6064 | a | 0 | 5053 | 19 | 84 | 28.94 | 62 | 44 | 26 | 62 | -13.37 | 0.01 |
| People | NOUN | ref | 341149 | ADJ | 1993 | 2432 | a | 0 | 6472 | 22 | 6 | 37.70 | 11 | 8 | 5 | 11 | -4.61 | 0.00 |
| meds | NOUN | obs | 143331 | PRON | 289 | 603 | f | 0 | 33 | 3 | 106 | 49.94 | 334 | 563 | 334 | 789 | 7.63 | 0.18 |
| trans | NOUN | obs | 635022 | ADV | 931 | 3941 | a | 0 | 118 | 41 | 174 | 40.28 | 84 | 141 | 84 | 198 | -2.02 | 0.04 |
| part | NOUN | ref | 591749 | NOUN | 2103 | 4162 | a | 0 | 5961 | 2 | 476 | 44.63 | 513 | 367 | 218 | 513 | 2.33 | 0.11 |
| cure | NOUN | obs | 1015639 | DET | 1554 | 1583 | d | 1 | 127 | 16 | 25 | 38.55 | 30 | 51 | 30 | 71 | -3.75 | 0.02 |

maintained by De Marneffe et al. (2021). Still the available data can only, within the pipeline of steadily growing the corpus and devising the noun distances developed be just a starting point from where with more datapoints statistical evaluation becomes relevant.

The dataframe used for our model (actual: dataset 13) consists of 142321 distance datapoints (sample cf. Tab. 2.1 below) derived from the posttagged corpus. Because the ranges of the url threads vary heavily between target and reference corpus, the distances are (in evaluation M1) normalised to the target corpus (cf. Fig. 3.5 for the raw vs. normalised distances comparison.) Outliers are excluded from the analysis since they very probably do not fulfill to can be counted as anaphoric references. We silently assume that all of the noun distances which are not by value excluded as outliers occur as anaphoric references. A manual annotation and close reading of the text would be necessary to exactly determine whether the references are associated at all. This may be the task for another qualitative evaluation of our quantitative study.

2.5 methods

To compute distances we queried the corpus for matching conditions where certain (probable) determiners appear before analogue nouns (anaphors).

| condition | value |
|-----------|--------------------------|
| a | any !(b,c,d,e,f) |
| b | this, that, those, these |
| c | the |
| d | a, any, some |
| e | my |
| f | his, her, their, your |

We decided for these 5 sets of determiners in order to see whether distances maybe influenced if the duplicated nouns are preceded by them. We would expect condition **b** to show different if not reziproke effects as condition **d**⁸ and yet the texts in the reference corpus show the expected behaviour while in the target corpus not.

⁸which can be considered as a control condition as it should naturally allow wider distances between the following noun and the reference than all other conditions.

For each datapoint we collect variables as:

- thread url
- author (anonymised)
- thread length (tokens)
- lexical diversity (type/token ratio)
- lemma
- distance (to the preceding occurrence, e.g. for three occurrences of dog we collect 2 distance datapoints)

The main function to determine the distances runs on a subset of the corpus with only including all nouns and their position in the corpus. It finds all duplicated nouns per url thread and computes their distances by token position.

2.6 reflections

2.6.1 range

Evaluating with a growing corpus we interestingly find our basic hypothesis tested again, showing an overall larger distance of analogue nouns within the range of 1 thread url for the target corpus. While earlier we devised distances from a manually assigned url identifier we saw the necessity to define our “range of interest” according to the original http url of the thread, since with a growing corpus the old url ids - derived from the `get_thread_url()` method of the `redditExtractoR` package (Rivera (2023)) used for fetching the reddit content - there a no new url ids created since one url fetch gets each time always only around 1000 urls. To ensure unique url ranges within the corpus we assigned the range (within which the noun distance is calculated) to the real thread url. The corpus itself is after each fetch sorted after url and timestamp so it represents the real flow of conversation within one thread which is important since our distance model is based on the token distances within that thread and they have to follow their natural occurrence in time.

The url range is an important variable which we used for normalising the distance values since the mean distances could also depend on the overall thread length. For that we calculated for each normalisation method as are 1. per target, 2. within target and 3. cross target a range factor by which the distance values are divided. The final regression model posits fixed effects of condition, target, determiner, range and embed score (where target, condition and determiner are interacting) and random effects of thread and author.

2.6.2 author trace id

An important integrated feature can be the `aut_id` variable which represents the comment author and is unique to that. In the base .sqlite database the authors are already anonymised, so there should be no way from the published data back to the original author name of the

comment. And as expected, including `aut_id` as random effect in the linear regression model, the significance level for the covariables of interest as are

1. `q` = the condition matching of the noun-preceding token
2. `det` = whether that match has postag “DET”
3. `target` = obs or reference corpus

finally increases.

2.6.3 lexical diversity

We thought about some serious caveats in modeling the evaluation: If (lucky for our hypothesis) the target corpus has significantly higher distance scores over nearly all conditions, does that automatically indicate a less coherent reference-referent association within what is expressed in the comments? Couldn't we also assume that if the analogue nouns appear more distanced in general that a topic which is including these nouns is simply expanding over a wider range resp. timeframe? What does that mean for our assumptions in terms of coherence? A good way here could be to integrate a general lexical diversity factor per url as fixed effect because we can assume that a higher type/token ratio logically decreases the probability of a noun appearing multiple times within a range and we could take that effect into account.⁹

2.6.4 semantics, word field, embeddings

Further we created another covariable possible to integrate in the evaluation model: The semantic embedding of one specific noun appearing on its specific position in the thread range, computed with help of an open LL word embedding model (Nussbaum et al. (2024).) This is a common AI way of devising semantic relations in a corpus which exceeds a just frequency based keyword analysis. Using an LLM here allows for a distinctive identification of world field embeddings of the noun in question. In that way we get another variable linguistic feature extracted which may give general insights into the level of standardisation that applies to the corpora. So if a noun is found to be embedded with a high score into its context (the url thread) then it can be much expected to be found there and appears less out-of-context.¹⁰

2.6.5 statistics

In this context we thought about what it means statistically, if a high-score embedded word also ranks high in (distance) significance i.e. generally what the relations of the covariates in the context of the linear regression evaluation express. Let us picture this:

⁹this is as of model 1-6 not yet integrated in the analysis

¹⁰only according to the LLM training data, which is still a blackbox

1. a word receives a high embed score if it is highly semantically related to the context within which it appears, here the comment thread.
2. therefore the necessity to introduce/elaborate on it sinks, since it may be considered a “known” or “inferable” entity within the context given.
3. now if a person is using this word, the determined use appears less incoherent by itself.
4. the reference distance thus may increase without losing in coherence.
5. **conclusion:** if we for our linear regression use a (base) formula like `distance ~ corpus`, a continuous `embed_score` predictor between `-1` and `1` should correlate positive with the estimates for `dist` if applied correctly?

2.6.6 caveats

Since devising the word embed score does take much computing resources we had a script run on a server that solves the computing. But the first essay to integrate the new var into the evaluation model failed due to levels < 2 . Why? Because in the beginning we ran the script just over a few chunks of the complete url ranges in the corpus¹¹ which is sorted after target,¹² we did not compute any values for the reference corpus. So we learned this way again on linear regression models which require that a variable has more than one level (which would not be the case if the `lmer()` function excludes all NA rows: there simply would be no observations left with `target=ref` since all its `embed.score` values are NA (not yet calculated) and so all `target.ref` rows will be removed during regression.)

The issue is solved since we found a resource saving method of computing the embed scores with a local instance of ollama that provides an API to use the model.

2.7 model evaluations

2.7.1 covariances

Effects of the same direction for target OBS and REF are observed in `qc`, `range` (with positive effects in `qc`) while contrary effects are observed in `qb`, `qd`, `qe`, `qf`, `det`, `embed.score`, `qb:det`, `qd:det` (with negative effects in `target=obs` and `vcvs`) (cf. sec. 3.2).

In words:

- the antecedents `the` seem to allow a wider distance between referent and reference in both `target=OBS` and `target=REF`.
- the antecedents `this,that,these,those` - `my` - `your,their,his,her` decrease distance in `target=OBS` and increase distance values in `target=REF`; condition `d` (`a,an,some,any`) `vcvs`.

¹¹to spare resources

¹²where “obs” comes first

- higher `embed.score` values (better embedded noun) decrease distance in `target=OBS` and increase distance values in `target=REF`. (cf. par 3.7.5.4, better embedding allows wider distance > the expectation seems only valid for the reference corpus!)

sidenote: Positing the url range only as fixed effect instead of normalising the distances still estimates smaller distances for the reference corpus, but with no significance, the only significant difference with that regression formula shows in `target=REF` under condition e (antecedents: my).

2.7.2 model fazit

As you can cf. in the appendix with the separate coefficient tables for each evaluation model, we find over all normalised subsets (vs. obs/ref/all) significantly smaller distances in the reference corpus with varying effects for the conditions. In the subsets, where we didn't normalise or remove outliers, we find the opposite effect; the raw data does not prove our hypothesis. But just looking into the (raw) mean values plot of Fig. 3.7 we clearly see that normalising and removing outliers is necessary since mean distances there extend up to over 2000 tokens thus we wouldn't like to count all analogue noun occurrences here as anaphora.

2.8 conclusion

After evaluating over the different approaches we find our hypothesis proved, that anaphora distances in the target corpus (`target=OBS`) stretch over a significantly ($p < 0.001$) wider range of tokens between reference and referent in contrast to the chosen reference corpus. With our assumptions this could prove a less appropriate estimate for the coherence of the own texts produced in schizophrenic language still having in mind, that a wider distance is not stating incoherence in general but instead just that these speakers allow for a wider anaphora distance in their text production. If these distances indeed lead to less coherent texts compared to the reference corpus must be subject to close reading and annotating samples manually and questioning them in terms of coherence by skilled readers though annotation may vary strongly depending on the disposition of readers and their general capacities of inferring references. But if we agree that shorter reference distances increase text coherence then we might say the texts produced in the target corpus are less coherent than those in the reference corpus which aligns with the common classification of patients language in psychiatry.

2.9 limitations

We had to do some silent assumptions, but the main limitation is that we will have to base our specification of the target corpus as being one that is containing schizophrenic language mainly on the statements of the reddit users in our target corpus which do describe themselves

as being diagnosed schizophrene to a large amount. To what extend these statements and assignments or identifications are true we cannot say and therefore limit the value of our findings only to that group of speakers.

Chapter 3

appendix

overall wordcount of paper: 3149.

3.1 legende

Table 3.1: model vars

| variable | explanation | values |
|-------------|--|-------------------------|
| target | corpus | obs,ref |
| q | condition | a,b,c,d,e,f |
| det | antecedent POS==DET | TRUE,FALSE |
| aut_id | author | author hash |
| lemma | lemma | noun lemma |
| range | url range of distance devised | 1..maxlength(urlthread) |
| embed.score | semantic similarity score lemma vs. thread | 0:1 (scaled 0:100) |
| q:a | query condition | any !{b,c,d,e,f} |
| q:b | query condition | this,that,those,these |
| q:c | query condition | the |
| q:d | query condition | a,an,any,some |
| q:e | query condition | my |
| q:f | query condition | his,her,their,your |

3.2 covariance effects in M1

```
## 19 x 19 Matrix of class "dpoMatrix"
##          (Intercept)  targetref          qb          qc
## (Intercept)  26.611291427 -5.408939785 -6.567060e-01  2.187928e-01
## targetref   -5.408939785  39.674221230  1.207098e+00  3.523953e-02
```

```

## qb          -0.656706044  1.207097617  2.331532e+02  4.972520e-02
## qc           0.218792760  0.035239530  4.972520e-02  3.023656e+01
## qd           0.213024201 -0.057995645 -1.123020e-01  2.139728e+01
## qe          -1.181562270  1.364128578  1.204280e+00  1.804251e-02
## qf          -0.999266163  1.466700458  1.321795e+00  7.762191e-02
## det         -1.792510882  1.297436814  1.285782e+00 -2.140515e+01
## range       -0.003430091 -0.004456289 -5.684751e-05 -1.771291e-06
## embed.score -0.304346598  0.003347917 -9.761775e-03 -5.578520e-03
## targetref:qb  0.654394998 -2.080569798 -2.331546e+02 -4.868618e-02
## targetref:qc -0.359874020  0.021438617 -5.243550e-02 -3.024022e+01
## targetref:qd -0.027304750  0.042580295  1.179001e-01 -2.139480e+01
## targetref:qe  1.174698802 -2.255321684 -1.203769e+00 -1.838955e-02
## targetref:qf  1.131431154 -2.338162076 -1.319105e+00 -7.419652e-02
## targetref:det 1.811527451 -2.212790533 -1.286549e+00  2.140615e+01
## qb:det       0.848433419 -0.992845654 -2.331005e+02  2.141809e+01
## qd:det       -0.311056815  0.114084228 -1.000347e-02 -4.340561e-03
## targetref:qb:det -0.716556378  1.847108798  2.331077e+02 -2.141755e+01
##
##                qd                qe                qf                det
## (Intercept)    2.130242e-01 -1.181562e+00 -9.992662e-01 -1.792511e+00
## targetref      -5.799564e-02  1.364129e+00  1.466700e+00  1.297437e+00
## qb            -1.123020e-01  1.204280e+00  1.321795e+00  1.285782e+00
## qc            2.139728e+01  1.804251e-02  7.762191e-02 -2.140515e+01
## qd            4.951568e+04 -3.122280e-02 -1.314356e-03 -2.147507e+01
## qe           -3.122280e-02  1.471083e+01  1.256452e+00  1.298793e+00
## qf           -1.314356e-03  1.256452e+00  2.393642e+01  1.298587e+00
## det          -2.147507e+01  1.298793e+00  1.298587e+00  2.279447e+01
## range        -3.063886e-05  1.601799e-05  2.964445e-05  1.314184e-05
## embed.score   -5.250995e-03 -5.662857e-03 -1.123025e-02  1.088365e-02
## targetref:qb  2.337161e+00 -1.204734e+00 -1.320686e+00 -1.286510e+00
## targetref:qc -1.144880e+02 -2.043544e-02 -8.345716e-02  2.141138e+01
## targetref:qd -1.572741e+02  3.386100e-02  6.049089e-03  2.146985e+01
## targetref:qe  4.821807e-01 -1.470978e+01 -1.257873e+00 -1.298964e+00
## targetref:qf  5.162239e-01 -1.257490e+00 -2.392701e+01 -1.301955e+00
## targetref:det 1.153981e+02 -1.298512e+00 -1.297449e+00 -2.279625e+01
## qb:det        2.160561e+01 -1.229842e+00 -1.099137e+00 -2.275232e+01
## qd:det        -4.948523e+04 -6.757926e-03 -7.304582e-03  1.082133e-02
## targetref:qb:det -1.180455e+02  1.233269e+00  1.101642e+00  2.274935e+01
##
##                range    embed.score    targetref:qb    targetref:qc
## (Intercept)   -3.430091e-03 -3.043466e-01  6.543950e-01 -3.598740e-01
## targetref     -4.456289e-03  3.347917e-03 -2.080570e+00  2.143862e-02
## qb           -5.684751e-05 -9.761775e-03 -2.331546e+02 -5.243550e-02
## qc           -1.771291e-06 -5.578520e-03 -4.868618e-02 -3.024022e+01
## qd           -3.063886e-05 -5.250995e-03  2.337161e+00 -1.144880e+02
## qe            1.601799e-05 -5.662857e-03 -1.204734e+00 -2.043544e-02
## qf            2.964445e-05 -1.123025e-02 -1.320686e+00 -8.345716e-02

```

```

## det          1.314184e-05  1.088365e-02 -1.286510e+00  2.141138e+01
## range        3.267330e-06  9.235581e-06  5.866084e-05  7.093443e-06
## embed.score  9.235581e-06  6.497771e-03  9.771409e-03  8.618392e-03
## targetref:qb 5.866084e-05  9.771409e-03  2.953345e+02  1.560137e-02
## targetref:qc 7.093443e-06  8.618392e-03  1.560137e-02  1.635460e+02
## targetref:qd -1.261267e-05  2.039760e-03 -1.220460e-01  1.153485e+02
## targetref:qe -9.407763e-06  5.516501e-03  2.087695e+00  8.220805e-03
## targetref:qf -4.502403e-05  9.146142e-03  2.189894e+00  3.583894e-02
## targetref:det -1.113598e-05 -1.136072e-02  2.176777e+00 -1.153443e+02
## qb:det       7.012525e-05  1.842562e-03  2.331055e+02 -2.142179e+01
## qd:det       3.758041e-05  6.309983e-03 -2.213302e+00  9.309397e+01
## targetref:qb:det -7.935980e-05 -4.612123e-03 -2.952775e+02  1.154446e+02
##
## targetref:qd targetref:qe targetref:qf targetref:det
## (Intercept) -2.730475e-02  1.174699e+00  1.131431e+00  1.811527e+00
## targetref    4.258029e-02 -2.255322e+00 -2.338162e+00 -2.212791e+00
## qb          1.179001e-01 -1.203769e+00 -1.319105e+00 -1.286549e+00
## qc          -2.139480e+01 -1.838955e-02 -7.419652e-02  2.140615e+01
## qd          -1.572741e+02  4.821807e-01  5.162239e-01  1.153981e+02
## qe          3.386100e-02 -1.470978e+01 -1.257490e+00 -1.298512e+00
## qf          6.049089e-03 -1.257873e+00 -2.392701e+01 -1.297449e+00
## det         2.146985e+01 -1.298964e+00 -1.301955e+00 -2.279625e+01
## range       -1.261267e-05 -9.407763e-06 -4.502403e-05 -1.113598e-05
## embed.score 2.039760e-03  5.516501e-03  9.146142e-03 -1.136072e-02
## targetref:qb -1.220460e-01  2.087695e+00  2.189894e+00  2.176777e+00
## targetref:qc 1.153485e+02  8.220805e-03  3.583894e-02 -1.153443e+02
## targetref:qd 1.573349e+02 -7.247316e-02 -4.640418e-02 -1.153777e+02
## targetref:qe -7.247316e-02  9.045770e+01  2.025662e+00  2.155388e+00
## targetref:qf -4.640418e-02  2.025662e+00  1.465018e+02  2.156294e+00
## targetref:det -1.153777e+02  2.155388e+00  2.156294e+00  1.175653e+02
## qb:det       -2.160838e+01  1.225973e+00  1.110890e+00  2.275511e+01
## qd:det       1.268228e+02 -4.451085e-01 -5.050676e-01 -9.393291e+01
## targetref:qb:det 1.155367e+02 -2.226150e+00 -1.965015e+00 -1.175746e+02
##
## qb:det       qd:det targetref:qb:det
## (Intercept)  8.484334e-01 -3.110568e-01 -7.165564e-01
## targetref    -9.928457e-01  1.140842e-01  1.847109e+00
## qb          -2.331005e+02 -1.000347e-02  2.331077e+02
## qc          2.141809e+01 -4.340561e-03 -2.141755e+01
## qd          2.160561e+01 -4.948523e+04 -1.180455e+02
## qe          -1.229842e+00 -6.757926e-03  1.233269e+00
## qf          -1.099137e+00 -7.304582e-03  1.101642e+00
## det         -2.275232e+01  1.082133e-02  2.274935e+01
## range        7.012525e-05  3.758041e-05 -7.935980e-05
## embed.score  1.842562e-03  6.309983e-03 -4.612123e-03
## targetref:qb 2.331055e+02 -2.213302e+00 -2.952775e+02
## targetref:qc -2.142179e+01  9.309397e+01  1.154446e+02

```

```

## targetref:qd      -2.160838e+01  1.268228e+02   1.155367e+02
## targetref:qe       1.225973e+00 -4.451085e-01   -2.226150e+00
## targetref:qf       1.110890e+00 -5.050676e-01   -1.965015e+00
## targetref:det      2.275511e+01 -9.393291e+01   -1.175746e+02
## qb:det             2.814856e+02  9.338525e-03   -2.814960e+02
## qd:det             9.338525e-03  4.948523e+04   9.642721e+01
## targetref:qb:det  -2.814960e+02  9.642721e+01   5.994966e+02

```

3.3 evaluation model: 1

3.3.1 meta

eval output data: 13, normalised to obs, distance ceiling = outliers removed

3.3.2 parameter setting

```

##                value
## norm_target _rel_obs
## det.t          TRUE
## limit          TRUE
## author         TRUE
## url            TRUE
## embed1         TRUE
## embed2         f
## range1         TRUE
## range2         f
## rel            TRUE
## lme            FALSE
## lemma          FALSE

```

3.3.3 anova analysis

3.3.3.1 anova plain

formula: [dist_rel_obs ~ target*q*det]

```

##                Df      Sum Sq   Mean Sq  F value    Pr(>F)
## target          1  452303747  452303747 7336.4625 < 2.2e-16 ***
## q                5   12320667    2464133   39.9688 < 2.2e-16 ***
## det              1    1636109    1636109   26.5380 2.588e-07 ***
## target:q         5    2747371     549474    8.9126 1.786e-08 ***
## target:det       1     251297     251297    4.0761 0.043496 *

```

```
## q:det          2      905292      452646      7.3420  0.000648 ***
## target:q:det   1      717222      717222     11.6335  0.000648 ***
## Residuals     126209 7780971239      61651
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.3.3.2 anova of linear regression model

```
[anova(summary(lmer))]
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq Mean Sq NumDF DenDF  F value    Pr(>F)
## target          1144219  1144219      1   3519   23.4567 1.333e-06 ***
## q                737483   147497      5 122421    3.0237 0.0098706 **
## det              12165     12165      1 118425    0.2494 0.6175055
## range           50399647 50399647      1   1025 1033.2042 < 2.2e-16 ***
## embed.score     25101881 25101881      1 122690   514.5942 < 2.2e-16 ***
## target:q         776335    155267      5 123486    3.1830 0.0070933 **
## target:det       541078    541078      1 123325   11.0922 0.0008672 ***
## q:det            359520    179760      2 120804    3.6851 0.0250971 *
## target:q:det     219844    219844      1 123315    4.5068 0.0337615 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.3.3.3 linear regression coefficients

```
formula: [dist_rel_obs ~ target*q*det+(1|aut_id)+range+(embed.score)+(1|url_id)]
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: eval(expr(lmeform))
## Data: dfa
##
## REML criterion at convergence: 1727648
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.8643 -0.5282 -0.1721  0.2469  6.9244
##
## Random effects:
## Groups Name Variance Std.Dev.
## aut_id (Intercept) 2856     53.44
## url_id (Intercept) 8187     90.48
```

```

## Residual          48780    220.86
## Number of obs: 126226, groups:  aut_id, 8238; url_id, 2145
##
## Fixed effects:
##
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   4.625e+02  5.159e+00  8.969e+03  89.651 < 2e-16 ***
## targetref    -4.342e+01  6.299e+00  1.300e+03  -6.893 8.50e-12 ***
## qb           -2.013e+01  1.527e+01  1.218e+05  -1.318 0.187483
## qc           -2.207e+01  5.499e+00  1.226e+05  -4.014 5.98e-05 ***
## qd           -3.178e+01  2.225e+02  1.184e+05  -0.143 0.886426
## qe           2.492e+01  3.835e+00  1.247e+05   6.498 8.14e-11 ***
## qf           -1.891e+01  4.892e+00  1.244e+05  -3.866 0.000111 ***
## det          1.273e+01  4.774e+00  1.229e+05   2.667 0.007662 **
## range        -5.810e-02  1.808e-03  1.025e+03 -32.143 < 2e-16 ***
## embed.score  -1.829e+00  8.061e-02  1.227e+05 -22.685 < 2e-16 ***
## targetref:qb  1.862e+01  1.719e+01  1.225e+05   1.083 0.278599
## targetref:qc  2.281e+01  1.279e+01  1.237e+05   1.784 0.074435 .
## targetref:qd  4.413e-01  1.254e+01  1.238e+05   0.035 0.971935
## targetref:qe -2.321e+01  9.511e+00  1.239e+05  -2.441 0.014662 *
## targetref:qf  1.801e+01  1.210e+01  1.238e+05   1.488 0.136766
## targetref:det -1.478e+01  1.084e+01  1.239e+05  -1.363 0.172784
## qb:det       5.915e+01  1.678e+01  1.219e+05   3.526 0.000423 ***
## qd:det       3.648e+01  2.225e+02  1.184e+05   0.164 0.869736
## targetref:qb:det -5.198e+01  2.448e+01  1.233e+05  -2.123 0.033761 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## fit warnings:
## fixed-effect model matrix is rank deficient so dropping 7 columns / coefficients
## Some predictor variables are on very different scales: consider rescaling

```

3.3.4 plots

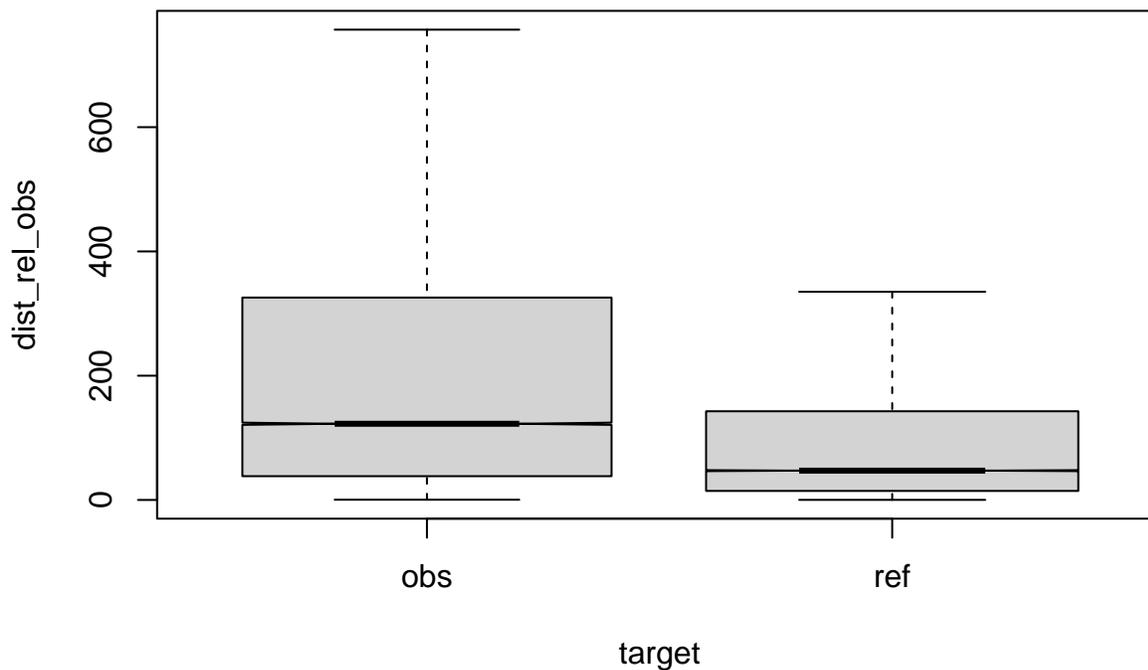


Figure 3.1: compare distances by corpus, normalised to obs, distance ceiling = outliers removed

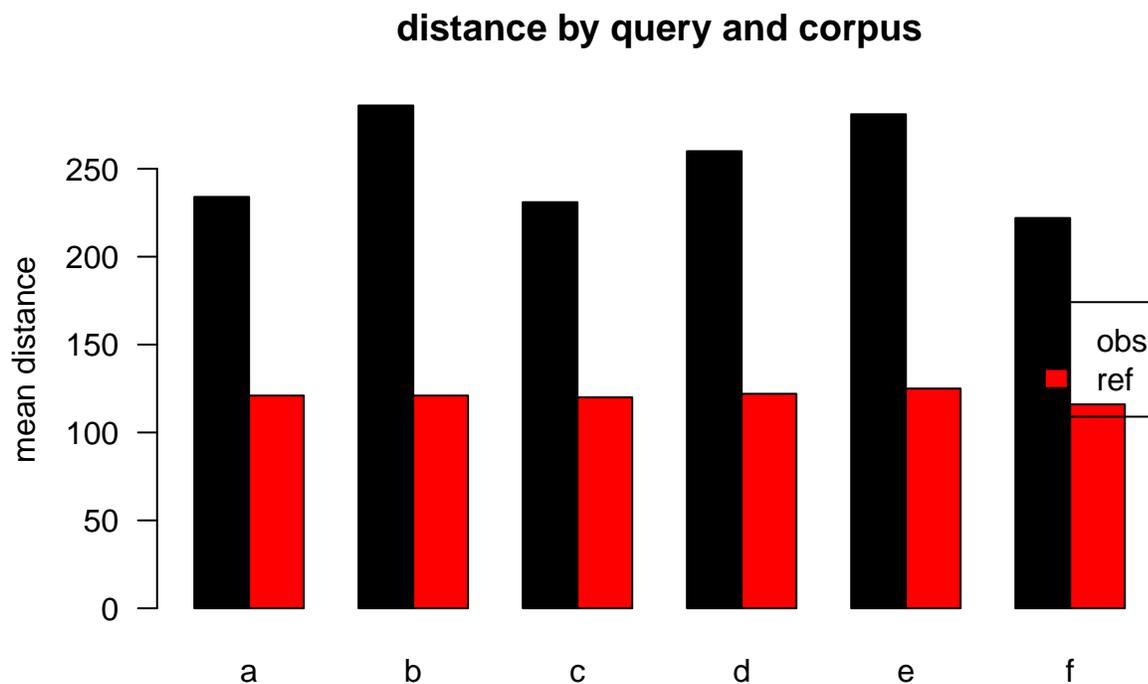


Figure 3.2: mean distances over query/corpus, normalised to obs, distance ceiling = outliers removed

Table 3.2: mean/median table for model: 1

| target | q | n | mean | median |
|--------|---|-------|------|--------|
| obs | a | 42836 | 234 | 117 |
| ref | a | 58615 | 121 | 47 |
| obs | b | 2116 | 286 | 165 |
| ref | b | 1130 | 121 | 44 |
| obs | c | 5770 | 231 | 114 |
| ref | c | 1274 | 120 | 48 |
| obs | d | 5654 | 260 | 144 |
| ref | d | 1525 | 122 | 49 |
| obs | e | 3911 | 281 | 147 |
| ref | e | 671 | 125 | 45 |
| obs | f | 2311 | 222 | 133 |
| ref | f | 413 | 116 | 47 |

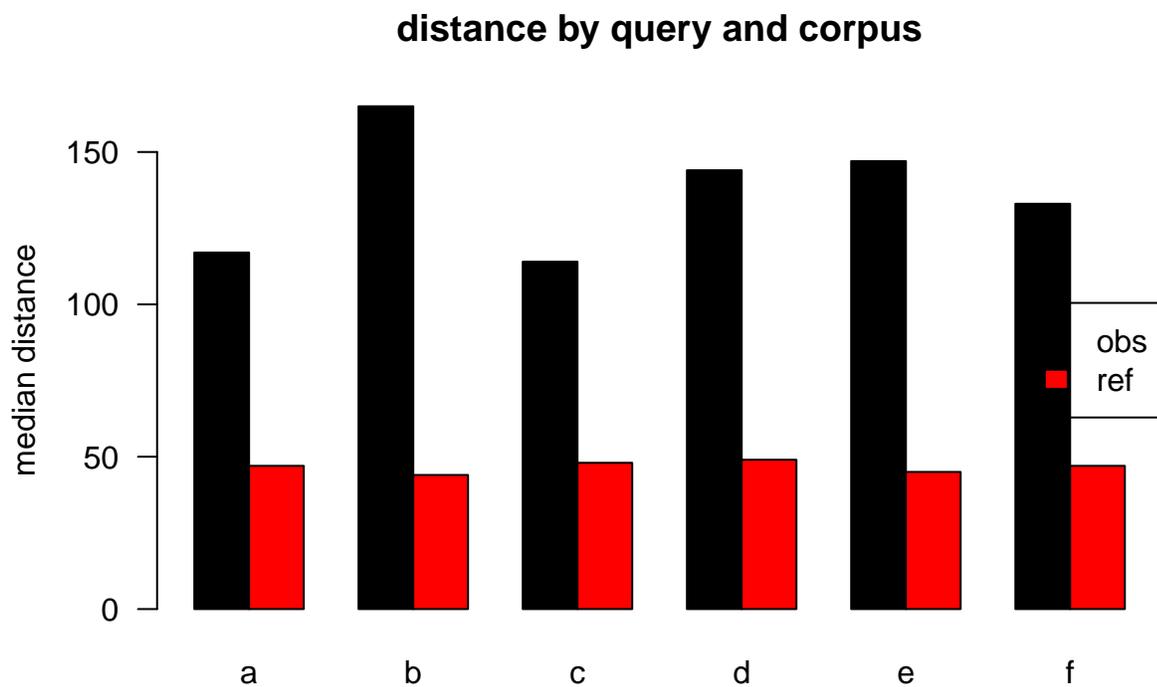


Figure 3.3: median distances over query/corpus, normalised to obs, distance ceiling = outliers removed

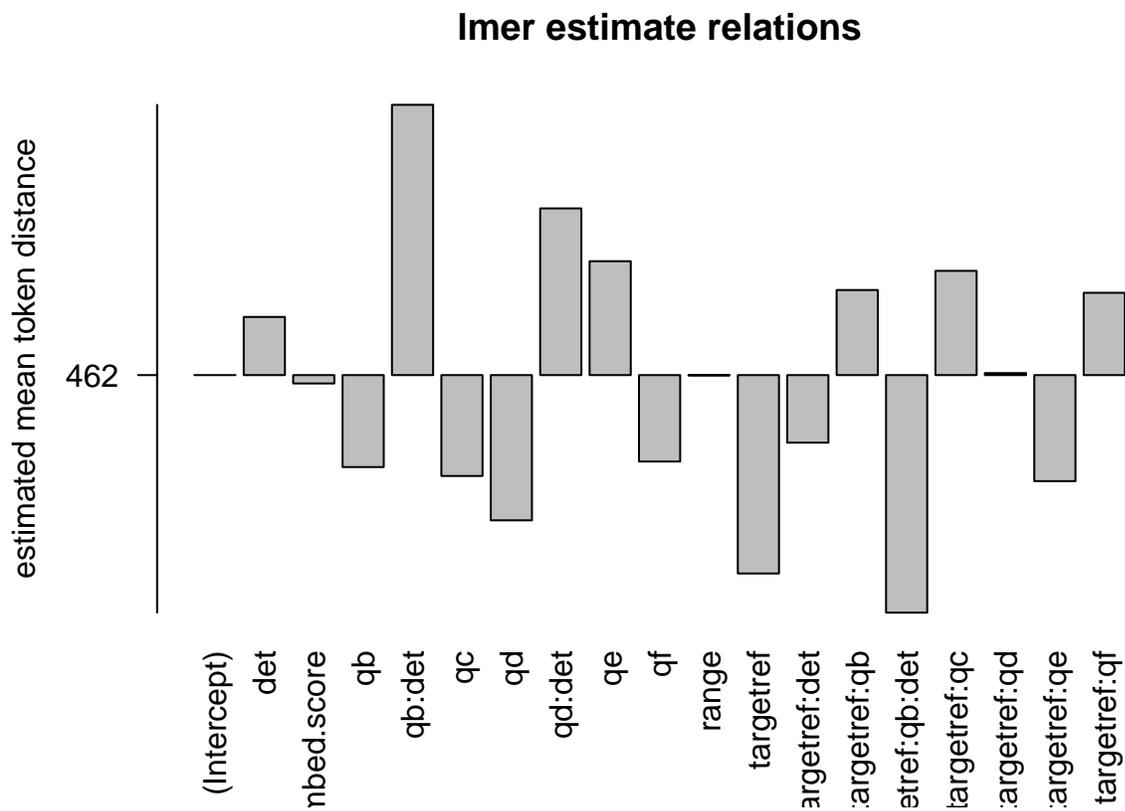


Figure 3.4: distances relation, normalised to obs, distance ceiling = outliers removed

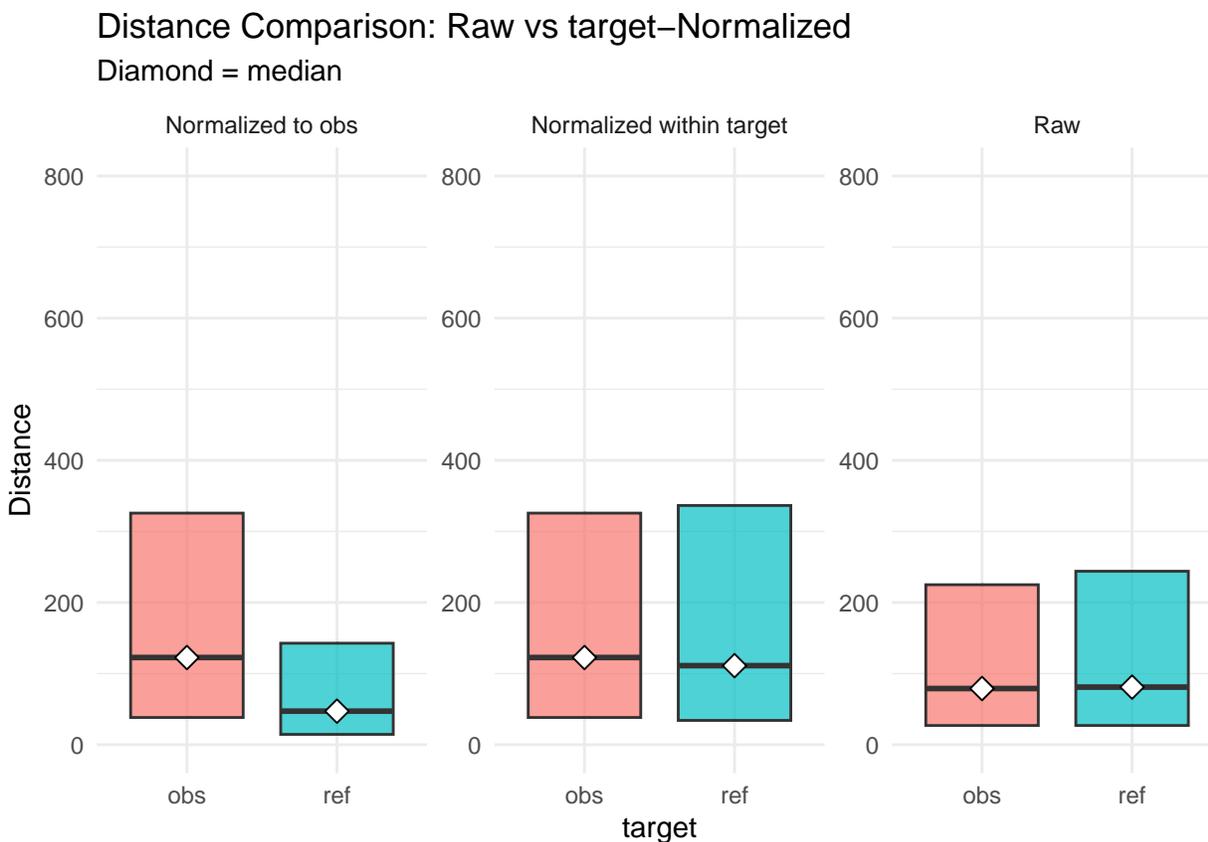


Figure 3.5: distances normalised vs. raw

3.4 evaluation model: 2

3.4.1 meta

eval output data: 13, not normalised, distance ceiling =outliers not removed

3.4.2 parameter setting

```
##          value
## norm_target
## det.t    TRUE
## limit    FALSE
## author   TRUE
## url      TRUE
## embed1   TRUE
## embed2   f
## range1   TRUE
## range2   f
```

```
## rel          FALSE
## lme          FALSE
## lemma       FALSE
```

3.4.3 anova analysis

3.4.3.1 anova plain

```
formula: [dist ~ target*q*det]
```

```
##           Df      Sum Sq   Mean Sq  F value  Pr(>F)
## target      1 1.1152e+11 1.1152e+11 268.8154 < 2e-16 ***
## q           5 9.8792e+08 1.9758e+08   0.4763 0.79425
## det         1 4.1537e+08 4.1537e+08   1.0012 0.31702
## target:q    5 2.3050e+09 4.6101e+08   1.1112 0.35184
## target:det  1 2.7199e+09 2.7199e+09   6.5561 0.01045 *
## q:det       2 2.4028e+08 1.2014e+08   0.2896 0.74857
## target:q:det 1 7.0024e+06 7.0024e+06   0.0169 0.89663
## Residuals 142304 5.9037e+13 4.1487e+08
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.4.3.2 anova of linear regression model

```
[anova(summary(lmer))]
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq   Mean Sq NumDF  DenDF  F value  Pr(>F)
## target      1.2717e+09 1.2717e+09     1   3751   5.5781 0.01824 *
## q           6.3534e+08 1.2707e+08     5 137654   0.5574 0.73281
## det         7.3359e+05 7.3359e+05     1 133172   0.0032 0.95476
## range       2.8637e+07 2.8637e+07     1   2113   0.1256 0.72307
## embed.score 2.7199e+10 2.7199e+10     1 141732 119.3005 < 2e-16 ***
## target:q    3.0753e+09 6.1507e+08     5 138840   2.6979 0.01920 *
## target:det  8.1028e+08 8.1028e+08     1 138434   3.5541 0.05940 .
## q:det       4.8717e+08 2.4358e+08     2 135770   1.0684 0.34355
## target:q:det 2.4585e+06 2.4585e+06     1 138496   0.0108 0.91729
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.4.3.3 linear regression coefficients

```
formula: [dist ~ target*q*det+(1|aut_id)+range+(embed.score)+(1|url_id)]
```

```

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: eval(expr(lmeform))
## Data: dfa
##
## REML criterion at convergence: 3153653
##
## Scaled residuals:
##   Min       1Q   Median       3Q      Max
## -23.760 -0.034 -0.006  0.025  55.672
##
## Random effects:
## Groups Name Variance Std.Dev.
## aut_id (Intercept) 28986087 5384
## url_id (Intercept) 98382081 9919
## Residual 227983587 15099
## Number of obs: 142321, groups: aut_id, 8395; url_id, 2145
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)  2.873e+03  4.211e+02  8.594e+03  6.823 9.53e-12 ***
## targetref    1.341e+03  6.536e+02  2.412e+03  2.051  0.0404 *
## qb           6.895e+01  1.008e+03  1.363e+05  0.068  0.9454
## qc          -6.307e+02  3.622e+02  1.372e+05 -1.741  0.0816 .
## qd          -1.993e+03  1.522e+04  1.332e+05 -0.131  0.8958
## qe          -1.006e+02  2.520e+02  1.385e+05 -0.399  0.6899
## qf          -1.355e+02  3.218e+02  1.384e+05 -0.421  0.6737
## det          7.031e+02  3.145e+02  1.375e+05  2.236  0.0254 *
## range        6.798e-02  1.918e-01  2.113e+03  0.354  0.7231
## embed.score  -5.793e+01  5.304e+00  1.417e+05 -10.922 < 2e-16 ***
## targetref:qb  6.675e+02  1.124e+03  1.371e+05  0.594  0.5527
## targetref:qc  3.752e+01  8.128e+02  1.395e+05  0.046  0.9632
## targetref:qd  2.022e+03  7.989e+02  1.395e+05  2.531  0.0114 *
## targetref:qe  2.269e+02  6.042e+02  1.395e+05  0.376  0.7073
## targetref:qf  3.210e+02  7.643e+02  1.393e+05  0.420  0.6745
## targetref:det -1.416e+03  6.890e+02  1.397e+05 -2.055  0.0398 *
## qb:det       -1.077e+03  1.107e+03  1.364e+05 -0.973  0.3304
## qd:det        1.039e+03  1.521e+04  1.332e+05  0.068  0.9456
## targetref:qb:det -1.651e+02  1.590e+03  1.385e+05 -0.104  0.9173
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## fit warnings:
## fixed-effect model matrix is rank deficient so dropping 7 columns / coefficients
## Some predictor variables are on very different scales: consider rescaling

```

3.4.4 plots

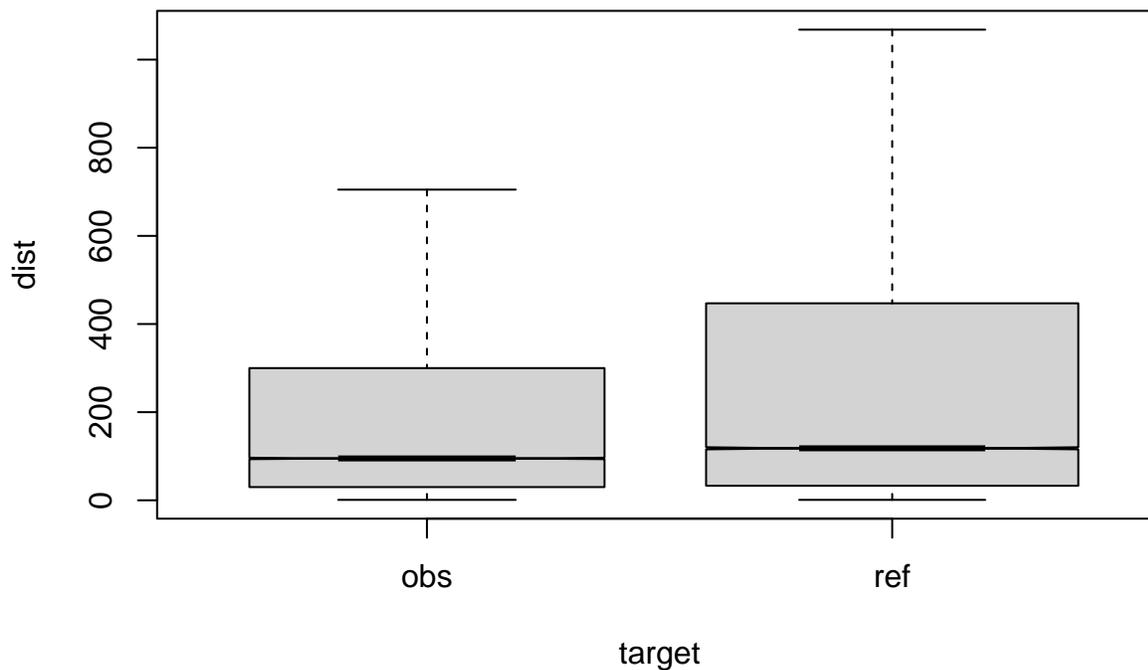


Figure 3.6: compare distances by corpus, not normalised, distance ceiling =outliers not removed

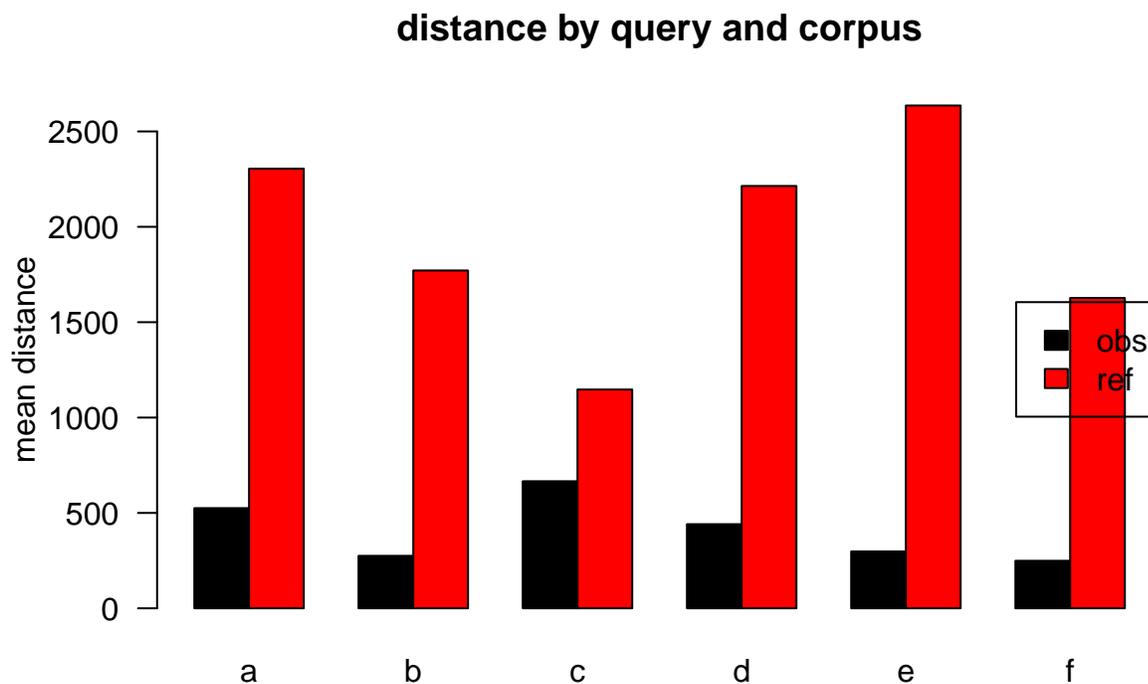


Figure 3.7: mean distances over query/corpus, not normalised, distance ceiling =outliers not removed

Table 3.3: mean/median table for model: 2

| target | q | n | mean | median |
|--------|---|-------|------|--------|
| obs | a | 46318 | 525 | 92 |
| ref | a | 68618 | 2305 | 118 |
| obs | b | 2287 | 275 | 109 |
| ref | b | 1315 | 1771 | 111 |
| obs | c | 6253 | 666 | 89 |
| ref | c | 1504 | 1147 | 119 |
| obs | d | 6171 | 441 | 105 |
| ref | d | 1765 | 2214 | 124 |
| obs | e | 4278 | 298 | 109 |
| ref | e | 795 | 2636 | 116 |
| obs | f | 2520 | 249 | 77 |
| ref | f | 497 | 1627 | 124 |

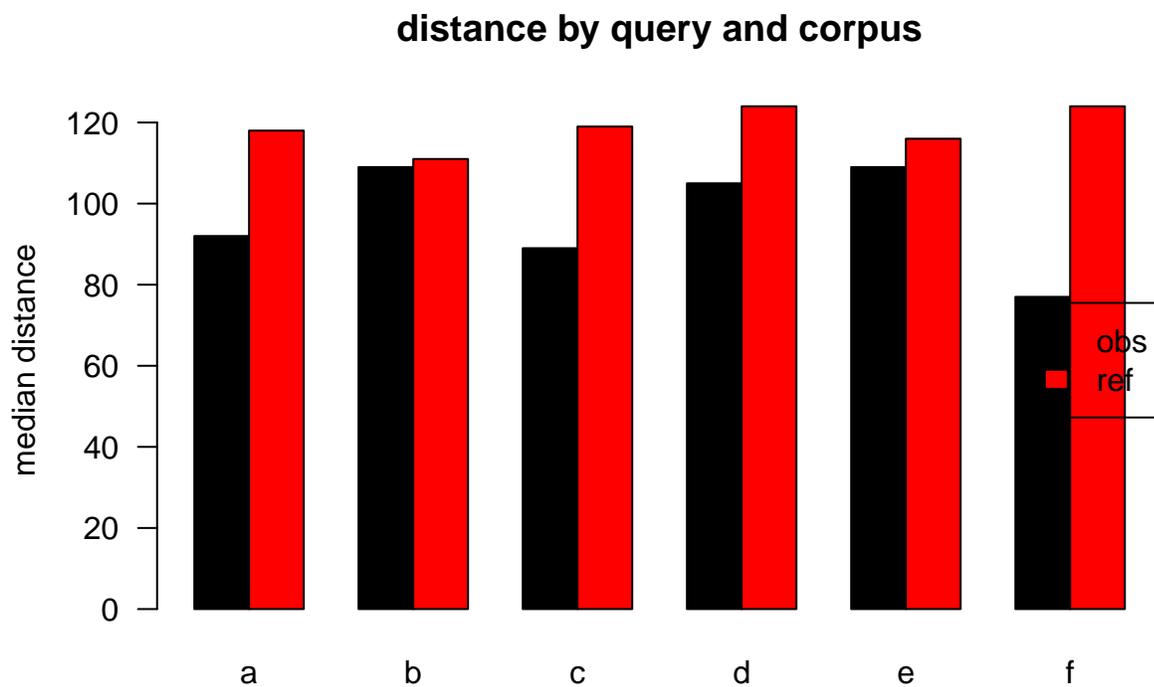


Figure 3.8: median distances over query/corpus, not normalised, distance ceiling =outliers not removed

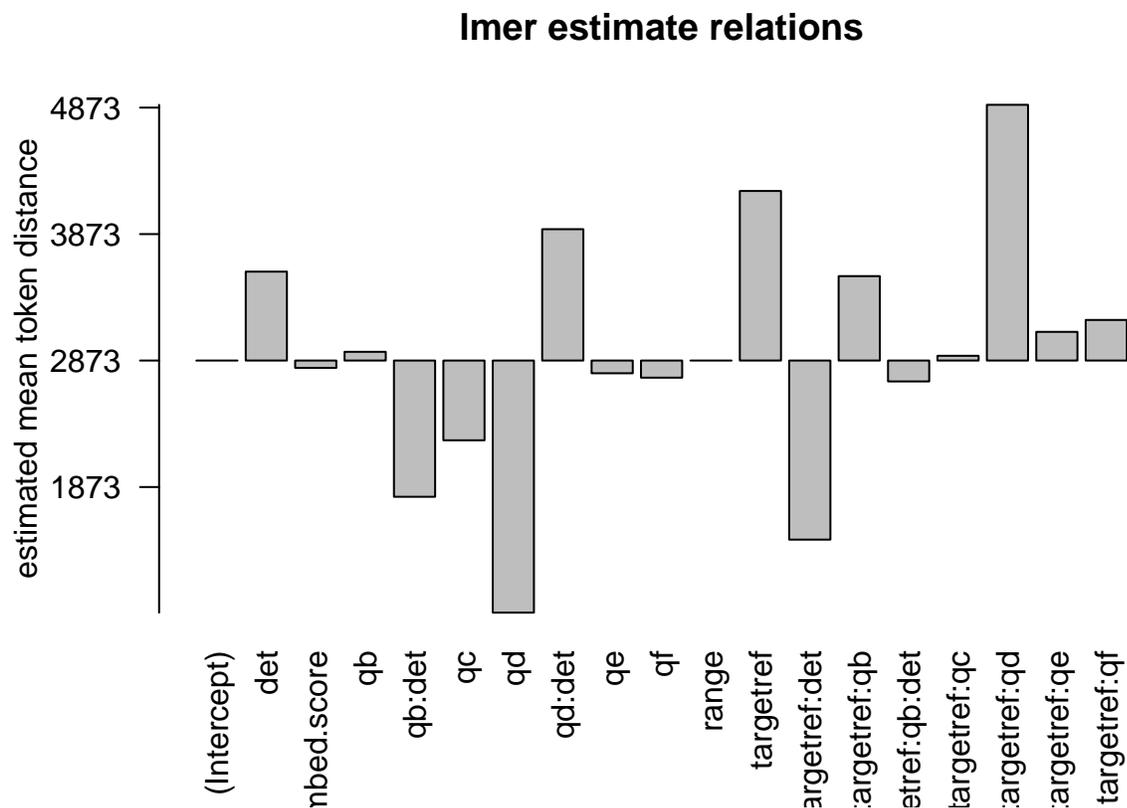


Figure 3.9: distances relation, not normalised, distance ceiling = outliers not removed

3.5 evaluation model: 3

3.5.1 meta

eval output data: 13, normalised to all, distance ceiling = outliers removed

3.5.2 parameter setting

```
##           value
## norm_target _rel_all
## det.t      TRUE
## limit     TRUE
## author    TRUE
## url       TRUE
## embed1    TRUE
## embed2     f
## range1    TRUE
## range2     f
## rel      TRUE
```

```
## lme          FALSE
## lemma       FALSE
```

3.5.3 anova analysis

3.5.3.1 anova plain

```
formula: [dist_rel_all ~ target*q*det]
```

```
##           Df      Sum Sq   Mean Sq   F value   Pr(>F)
## target      1 1.2830e+09 1283010757 7336.4625 < 2.2e-16 ***
## q           5 3.4949e+07   6989793   39.9688 < 2.2e-16 ***
## det         1 4.6410e+06    4641007   26.5380 2.588e-07 ***
## target:q    5 7.7932e+06    1558646    8.9126 1.786e-08 ***
## target:det  1 7.1283e+05     712833    4.0761 0.043496 *
## q:det       2 2.5680e+06    1283981    7.3420 0.000648 ***
## target:q:det 1 2.0345e+06    2034482   11.6335 0.000648 ***
## Residuals 126209 2.2072e+10    174881
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.5.3.2 anova of linear regression model

```
[anova(summary(lmer))]
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq   Mean Sq NumDF  DenDF   F value   Pr(>F)
## target      3245706   3245706     1   3519   23.4567 1.333e-06 ***
## q           2091953    418391     5 122421    3.0237 0.0098706 **
## det          34508     34508     1 118425    0.2494 0.6175055
## range      142964302 142964302     1   1025 1033.2042 < 2.2e-16 ***
## embed.score 71204325 71204325     1 122690 514.5942 < 2.2e-16 ***
## target:q    2202162    440432     5 123486    3.1830 0.0070933 **
## target:det  1534830    1534830     1 123325   11.0922 0.0008672 ***
## q:det       1019818    509909     2 120804    3.6851 0.0250971 *
## target:q:det 623611     623611     1 123315    4.5068 0.0337615 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.5.3.3 linear regression coefficients

```
formula: [dist_rel_all ~ target*q*det+(1|aut_id)+range+(embed.score)+(1|url_id)]
```

```

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: eval(expr(lmeform))
## Data: dfa
##
## REML criterion at convergence: 1859233
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.8643 -0.5282 -0.1721  0.2469  6.9244
##
## Random effects:
## Groups Name Variance Std.Dev.
## aut_id (Intercept) 8101 90.01
## url_id (Intercept) 23223 152.39
## Residual 138370 371.98
## Number of obs: 126226, groups: aut_id, 8238; url_id, 2145
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 7.789e+02 8.688e+00 8.969e+03 89.651 < 2e-16 ***
## targetref -7.312e+01 1.061e+01 1.300e+03 -6.893 8.50e-12 ***
## qb -3.390e+01 2.572e+01 1.218e+05 -1.318 0.187483
## qc -3.717e+01 9.261e+00 1.226e+05 -4.014 5.98e-05 ***
## qd -5.353e+01 3.748e+02 1.184e+05 -0.143 0.886426
## qe 4.198e+01 6.460e+00 1.247e+05 6.498 8.14e-11 ***
## qf -3.185e+01 8.240e+00 1.244e+05 -3.866 0.000111 ***
## det 2.144e+01 8.041e+00 1.229e+05 2.667 0.007662 **
## range -9.786e-02 3.044e-03 1.025e+03 -32.143 < 2e-16 ***
## embed.score -3.080e+00 1.358e-01 1.227e+05 -22.685 < 2e-16 ***
## targetref:qb 3.136e+01 2.894e+01 1.225e+05 1.083 0.278599
## targetref:qc 3.842e+01 2.154e+01 1.237e+05 1.784 0.074435 .
## targetref:qd 7.432e-01 2.113e+01 1.238e+05 0.035 0.971935
## targetref:qe -3.910e+01 1.602e+01 1.239e+05 -2.441 0.014662 *
## targetref:qf 3.033e+01 2.039e+01 1.238e+05 1.488 0.136766
## targetref:det -2.490e+01 1.826e+01 1.239e+05 -1.363 0.172784
## qb:det 9.962e+01 2.826e+01 1.219e+05 3.526 0.000423 ***
## qd:det 6.144e+01 3.747e+02 1.184e+05 0.164 0.869736
## targetref:qb:det -8.754e+01 4.124e+01 1.233e+05 -2.123 0.033761 *
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## fit warnings:
## fixed-effect model matrix is rank deficient so dropping 7 columns / coefficients
## Some predictor variables are on very different scales: consider rescaling

```

3.5.4 plots

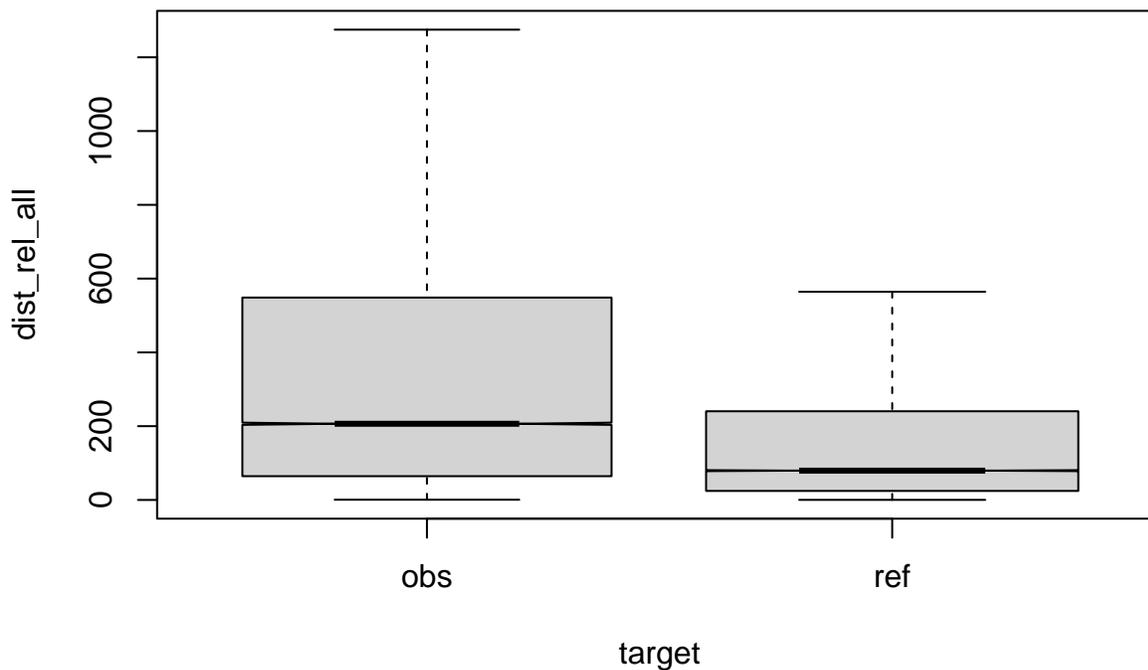


Figure 3.10: compare distances by corpus, normalised to all, distance ceiling = outliers removed

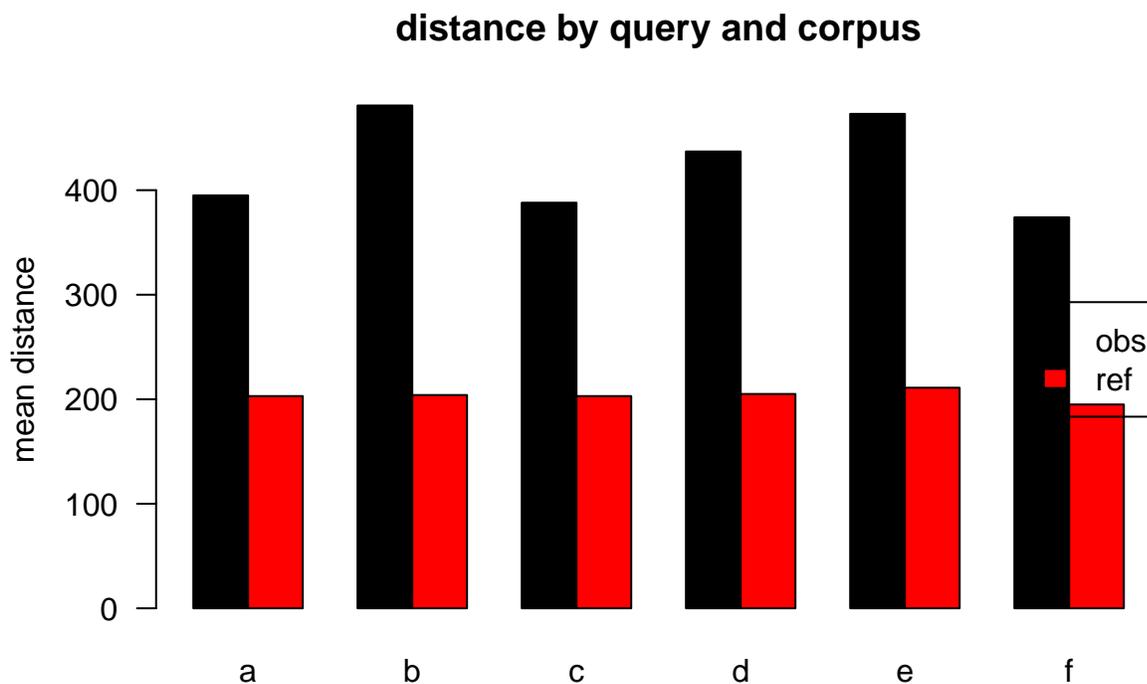


Figure 3.11: mean distances over query/corpus, normalised to all, distance ceiling = outliers removed

Table 3.4: mean/median table for model: 3

| target | q | n | mean | median |
|--------|---|-------|------|--------|
| obs | a | 42836 | 395 | 196 |
| ref | a | 58615 | 203 | 79 |
| obs | b | 2116 | 481 | 279 |
| ref | b | 1130 | 204 | 75 |
| obs | c | 5770 | 388 | 191 |
| ref | c | 1274 | 203 | 80 |
| obs | d | 5654 | 437 | 243 |
| ref | d | 1525 | 205 | 83 |
| obs | e | 3911 | 473 | 248 |
| ref | e | 671 | 211 | 75 |
| obs | f | 2311 | 374 | 224 |
| ref | f | 413 | 195 | 79 |

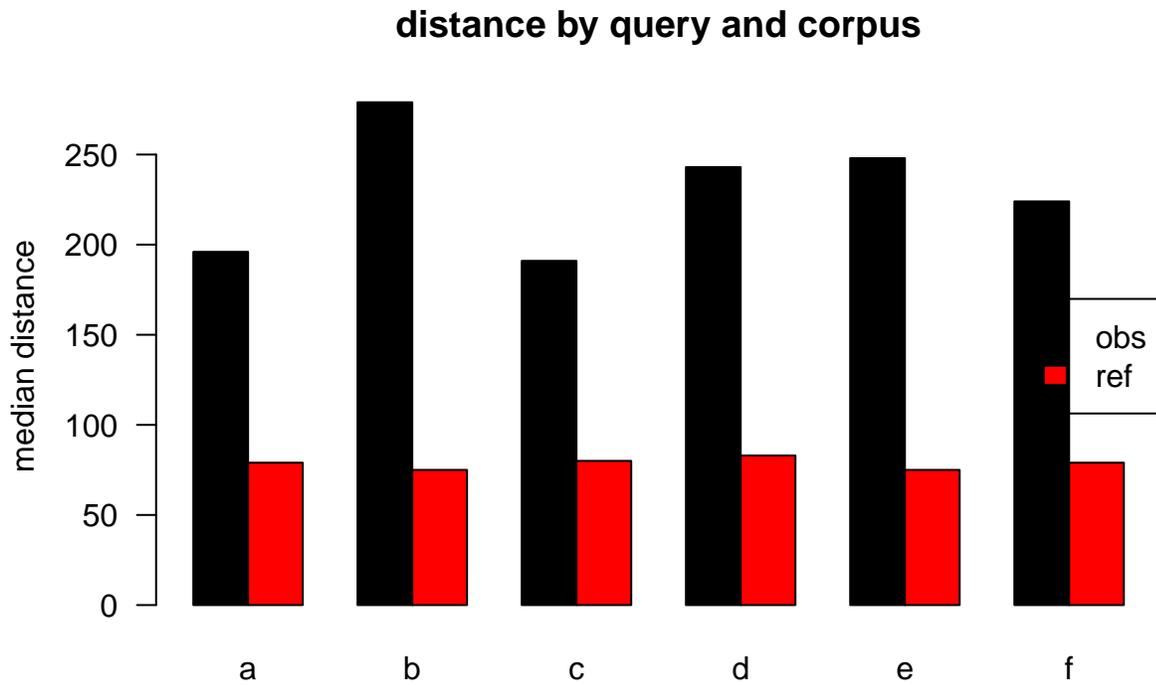


Figure 3.12: median distances over query/corpus, normalised to all, distance ceiling = outliers removed

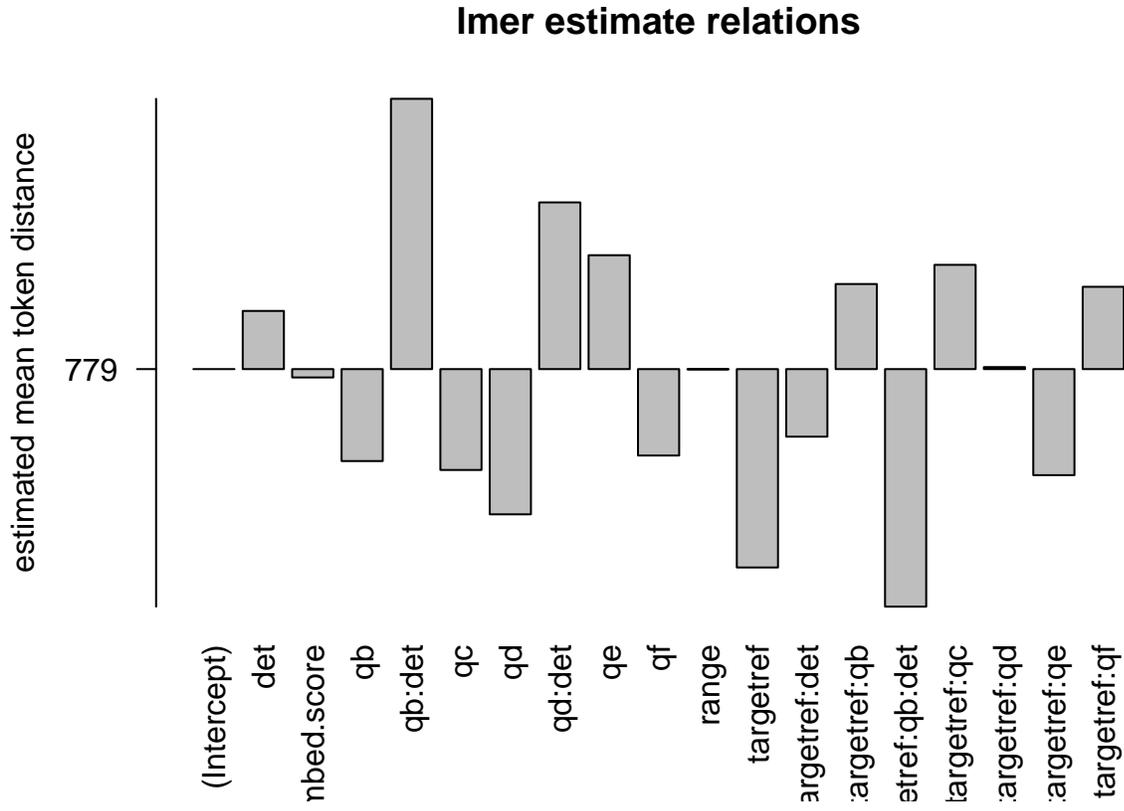


Figure 3.13: distances relation, normalised to all, distance ceiling = outliers removed

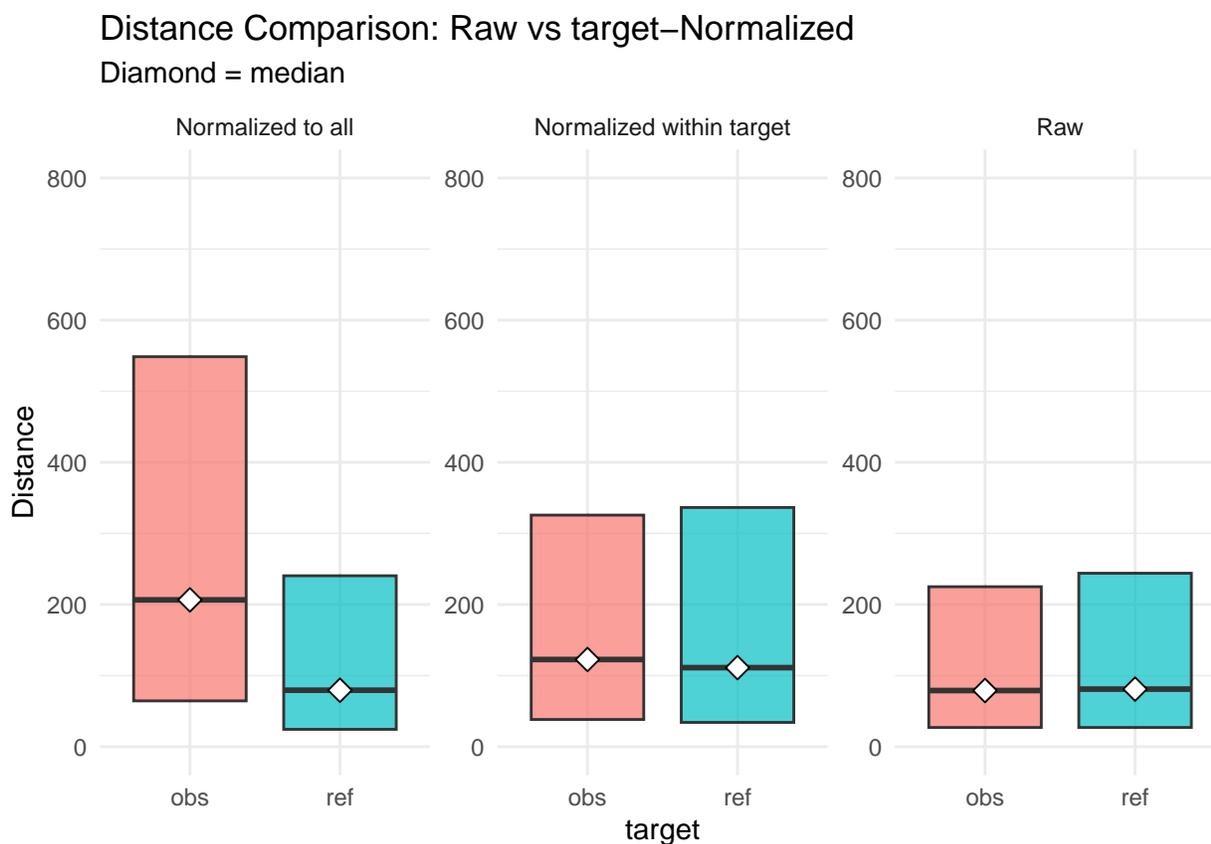


Figure 3.14: distances normalised vs. raw

3.6 evaluation model: 4

3.6.1 meta

eval output data: 13, normalised to ref, distance ceiling = outliers removed

3.6.2 parameter setting

```
##          value
## norm_target _rel_ref
## det.t      TRUE
## limit      TRUE
## author     TRUE
## url        TRUE
## embed1     TRUE
## embed2     f
## range1     TRUE
## range2     f
```

```
## rel          TRUE
## lme          FALSE
## lemma       FALSE
```

3.6.3 anova analysis

3.6.3.1 anova plain

```
formula: [dist_rel_ref ~ target*q*det]
```

```
##           Df      Sum Sq   Mean Sq  F value    Pr(>F)
## target     1 2.5135e+09 2513546743 7336.4625 < 2.2e-16 ***
## q          5 6.8469e+07  13693706   39.9688 < 2.2e-16 ***
## det        1 9.0922e+06   9092198   26.5380 2.588e-07 ***
## target:q   5 1.5268e+07   3053543    8.9126 1.786e-08 ***
## target:det 1 1.3965e+06   1396511    4.0761 0.043496 *
## q:det      2 5.0309e+06   2515448    7.3420 0.000648 ***
## target:q:det 1 3.9858e+06   3985754   11.6335 0.000648 ***
## Residuals 126209 4.3240e+10   342610
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.6.3.2 anova of linear regression model

```
[anova(summary(lmer))]
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq   Mean Sq NumDF  DenDF  F value    Pr(>F)
## target     6358663   6358663     1   3519   23.4567 1.333e-06 ***
## q          4098347    819669     5 122421    3.0237 0.0098706 **
## det         67605     67605     1 118425    0.2494 0.6175055
## range     280081404 280081404     1   1025 1033.2042 < 2.2e-16 ***
## embed.score 139496414 139496414     1 122690 514.5942 < 2.2e-16 ***
## target:q   4314256    862851     5 123486    3.1830 0.0070933 **
## target:det 3006886    3006886     1 123325   11.0922 0.0008672 ***
## q:det      1997926    998963     2 120804    3.6851 0.0250971 *
## target:q:det 1221717   1221717     1 123315    4.5068 0.0337615 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.6.3.3 linear regression coefficients

```
formula: [dist_rel_ref ~ target*q*det+(1|aut_id)+range+(embed.score)+(1|url_id)]
```

```

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: eval(expr(lmeform))
## Data: dfa
##
## REML criterion at convergence: 1944105
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.8643 -0.5282 -0.1721  0.2469  6.9244
##
## Random effects:
## Groups   Name                Variance Std.Dev.
## aut_id   (Intercept)          15871    126.0
## url_id   (Intercept)          45496    213.3
## Residual                    271080    520.7
## Number of obs: 126226, groups: aut_id, 8238; url_id, 2145
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)  1.090e+03  1.216e+01  8.969e+03  89.651 < 2e-16 ***
## targetref   -1.024e+02  1.485e+01  1.300e+03  -6.893 8.50e-12 ***
## qb          -4.744e+01  3.600e+01  1.218e+05  -1.318 0.187483
## qc          -5.203e+01  1.296e+01  1.226e+05  -4.014 5.98e-05 ***
## qd          -7.492e+01  5.246e+02  1.184e+05  -0.143 0.886426
## qe           5.876e+01  9.042e+00  1.247e+05   6.498 8.14e-11 ***
## qf          -4.458e+01  1.153e+01  1.244e+05  -3.866 0.000111 ***
## det         3.001e+01  1.125e+01  1.229e+05   2.667 0.007662 **
## range       -1.370e-01  4.261e-03  1.025e+03 -32.143 < 2e-16 ***
## embed.score -4.311e+00  1.900e-01  1.227e+05 -22.685 < 2e-16 ***
## targetref:qb  4.389e+01  4.051e+01  1.225e+05   1.083 0.278599
## targetref:qc  5.378e+01  3.015e+01  1.237e+05   1.784 0.074435 .
## targetref:qd  1.040e+00  2.957e+01  1.238e+05   0.035 0.971935
## targetref:qe -5.472e+01  2.242e+01  1.239e+05  -2.441 0.014662 *
## targetref:qf  4.246e+01  2.853e+01  1.238e+05   1.488 0.136766
## targetref:det -3.485e+01  2.556e+01  1.239e+05  -1.363 0.172784
## qb:det       1.394e+02  3.955e+01  1.219e+05   3.526 0.000423 ***
## qd:det       8.600e+01  5.244e+02  1.184e+05   0.164 0.869736
## targetref:qb:det -1.225e+02  5.772e+01  1.233e+05  -2.123 0.033761 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## fit warnings:
## fixed-effect model matrix is rank deficient so dropping 7 columns / coefficients
## Some predictor variables are on very different scales: consider rescaling

```

3.6.4 plots

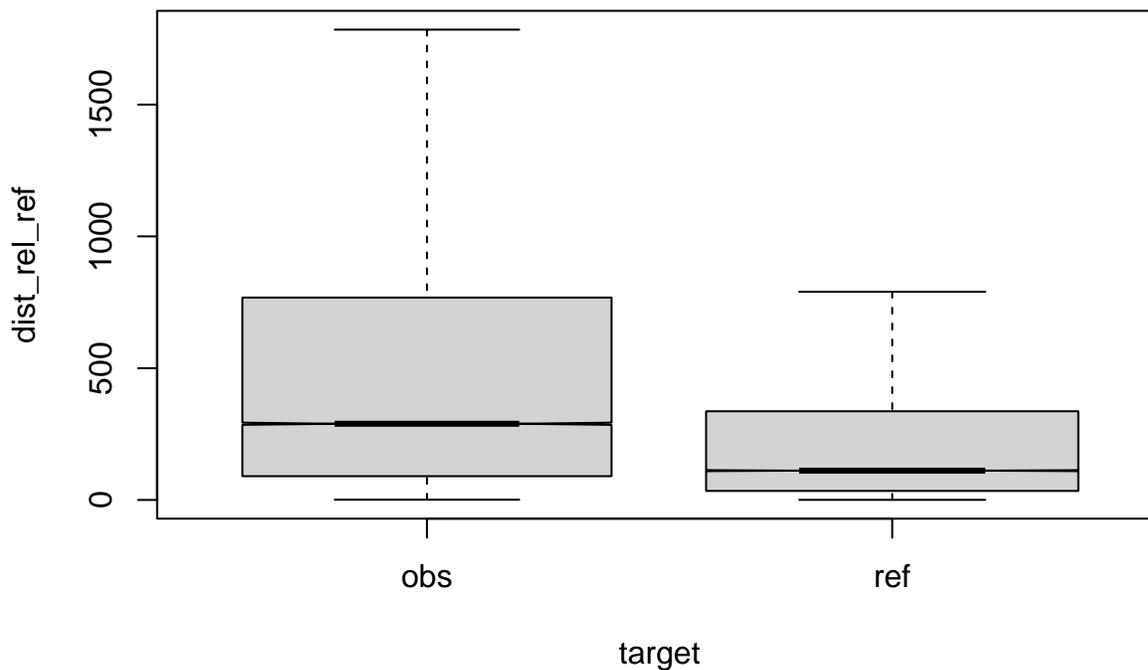


Figure 3.15: compare distances by corpus, normalised to ref, distance ceiling = outliers removed

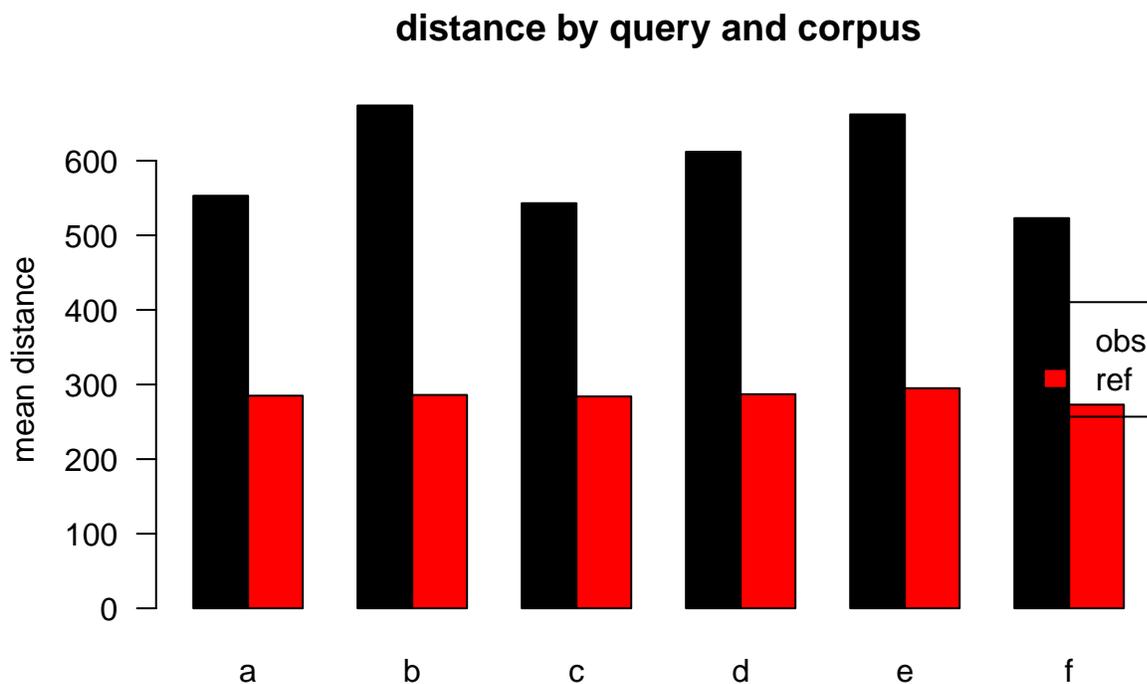


Figure 3.16: mean distances over query/corpus, normalised to ref, distance ceiling = outliers removed

Table 3.5: mean/median table for model: 4

| target | q | n | mean | median |
|--------|---|-------|------|--------|
| obs | a | 42836 | 553 | 275 |
| ref | a | 58615 | 285 | 111 |
| obs | b | 2116 | 674 | 390 |
| ref | b | 1130 | 286 | 104 |
| obs | c | 5770 | 543 | 268 |
| ref | c | 1274 | 284 | 112 |
| obs | d | 5654 | 612 | 340 |
| ref | d | 1525 | 287 | 116 |
| obs | e | 3911 | 662 | 347 |
| ref | e | 671 | 295 | 105 |
| obs | f | 2311 | 523 | 313 |
| ref | f | 413 | 273 | 111 |

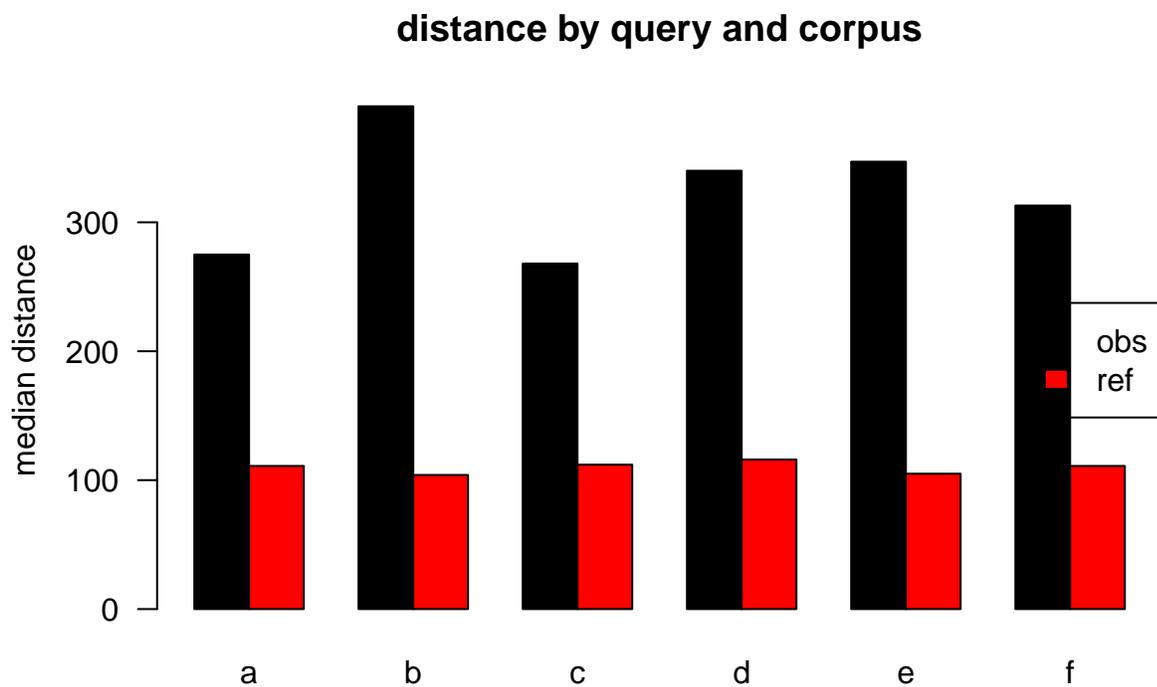


Figure 3.17: median distances over query/corpus, normalised to ref, distance ceiling = outliers removed

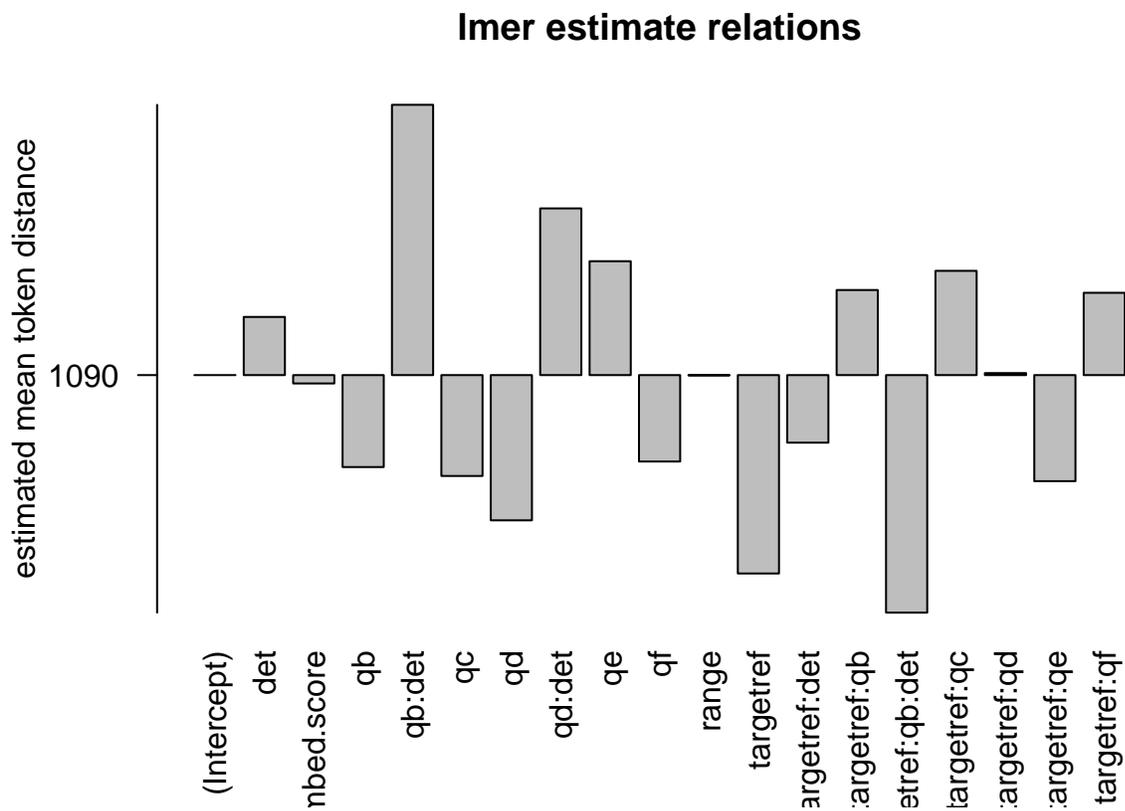


Figure 3.18: distances relation, normalised to ref, distance ceiling = outliers removed

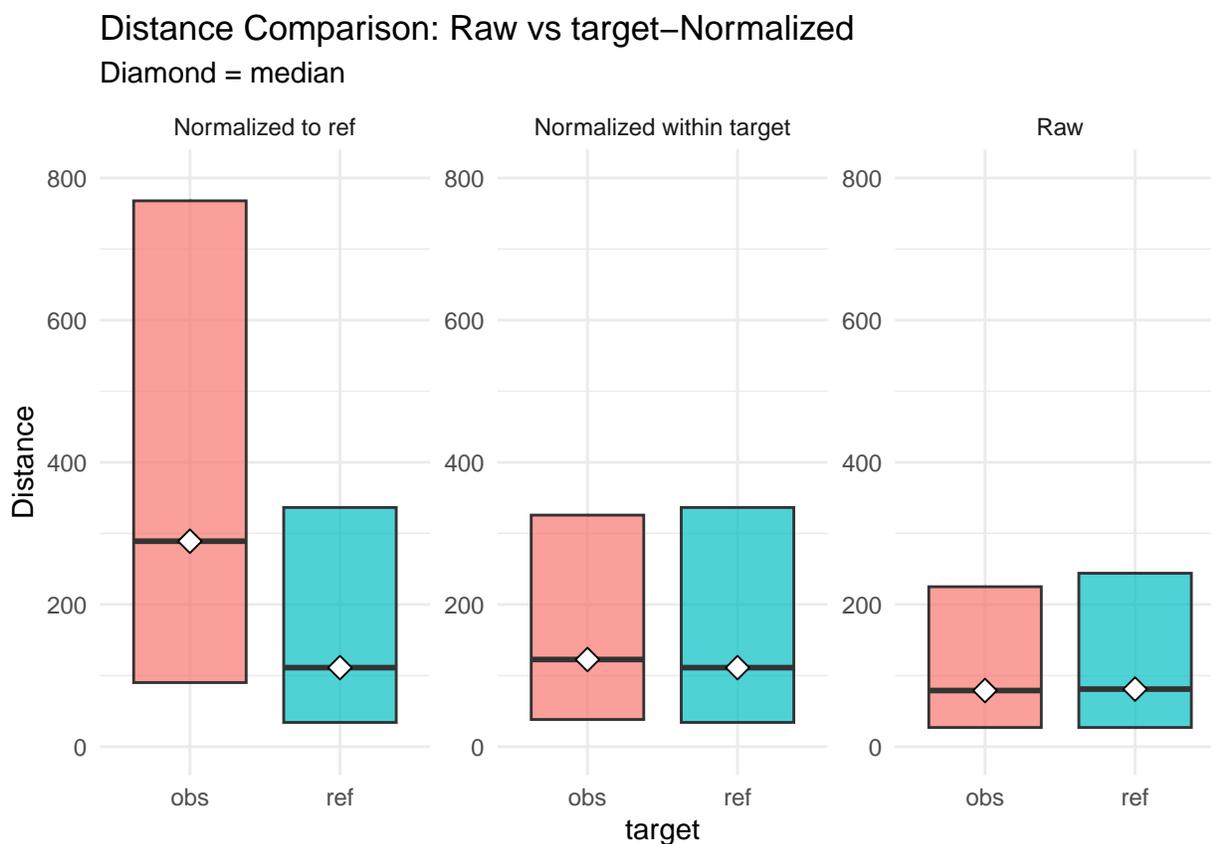


Figure 3.19: distances normalised vs. raw

3.7 evaluation model: 6

3.7.1 meta

eval output data: 13, not normalised, distance ceiling =outliers removed

3.7.2 parameter setting

```
##          value
## norm_target
## det.t     TRUE
## limit     TRUE
## author    TRUE
## url       TRUE
## embed1    TRUE
## embed2    f
## range1    TRUE
## range2    f
```

```
## rel          FALSE
## lme          FALSE
## lemma       FALSE
```

3.7.3 anova analysis

3.7.3.1 anova plain

```
formula: [dist ~ target*q*det]
```

```
##           Df      Sum Sq Mean Sq F value    Pr(>F)
## target     1   3284330 3284330 84.1223 < 2.2e-16 ***
## q          5   1633205  326641  8.3663  6.39e-08 ***
## det        1    431404  431404 11.0496 0.0008873 ***
## target:q   5    441118   88224  2.2597 0.0457798 *
## target:det 1     16732   16732  0.4286 0.5126999
## q:det       2     25549   12774  0.3272 0.7209470
## target:q:det 1      6009    6009  0.1539 0.6948226
## Residuals 126209 4927490433  39042
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.7.3.2 anova of linear regression model

```
[anova(summary(lmer))]
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF  DenDF    F value Pr(>F)
## target         218      218     1  17034    0.0061 0.9377
## q           109358    21872     5 124317    0.6129 0.6901
## det           20678    20678     1 121247    0.5794 0.4465
## range       15332432 15332432     1   912  429.6377 <2e-16 ***
## embed.score  77286240 77286240     1 105351 2165.6761 <2e-16 ***
## target:q      304923    60985     5 125126    1.7089 0.1287
## target:det    17833    17833     1 124982    0.4997 0.4796
## q:det         37151    18576     2 123066    0.5205 0.5942
## target:q:det  23985    23985     1 124972    0.6721 0.4123
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.7.3.3 linear regression coefficients

```
formula: [dist ~ target*q*det+(1|aut_id)+range+(embed.score)+(1|url_id)]
```

```

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: eval(expr(lmeform))
## Data: dfa
##
## REML criterion at convergence: 1685342
##
## Scaled residuals:
##   Min      1Q  Median      3Q      Max
## -2.0402 -0.6622 -0.3317  0.3419  4.1697
##
## Random effects:
## Groups Name Variance Std.Dev.
## aut_id (Intercept) 1394 37.34
## url_id (Intercept) 1072 32.74
## Residual 35687 188.91
## Number of obs: 126226, groups: aut_id, 8238; url_id, 2145
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 2.533e+02 3.618e+00 1.966e+04 70.000 < 2e-16 ***
## targetref 1.326e+00 2.954e+00 1.890e+03 0.449 0.65362
## qb -8.195e+00 1.300e+01 1.239e+05 -0.630 0.52845
## qc -8.144e+00 4.675e+00 1.243e+05 -1.742 0.08150 .
## qd -1.117e+02 1.902e+02 1.212e+05 -0.587 0.55726
## qe 1.392e+01 3.248e+00 1.256e+05 4.285 1.83e-05 ***
## qf -6.628e+00 4.145e+00 1.253e+05 -1.599 0.10981
## det 3.793e+00 4.058e+00 1.245e+05 0.935 0.35005
## range 1.535e-02 7.406e-04 9.124e+02 20.728 < 2e-16 ***
## embed.score -3.110e+00 6.682e-02 1.054e+05 -46.537 < 2e-16 ***
## targetref:qb 4.017e+00 1.464e+01 1.244e+05 0.274 0.78373
## targetref:qc 4.577e+00 1.089e+01 1.253e+05 0.420 0.67442
## targetref:qd -2.061e+00 1.069e+01 1.253e+05 -0.193 0.84707
## targetref:qe -2.134e+01 8.099e+00 1.255e+05 -2.635 0.00841 **
## targetref:qf 8.889e+00 1.031e+01 1.254e+05 0.862 0.38849
## targetref:det 1.178e+00 9.236e+00 1.253e+05 0.127 0.89855
## qb:det 1.714e+01 1.428e+01 1.239e+05 1.200 0.23002
## qd:det 1.126e+02 1.902e+02 1.212e+05 0.592 0.55380
## targetref:qb:det -1.710e+01 2.086e+01 1.250e+05 -0.820 0.41233
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## fit warnings:
## fixed-effect model matrix is rank deficient so dropping 7 columns / coefficients
## Some predictor variables are on very different scales: consider rescaling

```

3.7.4 plots

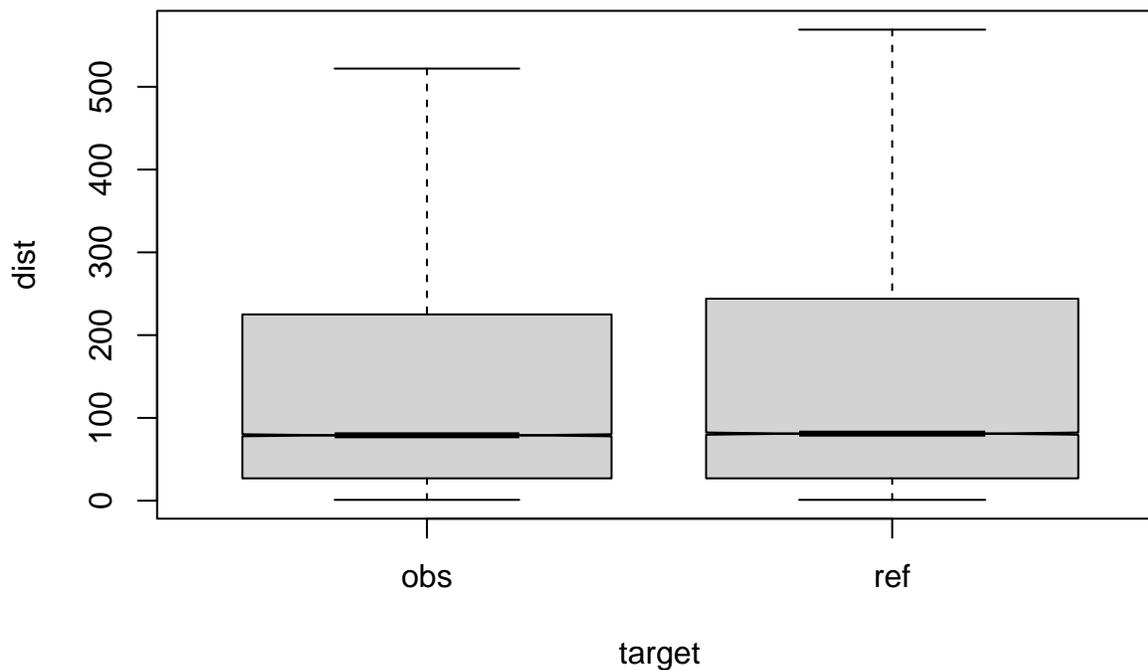


Figure 3.20: compare distances by corpus, not normalised, distance ceiling =outliers removed

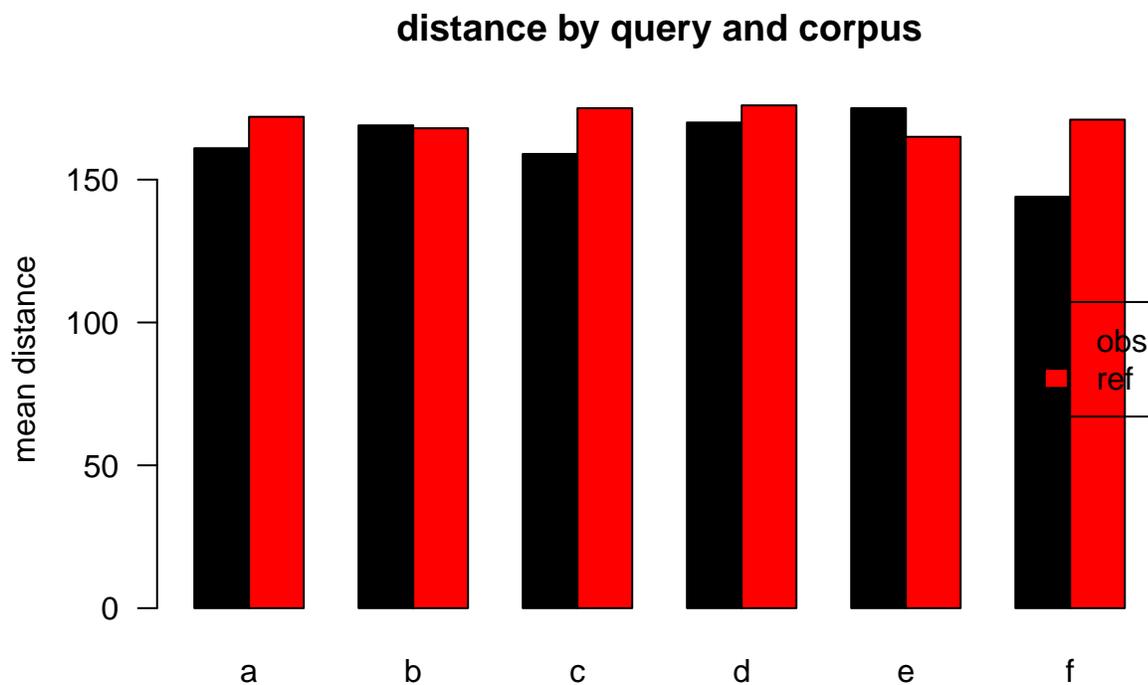


Figure 3.21: mean distances over query/corpus, not normalised, distance ceiling =outliers removed

Table 3.6: mean/median table for model: 6

| target | q | n | mean | median |
|--------|---|-------|------|--------|
| obs | a | 42836 | 161 | 77 |
| ref | a | 58615 | 172 | 81 |
| obs | b | 2116 | 169 | 109 |
| ref | b | 1130 | 168 | 78 |
| obs | c | 5770 | 159 | 75 |
| ref | c | 1274 | 175 | 84 |
| obs | d | 5654 | 170 | 86 |
| ref | d | 1525 | 176 | 83 |
| obs | e | 3911 | 175 | 92 |
| ref | e | 671 | 165 | 71 |
| obs | f | 2311 | 144 | 62 |
| ref | f | 413 | 171 | 82 |

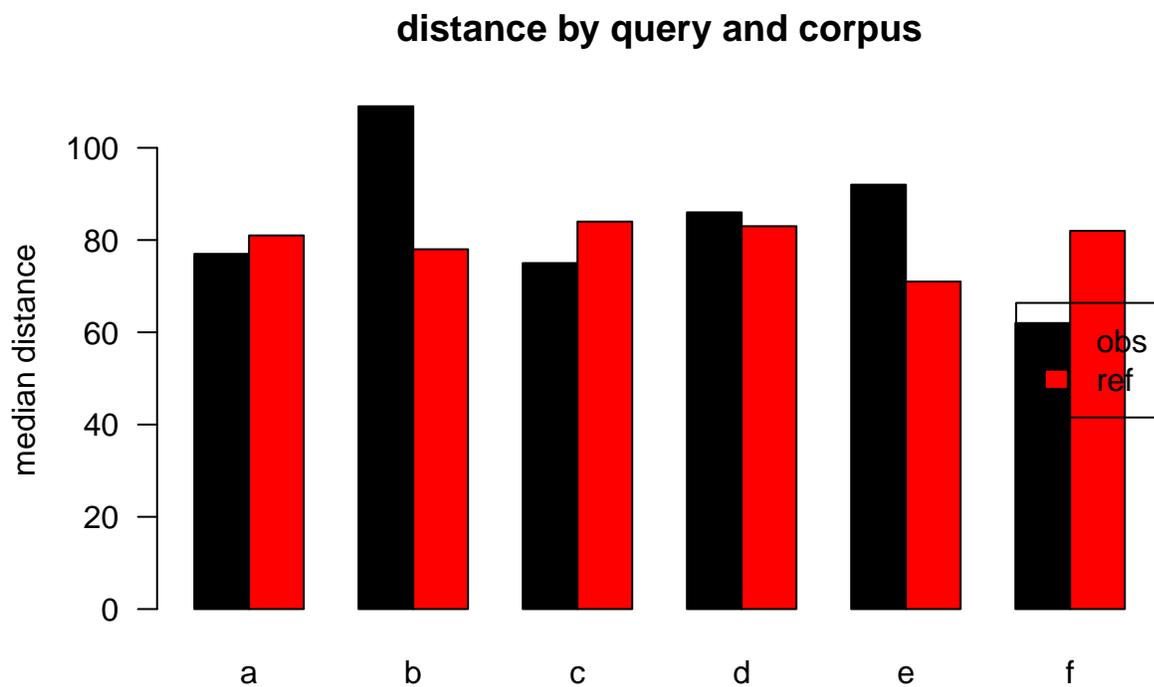


Figure 3.22: median distances over query/corpus, not normalised, distance ceiling =outliers removed

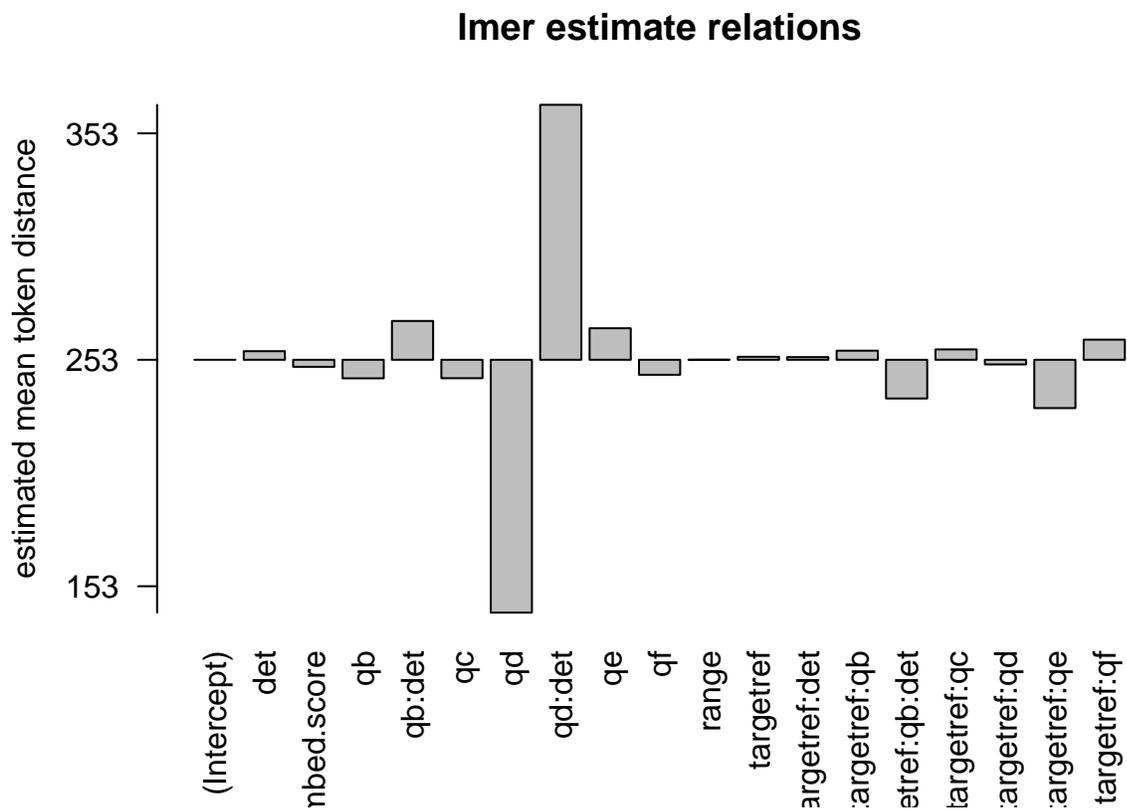


Figure 3.23: distances relation, not normalised, distance ceiling =outliers removed

3.8 Selbständigkeit: benutzte Hilfestellung

In der vorliegenden Arbeit wurden keinerlei nicht erlaubte Hilfsmittel zur Erstellung von Inhalten verwendet. Die Benutzung von KI beschränkt sich auf (Tabelle):

```
## Warning: 'xfun::attr()' is deprecated.
## Use 'xfun::attr2()' instead.
## See help("Deprecated")

## Warning: 'xfun::attr()' is deprecated.
## Use 'xfun::attr2()' instead.
## See help("Deprecated")
```

Table 3.7: verwendete Hilfsmittel

| Hilfsmittel | Verwendung |
|--------------------------|---|
| github copilot | Hilfe bei der Skripterstellung (R, Python) zur Programmierung der Distanzenberechnung, semantic embeddings und statistischen Auswertung |
| chatgpt.com | dito |
| claude.ai | dito |
| deepseek.com | dito |
| nomic-embed-text (model) | calculate semantic embeddings |

3.9 references

literature used and alii. . .

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