Understanding the Use of Quantifiers in Mandarin

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Abstract

We introduce a corpus of short texts in Mandarin, in which quantified expressions figure prominently. We illustrate the significance of the corpus by examining the hypothesis (known as Huang’s “coolness” hypothesis) that speakers of East Asian Languages tend to speak more briefly but less informatively than, for example, speakers of West-European languages. The corpus results from an elicitation experiment in which participants were asked to describe abstract visual scenes. We compare the resulting corpus, called MQTUNA, with an English corpus that was collected using the same experimental paradigm. The comparison reveals that some, though not all, aspects of quantifier use support the above-mentioned hypothesis. Implications of these findings for the generation of quantified noun phrases are discussed. MQTUNA is available at: https://github.com/a-quei/qtuna.

1 Introduction

Speakers trade-off clarity against brevity (Grice, 1975). It is often thought that speakers of East Asian languages handle this trade-off differently than those who speak Western European languages such as English (Newnham, 1971). This idea was elaborated in Huang (1984), when Huang borrowed a term from media studies, hypothesizing that Mandarin is “cooler” than English in that the intended meaning of Mandarin utterances depends more on context than that of their English counterparts; in other words, Mandarin speakers make their utterances shorter but less clear than English speakers. This “coolness” hypothesis is often worded imprecisely, conflating (a) matters that are built into the grammar of a language (e.g., whether it permits number to be left unspecified in a given sentence position), and (b) choices that speakers make from among the options that the grammar permits. Here we focus on the latter.

Studies of coolness have often focused on referring expressions (e.g., van Deemter et al. (2017); Chen et al. (2018); Chen and van Deemter (2020); Chen (2022)). The present paper focuses on quantification, as in the Quantified Expressions (QEs) “All A are B”, “Most A are B”, and so on. In a nutshell, we want to know whether Mandarin speakers use QEs less clearly, and more briefly, than English ones.

We report on an elicitation experiment, MQTUNA, inspired by the QTUNA experiment of Chen et al. (2019b, see §2). The experiment asks Mandarin speakers to produce sequences of QEs to describe abstract visual scenes. Sequences of QEs that are used to describe visual scenes are called Quantified Descriptions (QDs, Chen et al., 2019b). The MQTUNA corpus will enable researchers to investigate a wide range of questions about quantification in Mandarin. We illustrate this potential by comparing the corpus with the English QTUNA corpus from the perspective of coolness and we ask how our findings impact computational models of the production of QDs.

In sum, our contribution is two-fold:

1. We constructed, annotated and analysed the MQTUNA corpus;
2. We compared MQTUNA to QTUNA from the perspective of Huang’s Coolness hypothesis.

2 QTUNA Experiment

A growing body of empirical work has studied how people understand and produce quantifiers (Moxey and Sanford, 1993; Szymanik and Zajenkowski, 2010; Grefenstette, 2013; Herbelot and Vecchi, 2015; Sorodoc et al., 2016). These studies have focused on a limited number of quantifiers (chiefly “all”, “most”, “many”, and “no”).

In Natural Language Generation (NLG), the QTUNA corpus was built to study how English
speakers use QDs to describe a visual scene (Figure 1). Participants were free to (1) describe a visual scene in whatever way they want, (2) use as many sentences as they choose, and (3) use any sentence pattern that they choose. For example, for the scene in Figure 1, a participant could say “Half of the objects are blue squares. The other half are red objects. There is only one red circle.” Given the domain contains four objects in no more than two shapes, this QD describes the scene completely and correctly. Participants were told that their descriptions should allow readers to reconstruct the scene modulo location. Each scene contains $N$ objects (NB: $N$ is defined as domain size), which is either a circle or a square and either blue or red. To test how domain size impacts the use of quantifiers, QTUNA experimented on 3 sizes, i.e., 4, 9, and 20.

Analysis of the resulting QTUNA corpus revealed that, as the domain size increase, (English) speakers (1) use more vague quantifiers (e.g., most and few); (2) use less complete QDs (NB: a QD is complete if the scene described is the only one modulo location that fits the description); (3) use more incorrect QDs (NB: a QD is incorrect if it is not true with respect to the scene); and (4) do not use longer QDs (measured in terms of the number of QEs).

3 Research Questions

Are the QTUNA findings true for MQTUNA? We are curious whether the above-mentioned findings about QTUNA (see §2) hold true for MQTUNA. We expected that domain size affects speakers of different languages in the same way, so these findings should hold for both corpora in the same way.

Are Mandarin QDs briefer and less clear than English QDs? “Coolness” says Mandarin speakers speak more briefly and less clearly than English speakers. We check this hypothesis by comparing QDs in QTUNA and MQTUNA.

Regarding brevity, we are curious about the length of QDs. If Mandarin QDs are briefer than English QDs, then we expect QDs in MQTUNA to contain less QEs than those in QTUNA.

Regarding clarity, if Mandarin speakers utter QDs in a less clear way, we expect to see more vague quantifiers in MQTUNA than in QTUNA and, more importantly, fewer logically complete QDs.

4 MQTUNA Experiment

We followed the same methodology as in the QTUNA experiment, re-using scenes of the QTUNA experiment, inheriting its experimental design, and translating its instructions participants.

4.1 Materials

To prepare materials for the MQTUNA experiment, we sampled scenes from QTUNA following two steps. First we eliminated all scenes all of whose objects share the same properties. For instance, we removed all scenes that can be described completely by a single QD like “all objects are red circles.” Next, for each domain size (i.e., 4, 9, or 20), we randomly sampled 5 scenes from QTUNA. In the second step, to familiarise participants with the experiment, we added a practice situation that uses a $N = 4$ scene whose objects are the same. For the instructions, we translated the instructions of QTUNA (Appendix A). More specifically, the instruction told subjects that (1) they should finish the experiment in limited time (i.e., 20 minutes); (2) their descriptions would then be used in a reader experiment where readers are asked to reconstruct the scenes; (3) they should not enumerate and not say where in the grid a particular object is located.

4.2 Design, Participants, and Procedure

Data from 31 participants were collected for domain sizes $N = 4$, 9 and 20 ($N$ is the number of objects in the scene). See Appendix B for details about participants. Participants were asked to read the instruction first and to complete the experiment (16 situations) in one sitting.

4.3 The MQTUNA Corpus

The resulting MQTUNA corpus contains 465 valid QDs and 1175 QEs. There are 155 QDs for each domain size and there are 383, 386, and 406 QEs for $N = 4$, $N = 9$, and $N = 20$ respectively. Table 1 lists a number of examples QDs in MQTUNA.
with respect to the corresponding scene; we also
(e.g., “QTUNA To check whether the findings of
Table 2: Frequencies of major QE types in the different
MQTUNA
viewing quantifiers that have the same meaning
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annotated each QE with whether it uses a vague
quantifier or not. Annotation details can be found
5.1 Analysing MQTUNA
We annotated the use of quantifiers in MQTUNA,
(p < .0001, adjusted p < .0001)¹).
Completeeness. We observed 33, 136, and 150
logically incomplete QDs from the three sub-
corpus. A binary logic regression test confirms
that there are more logically incomplete QDs in
larger domains (p < .0001, adjusted p < .0001).
Correctness. The 3 subcorpora contained 7, 14,
and 30 wrong QDs, so more incorrect QDs are used
in larger domains (p < .0001, adjusted p < .0001)
using a binary logic regression test.
Length. QDs in larger domains in MQTUNA con-
tain more QEs than those in smaller domains. We
computed the Pearson correlation between the do-
main size and the QD length. After Bonferroni
correction, the difference fell just short of signifi-
cance (p = 0.1025, adjusted p = 0.615).
In a nutshell, all findings of QTUNA are also true
for MQTUNA.

5 Analysis
Focusing on the research questions of §3, we anal-
yse the MQTUNA corpus (§5.1), and we compare
MQTUNA with QTUNA (§5.2). We conclude with a
few post-hoc observations (§5.3).

5.1 Analysing MQTUNA
To check whether the findings of QTUNA (§2) hold
for MQTUNA, we annotated each QD with whether
it is logically complete and whether it is correct
with respect to the corresponding scene; we also
annotated each QE with whether it uses a vague
quantifier or not. Annotation details can be found
in Appendix D. To avoid compromising the com-
parison between MQTUNA and QTUNA, we did not
only annotate MQTUNA but we also re-annotated
the QTUNA corpus, using the same annotators fol-
lowing the same set of principles. Table 2 charts
the results.

Vagueness. We identified 57, 201, and 234 QEs
that contain vague quantifiers out of 383, 386, and
406 QEs from the three sub-corpora, confirming
that vagueness is more frequent with increasing do-
main size. This was confirmed by a binary logistic
regression test (p < .0001, adjusted p < .0001).

We annotated the use of quantifiers in MQTUNA,
viewing quantifiers that have the same meaning
(e.g., “所有” (suoyou; all) and “全部” (quanbu,
all) as identical. See Appendix C for a list of top-10
quantifiers and their usage in MQTUNA.
As for quantifier use, the quantifier “所有” (suoyou;
all) and “一半” (yiban; half) are two of the
most frequent quantifiers. In the top-10 most fre-
cuent quantifiers of MQTUNA, 4 are vague, includ-
ing “绝大多数” (overwhelming majority), “大多
数” (most), “少数” (minority). This is very
different from QTUNA, where only 1 vague
quantifier (i.e., most) is in top-10. Appendix C also
presents lists of crisp and vague quantifiers.

Table 1: List of example descriptions from the MQTUNA corpus, with their annotations. N indicates domain size.

| Description | N = 4 | N = 9 | N = 20 |
|-------------|-------|-------|-------|
| All objects are blue. The number of squares is triple that of circles. | 155 | 155 | 155 |
| All circles are red. All squares are blue. There are fewer squares than circles. | 383 | 386 | 406 |
| All circles are red. All squares are blue. | 122 | 19 | 5 |
| All squares are red. All circles are blue. | 33 | 136 | 150 |
| There are more red squares than blue squares | 25 | 143 | 184 |
| and more blue circles than red circles. | 7 | 14 | 30 |

Table 2: Frequencies of major QE types in the different subcorpora of MQTUNA.

| Quantified Description | Quantified Expression | Complete Description | Incomplete Description | Vague Quantifier | Wrong Description |
|------------------------|-----------------------|---------------------|------------------------|-----------------|------------------|
| 75 | 75 | 70 | 98 | 12 | 4 |

¹The p-value was adjusted by Bonferroni correction.
Brevity. We compared the length of QDs in QTUNA and MQTUNA and found that QDs in MQTUNA are longer than those in QTUNA in every sub-corpus. This rejects our hypothesis that Mandarin speakers prefer brevity and, thus, produce shorter QDs than English speakers.

Completeness. Table 3 reports the number of logically complete QDs in QTUNA and MQTUNA, respectively. 379 out of 710 QDs in QTUNA are logically complete while 146 out of 465 QDs in MQTUNA are complete. Using a Chi-squared test, this confirms that there are more complete QDs in QTUNA than in MQTUNA ($\chi^2(2, N = 1175) = 54.93, p < .0001$, adjusted $p < .0001$). Mandarin speakers produce longer but less logically complete QDs. Interestingly, if we look into more details (see Table 3), the difference only exists in domain sizes 4 and 9. We suspect that both English and Mandarin speakers find it hard to come up with a logically complete QD if the domain size is large.

Vagueness. In QTUNA, 222 of the 1342 QEs were vague whereas, in MQTUNA, 352 of the 1175 QEs were vague. A Chi-squared test confirms that Mandarin speakers used more vague quantifiers than English speakers ($\chi^2(2, N = 2517) = 64.04, p < .0001$, adjusted $p < .0001$).

5.3 Post-hoc Observations

Surface Forms. We observed that QEs in MQTUNA are generally realised in three kinds of forms: (1) “Q A 是 B” (“Q are A are B”), where “Q” is a quantifier, for example, "大部分 A 是 B” (“most A are B”); (2) “A 中 Q 是 B” (“in A, Q are B”); and (3) “B 在 A 中 占 Q” (“B takes up Q of A”).

A-Drop. Akin to the previous findings that pronouns and nouns are often dropped in Mandarin NPs (Huang, 1984; Osborne and Liang, 2015), we found that nouns that take up A positions in the above forms are also often dropped (henceforth, A-drop), for example, saying “B 占 Q” (“B takes up Q”). In MQTUNA, we found 304 out of 1175 QEs (approximately 25.87%).

Plurality. van der Auwera and Baoill (1998) pointed out that Mandarin briefer in that plurality is often not expressed explicitly. Consistent with this, we found that in MQTUNA, numbers are rare. This makes a QE in Mandarin sometimes less informative than an English QE. Mandarin QDs are less likely to be logical complete. For example, Mandarin QE “图片中有红色方块” could mean “there are red squares” or “there is a red square”.

6 Discussion

We have presented and analysed the MQTUNA corpus of quantifier use in Mandarin.

Coolness. We assessed the coolness hypothesis by analysing MQTUNA and comparing QTUNA and MQTUNA. As for the brevity of QDs, we found both evidence (i.e., Mandarin speakers often performed A-drop and expressed plurality implicitly) and counter-evidence (i.e., Mandarin speakers uttered longer QDs than English speakers).

As for the clarity of QDs, we confirmed that the Mandarin corpus (MQTUNA) contains significantly more incomplete QDs and vague quantifiers than its English counterpart (QTUNA).

Generating QDs. Chen et al. (2019a) proposed algorithms for generating QDs (QDG algorithms). Let us list issues to be heeded when building QDG algorithms for Mandarin.

First, plurality plays an important role in the QDG Algorithms of Chen et al. (2019a). If these algorithms are to be adapted to Mandarin, then they should first “decide” whether to realise the plurality of a QE explicitly, since this will influence how much information the QD should express in other ways. Second, modelling the meaning of vague quantifiers is vital for generating human-like QDs. Since Mandarin speakers use vague quantifiers more frequently than English speakers, Mandarin QDG needs to handle a larger number of vague quantifiers and capture nuances between them, which is a difficult and data-intensive challenge. Lastly, QD surface realisation in Mandarin needs to handle more syntactic variations than current QDG algorithms are capable of, because (1) a QE can be realised in multiple possible forms (see §5.3); (2) A-drop frequently happens; (3) Plurality can be expressed implicitly or explicitly.

|    | QTUNA | MQTUNA |
|----|-------|--------|
|    | C | I | C | I | p-value |
| 4  | 298 | 32 | 122 | 33 | $p < .001$ |
| 9  | 77 | 113 | 19 | 136 | $p < .0001$ |
| 20 | 4 | 186 | 5 | 155 | $p = .5$ |
| all | 379 | 331 | 146 | 319 | $p < .0001$ |

Table 3: Numbers of complete (C) and incomplete (I) QEs in QTUNA and MQTUNA. $N$ is domain size.
Future Work. Our comparison between Mandarin and English was based on two corpora, QTUNA and MQTUNA, that were collected using elicitation experiments that were conducted following the same experimental paradigm, and using very similar sets of stimuli. Yet, language may not have been the only difference between these experiments; participants in QTUNA and MQTUNA are also likely to differ in terms of their cultural background, and possibly in terms of other variables, such as their education; there is no absolute guarantee that all our annotations are correct. To create an even playing field between the two corpora, we asked our annotators to re-annotate QTUNA. But although our annotator were native speakers of Chinese, they were merely fluent (not native) in English, which may have caused a difference in the way both corpora were annotated. In future, it would be interesting to conduct even more tightly controlled experiments to tease apart the variable of language use from such possibly confounding variables.

Finally, our experiment has looked at a wide range of quantifiers. We also plan experiments that zoom in on specific subsets, such as the different range of quantifiers. We also plan experiments that were conducted following the same experimental paradigm, and using very similar sets of stimuli. Yet, language may not have been the only difference between these experiments; participants in QTUNA and MQTUNA are also likely to differ in terms of their cultural background, and possibly in terms of other variables, such as their education; there is no absolute guarantee that all our annotations are correct. To create an even playing field between the two corpora, we asked our annotators to re-annotate QTUNA. But although our annotator were native speakers of Chinese, they were merely fluent (not native) in English, which may have caused a difference in the way both corpora were annotated. In future, it would be interesting to conduct even more tightly controlled experiments to tease apart the variable of language use from such possibly confounding variables.

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A Instruction

We’re interested in understanding how people describe sets of objects. To find out, we’re doing a small experiment, in which we’ll show you a number of situations in which some (16) objects are displayed on a screen. We’d like you to describe each situation in one or more grammatically correct Mandarin sentences.

1 You will complete the experiment in a limited amount of time (20 minutes). The experiment should take you less than 20 minutes.

2 Based on your description, a reader will try to “reconstruct” the situation. We use the word “reconstruct” loosely here, because the only thing that matters is the different types of objects that the sheet contains. Therefore, please do not say *where* in the grid a particular object is located (e.g., “top left”, “in the middle”, “on the diagonal”). Each object is a circle or a square, and either red or blue. Your reader knows this.

3 Please do not “enumerate” the different types of objects. For example, do not say “There is a red circle, two blue circles, and ...”.

B Participants

All of our participants are Mandarin native speakers. 21 subjects are undergraduate students in computer science from the Utrecht University. Each of the rest at least has a bachelor degree in any of computer science, statistics, and management. 11 subjects are female and 20 subjects are male.
C  Quantifiers in MQTUNA

Table 4 enumerates the top-10 quantifiers and their usage in MQTUNA. In what follows, we provide a list of vague quantifiers and a list of crisp quantifiers in MQTUNA.

- **Crisp Quantifiers**: 所有 (all), 只有 (only), 比...多... (more), 倍 (times), 除了...都是... (all...except...), 有 (there is), 多于n倍 (more than n times), 少于n倍 (less than n times), 各半 (half...the other half...), 相同 (same as), 一半 (half), 不同 (different amount of), 一半以上 (more than half), 没有 (no), 少于 (less than), 所有组合 (all possible combinations);

- **Vague Quantifiers**: 大部分 (most), 小部分 (a small part of), 绝大部分 (overwhelming majority), 除了...大多数... (most...except...), 少量的 (a few), 远多于 (way more than), 极少数 (a very few), 多一点 (slightly more than), 多不少 (greatly more than), 相近 (close to each other), 基本都是 (almost all), 略少 (a bit less), 略多 (a bit more), 大约各半 (approximately half ... the rest ...), 基本相同 (almost the same), 多一些 (several more), 多好几倍 (several times more), 多得多 (much more), n倍多一点 (slightly more than n times), n倍少一点 (slightly less than n times), 大约一半 (approximately half), 少数 (minority).

D  Annotating MQTUNA

We asked our annotator to annotate logical completeness, correctness and vagueness based on the following principles:

1. **Logical Completeness**: we asked our annotator whether s/he can fully recover the scene given a QD. For example, for a scene with 3 red circles and 1 blue square, one could say “Most objects are red circles and there is only one blue square.” Though s/he uses a vague quantifier “most”, we still can infer that, given domain size 4, “most objects” means 3 objects, and, therefore, this QD is logically complete. However, for a scene with 8 red circles and 1 blue circle, one could say “All objects are circles and almost all of them are 8.” Though using “almost all” to describe “8 out of 9” is definitely correct, it does not necessarily mean “8 out of 9” but possibly mean “7 out of 9”. Therefore, this QD is not logically complete;

2. **Correctness**: we asked our annotator to annotate a QD as “incorrect” if and only if the QD contains definitely incorrect information, for example, saying a “red object” blue or describing a scene with 3 red squares and 1 blue square as “half of the objects are red”;

3. **Vagueness**: our annotator decided whether a QE uses a vague quantifier based on the vague quantifier list in Appendix C.
| Notation | English | Surface Form(s) | Example Quantified Expression(s) | Frequency |
|----------|---------|-----------------|----------------------------------|-----------|
| 所有     | all     | (所有)...都... (全部)...都... | (全部)A都是B / A中(全部)都是B | N=4 100 127 53 280 |
| 一半     | half    | 一半，百分之五十 | 一半A是B / A中的一半是B / B在A中占一半 | N=9 101 19 28 148 |
| 相同     | equal   | 数量相同, 一样多, 个数一样 | A与B数量相同 | N=20 59 11 29 99 |
| 绝大多数 | overwhelming majority | 绝大部分, 绝大多数 | A中绝大多数是B / 绝大多数A是B / B在A中占绝大多数 | N=4 7 50 37 94 |
| 各半     | half ... rest ... | 各半, 一半一半, 一半...另一边... | BC在A中各半 / A中BC各半 / 一半的A是B, 另一半是C | N=9 60 6 24 90 |
| 比多     | more    | 比...多 | Half of A are B, the other half of A are C | N=20 10 28 48 96 |
| 大多数   | most    | 大多数, 大部分 | A中大多数是B / 大多数A是B / B在A中占大多数 | N=4 7 35 33 75 |
| 少数     | minority | 少数, 少部分 | A中少数是B / 少数A是B / B在A中占少数 | N=9 5 31 24 60 |
| 有       | exist   | 有 , 存在 | 图片中有A (There are A in the scene) | N=20 4 12 18 34 |
| 多数     | most    | 多数 | A中多数是B / 多数A是B / B在A中占多数 | N=4 5 4 20 29 |

Table 4: Top-10 most frequently occurring quantifiers with their English translation and Mandarin examples as well as frequencies in the three MQTUNA sub-corpora.