

Creating a Live, Public Short Message Service Corpus: The NUS SMS Corpus

Tao Chen · Min-Yen Kan

Received: date / Accepted: date

Abstract Short Message Service (SMS) messages are largely sent directly from one person to another from their mobile phones. They represent a means of personal communication that is an important communicative artifact in our current digital era. As most existing studies have used private access to SMS corpora, comparative studies using the same raw SMS data has not been possible up to now.

We describe our efforts to collect a public SMS corpus to address this problem. We use a battery of methodologies to collect the corpus, paying particular attention to privacy issues to address contributors' concerns. Our live project collects new SMS message submissions, checks their quality and adds the valid messages, releasing the resultant corpus as XML and as SQL dumps, along with corpus statistics, every month. We opportunistically collect as much metadata about the messages and their sender as possible, so as to enable different types of analyses. To date, we have collected about 60,000 messages, focusing on English and Mandarin Chinese.

Keywords SMS Corpus · Corpus creation · English · Chinese · Crowdsourcing · Mechanical Turk · Zhubajie

The authors gratefully acknowledge the support of the China-Singapore Institute of Digital Media's support of this work by the "Co-training NLP systems and Language Learners" grant R 252-002-372-490.

Tao Chen
AS6 04-13 Computing 1, 13 Computing Drive National University of Singapore Singapore 117417
Tel.: +65-83988018
E-mail: taochen@comp.nus.edu.sg

Min-Yen Kan
AS6 05-12 Computing 1, 13 Computing Drive National University of Singapore Singapore 117417
Tel.: +65-65161885
Fax: +65-6779-4580
E-mail: kanmy@comp.nus.edu.sg

1 Introduction

1.1 SMS in communication

Short Message Service (SMS) is a simple and ubiquitous modern form of world-wide communication. As mobile handsets increasingly become cheaper to manufacture, and as the secondhand handset market distributes them more widely downstream, SMS emerges as the most widely-used form of digital communication next to voice telephony. As of 2010, there were 5.3 billion active users of SMS, globally sending 6.1 trillion messages as estimated by the International Telecommunication Union (ITU)¹. In the same year, Americans alone sent 1.8 trillion messages². Even in China, 98.3% of phone owners use SMS service, averaging 42.6 received messages weekly³.

The 160 character limit of SMS was designed by Hildebrandt⁴ to accommodate the “communication of most thoughts” presumably in English and other Latin languages. The limits as well as the early difficulties with text input pushed users to be inventive and create shortenings for communication. The resulting genre of communication has its own name: “texting” (Crystal, 2008), and has been debated as to whether it is a friend or foe of language creation, use and understanding. With the advent of the smartphone, other informal communications (e.g., tweets, instant messages), which were previously computer mediated, now are enabled on mobile phones as well, and the length restriction has been circumvented by standards that allow multiple messages to be concatenated together. They share some characteristics with SMS, such as the frequent use of emoticons, unconventional short forms and misspelled words. Tweets, for instance, have been dubbed as “SMS of the Internet”⁵.

SMS messages have been studied since the late 1990s, when SMS communication became widely available among cellular carriers. The ubiquitous, personal and informal nature of SMS attracted researchers’ attention, resulting in sociographic, linguistic and usability research topics – e.g., the impact of SMS on social culture, linguistics analysis, text-entry improvement, name-entity extraction, SMS normalization, authorship detection and spam messages detection.

With such a clear societal impact, however, SMS are underwhelming studied. It is clear why – gathering a large corpus to study is difficult and fraught with confidentiality problems, as messages are often personal or contain confidential information. Unsurprisingly, there are thus few publicly available SMS corpora, discouraging comparative studies. The unavailability of corpora also becomes an onus on the aspiring researcher, forcing them to gather messages themselves.

We now discuss three issues related to SMS corpus collection: 1) Why are there so few public SMS corpora? 2) What factors make collecting SMS so difficult? and 3) Can other corpora of communication vehicles, such as tweets, replace SMS in studies?

SMS messages are primarily stored in mobile phone carriers’ database; only a small portion of them are stored in users’ phones given limited phone storage. For obvious legal and privacy reasons, carriers cannot release their SMS databases for research, as users’ messages are often personal, privileged and private and users would not want them known to others.

¹ <http://www.itu.int/ITU-D/ict/material/FactsFigures2010.pdf>

² <http://www.ctia.org/media/press/body.cfm/prid/2021>

³ <http://anti-spam.cn/pdf/sms1002.pdf>

⁴ <http://latimesblogs.latimes.com/technology/2009/05/invented-text-messaging.html>

⁵ <http://www.business-standard.com/india/news/swine-flu\s-tweet-tweet-causes-online-flutter/356604/>

Even when SMS corpora are collected by researchers from phone owners, such researchers have to maintain exclusive access for the same private reasons. Thus, the private nature of SMS results in the scarcity of public SMS corpora.

In this article, *SMS collection* in particular refers to gathering messages directly from phone owners, largely for research purposes. There are two major explanations for the difficulty of SMS collection. As researchers want the text and the metadata for study, privacy is a major concern, as the majority of phone owners are uncomfortable with having their private messages revealed, even when the purpose is for research and academic pursuits. Additionally, in collecting SMS directly from users, the target messages to be collected are stored on the users' mobile phones, which means that the collection of a large corpus requires the cooperation of many phone owners, and the support of software to ease the collection over many potential mobile phone platforms.

In recent times, Twitter and social networks such as Facebook have made the genre of the short message even more ubiquitous. Tweets and status updates are closely related to SMS, sharing the characteristic terse style of messages. However compared to SMS, tweets are remarkable easier to gather since Twitter release API for accessing data. So a natural question arises: can tweets replace SMS for related studies? Perhaps for some purposes, the answer can be "yes", but they have fundamental differences which still preserves SMS as an important medium to study. First, SMS is a private communication between two parties, which may contain very sensitive topics or information (e.g., bank account, email address), hence its difficulty for collection. In contrast, tweets and a large portion of social network messages and comments are decidedly broadcast media, and hence far less private and sensitive. Second, though both SMS and tweets have the 140 characters restriction, they still differs in length. Ayman reported that the bulk of tweets are around 40 characters long⁶ in a corpus of 1.5 million tweets, while Tagg (2009) mentioned that average words of SMS is 17.2 words in her corpus of 11,067 messages. Bach and Gunnarsson (2010) validates this, pointing out that SMS messages were more likely to be very short – containing only one word – compared to tweets, due to the more personal and conversational aspects of SMS. If the understanding of personal informal communication and how it is evolving is important, then SMS deserves to be collected and studied for the public good.

A public SMS corpus is needed to fill this gap for research material. which will benefit all the researchers who are interested in SMS studies. In 2004, our former project established a SMS collection project for this aim, gathering and publishing a corpus of 10,117 English SMS, mainly from students in our university (How and Kan, 2005). The corpus was released freely online. It was the largest publicly available English SMS corpus until 2010, and used in a number of SMS studies. However, mobile technology has undergone a great development in the past six years, especially with the advent of smartphone, which have featured newer text input technologies and have influenced people's texting habits. Moreover, there is an extreme scarcity of Chinese SMS corpora in the public domain.

Considering this, we resurrected the SMS collection project in October 2010, reviving it as a live corpus collection project for both English and Mandarin Chinese SMS. The "live" aspect of our project emphasizes our aim to continually enlarge and publish the corpus for end users. Our SMS collection makes use of an array of collection methodologies, leveraging current technology trends, with the aim of making the resultant corpus be more representative of SMS worldwide (rather than a specific community⁷), to enable more general studies.

⁶ <http://www.ayman-naaman.net/2010/04/21/how-many-characters-do-you-tweet/>

⁷ In contrast, our 2004 corpus was collected locally within the University in Singapore, not representative of general worldwide SMS use.

Our current corpus also features improved collection methodology, making the collection process more accurate with fewer transcription errors, and is continuously released publicly with an effective anonymization process.

As of October 2011, we have collected 28,724 English messages and 29,100 Chinese messages, resulting in the largest public SMS corpora (to our knowledge), in terms of both English and Mandarin Chinese languages, independently.

Our article reports on the contributions of our corpus and its collection methods. In particular, we:

- use a battery of methodologies to collect the corpus, paying particular attention to privacy issues to address contributors’ concerns (section 3);
- create a website to document and disseminate our gradual achievement, enabling direct, online browsing of the messages. We also release the resultant corpus as XML and as SQL dumps, along with salient corpus statistics, on a regular monthly schedule (section 4); and
- exploit a good Chinese crowdsourcing website for language data collection and compare it with its more well-known, U.S. counterpart (section 5).

2 Related Work

2.1 Comparison of SMS Corpora

While the scope of related work to texting in general is vast, for the purposes of this report, we limit the scope of our review to scholarly publications concerning SMS studies. This makes the task feasible and allows us to further break the review down into particular facets of interest. In particular, we pay attention to the size and language of each collection, the characteristics of its contributors, how the respective authors have collected their corpus, and the respective corpus’ availability. An important goal of this chapter is to provide a comprehensive inventory of SMS corpora that have been collected and pointers to their associated studies.

A survey of the literature shows that publicly-available SMS corpora are scarce. The resulting scarcity motivates subsequent researchers to collect their own SMS corpora for their specific projects, but as these projects are often one-off, the resulting collections are also not publicly available, creating a vicious cycle. We are interested in the underlying facets of their contributors’ identity and the collection methods used. For ease of reference, we have also compiled and listed the existing corpora in Table 1 (publicly available corpora are indicated by an asterisk).

- The **Size** of existing corpora is tiny when comparing to the Twitter corpus with 97 million of posts (Petrović et al., 2010). Even the largest SMS corpus consists of “only” 85,870 messages (Liu and Wang, 2010). 50% of the corpora contain less than 1000 messages, and only five corpora comprise of more than 10,000 messages. We attribute the small scale of these corpora to the aforementioned difficulty of collecting SMS. However when the corpus is small, the resultant findings of the studies are often not statistically significant (Dürscheid and Stark, 2011).
- The **Language** of the corpora ranges from European languages (English, French, German, Italian, Polish, Swedish, etc), Asian languages (Mandarin Chinese), to African ones (Kiswahili and Xhosa). However, European languages dominate, with only two

Chinese corpora and two African corpora being the exceptions. A corpus can be classified as monolingual and multilingual, describing how many languages are exhibited in its component messages. Most corpora are monolingual, and to our knowledge, only five existing corpora are multilingual (Deumert and Oscar Masinyana, 2008; Elvis, 2009; Bach and Gunnarsson, 2010; Barasa, 2010; Bodomo, 2010; Dürscheid and Stark, 2011).

- **Contributors** of the SMS collections can be categorized into known and anonymous contributors. Families and friends are the most common known contributors (Segerstad, 2002; Žic Fuchs and Tudman Vukovic, 2008; Gibbon and Kul, 2008; Tagg, 2009; Barasa, 2010). Others include colleagues (Ju and Paek, 2009; Bach and Gunnarsson, 2010), students in a specific university (Thurlow and Brown, 2003; How and Kan, 2005; Gibbon and Kul, 2008), recruited teenagers (Kasesniemi and Rautiainen, 2002; Grinter and Eldridge, 2003).

Anonymous contributors are those that the researchers do not personally know or need to make direct contact with. The methods to carry out the collection are also more varied in such cases than in known contributor cases. An example is the corpus collected by Ling (2005), which involves 2,003 anonymous respondents via a telephone survey. Another example is the corpus collected by Herring and Zelenkauskaitė (2009) whose participants are anonymous audience members of an Italian interactive television program. Perhaps the most important instance is the distributed effort by the sms4science project, an international collaboration aiming to build an SMS corpus alongside corpus-based research on the resulting corpus. The sms4science subprojects have been carried out in nine countries, such as Belgium (Fairon and Paumier, 2006), Switzerland (Dürscheid and Stark, 2011), France⁸, Greece, Spain and Italy. Anonymous contributors were recruited from across the subproject's country or region.

The difference between the known versus anonymous contributor corpora affects the corpora's representativeness. Known contributors usually share similar demographic features, such as similar age (teenagers or college students), same career (colleagues), and/or same geographic location (living in a same city). Hence, the corpora from known contributors may not be representative of the general landscape of SMS usage. This characteristic may be perfectly acceptable or desired for the particular project for which the corpus is collected, since the project may be restricted in a particular purpose or study. For instance, Grinter and Eldridge (2003) collected 477 messages from 10 teenagers for studying how messages have been incorporated into British teenagers' lives. Corpora from anonymous contributor projects, such as the sms4science project, are more broad and aim to satisfy general studies. We note that both aims can be achieved in an anonymous collection process, as when suitable demographics are taken per message and the corpus is sufficiently large, an identifiable subset of the corpus can still serve for specialized studies.

- **Collection Methods.** The most interesting facet of the studies for our purposes is how they collect their corpus. We observed three primary methods to collect SMS. The simplest approach is to simply transcribe messages from the mobile phone, by typing them into a web based submission form (Segerstad, 2002; How and Kan, 2005), into a word processing or other electronic document (Segerstad, 2002; Deumert and Oscar Masinyana, 2008; Tagg, 2009; Elizondo, 2011), or even the simple method of writing them down on paper (Kasesniemi and Rautiainen, 2002; Grinter and Eldridge, 2003; Thurlow and Brown, 2003; Deumert and Oscar Masinyana, 2008; Bodomo, 2010). Transcription can also happen later to facilitate collection speed – Alexander (2011) took

⁸ <http://www.alpes4science.org>

photos of messages stored on participant's phone, for later transcription by researchers. A second method by exporting or uploading SMS messages via software. The corpus collected by Jonsson et al. (2010) is such an example. They implemented a phone widget for providing location-based SMS trend service and collecting SMS messages as well, since messages will be uploaded to the server when using the service. Sotillo (2010) and Walkowska (2009) gathered messages by collecting SMS exported from contributors using mobile phone software suites such as Treo desktop and Microsoft's My Phone. The third class of methods is to have contributors forward messages to a collection number. Messages usually are forwarded to researcher's own mobile phone (Segerstad, 2002; Walkowska, 2009; Barasa, 2010), which may incur cost for the contributors. They are typically compensated for their cost, thus the large-scale collection can be costly. The studies done by (Fairon and Paumier, 2006; Dürscheid and Stark, 2011), were in collaboration with mobile phone operators, such that contributors could forward their messages to the operator-central number for free, further lowering the barrier for potential contributors.

Aside from these common methods, we observed other one-off methods used in particular studies. Ogle (2005) collected broadcasted SMS by subscribing to the SMS promotion of several nightclubs; Ling (2005) asked respondents to read their SMS aloud during a telephone survey; Herring and Zelenkauskaitė (2009) downloaded the audience's SMS from an SMS archive of an interactive TV program; and finally, Choudhury et al. (2007) collected SMS from an online SMS backup website.

Which method is best? Each method has its own merits and drawbacks. If the scale needed is small, transcribing a few messages is easiest, needing virtually no effort in preparation and cost. However for medium to large corpus projects, this methodology is not scalable, being time-consuming and prone to both transcription and deliberate correction errors, despite instructions to transcribe messages exactly as displayed.

Exporting via software support preserves the originality of messages and in certain cases, gather valuable metadata (sender and receiver's telephone number and sending timestamp). Exporting also enables batch submission, easily enabling a stream of valid and accurate messages to be collected. It also encourages continuous SMS contribution, especially when the export-and-collection process can be automated and continuous. The key drawback with this method is that it is tied to the phone model, and thus creates a selection bias in the possible contributors. Exacerbating this problem is that some phone models do not even have (free) software to export SMSes.

Forwarding messages is also effective to maintain the original message, but may be costly if the sending cost needs to be recouped by the researcher. Forwarding may be easy for newly-sent messages as the collection number can be added as a second recipient. However, many phone models allow only forwarding single messages, such that forwarding lots of individual messages may be tedious. This discourages the collection of many messages from a single contributor.

- **Availability.** In terms of availability, the existing corpora range from private, partially public, to completely public. As displayed in Table 1, most existing SMS corpora are private access. Without a doubt privacy and non-disclosure issues are the underlying cause. On one hand, it is the responsibility of researchers to protect the contributors' privacy and the easiest way to achieve the aim is by not making the corpus public (Dürscheid and Stark, 2011). On the other hand, researchers may not be able to get the consent from contributors to release the corpus or be restricted by the rules of their university's IRB (Institutional Review Board) (Sotillo, 2010).

We define partially public corpora as corpora that are not immediately freely accessible, and require some type of initiative on the part of the scholar to secure. The two partially public corpora are the Belgium Corpus (Fairon and Paumier, 2006) and Swiss Corpus (Dürscheid and Stark, 2011), collected by two sub-projects of sms4science. The former was distributed as a Microsoft Access database on a CD-ROM and is purchasable but restricted to bona fide research purposes only. The latter corpus is browsable online for researchers and students, but not downloadable as an entire corpus. Online browsing is very convenient for reading a few SMS without the need to parse the raw data, but makes it difficult to obtain all the SMS for serious corpus study. We feel that this limits the potential studies that could employ the corpus.

Completely public corpora are freely, immediately and wholly accessible. Shortis (2001) published 202 English SMS as a webpage⁹. Although the corpus is not directly downloadable as a file, we still consider it as public as all of the messages are displayed on the single web page. Other public corpora were released as a file for freely downloading but vary in the file format. Both the German Corpus (Schlobinski et al., 2001)¹⁰ and HKU Corpus (Bodomo, 2010)¹¹ were released in Portable Document Format (.pdf), while the IIT Corpus (Choudhury et al., 2007)¹² and our aforementioned 2004 NUS SMS Corpus¹³ were released as text and XML files, respectively. The HKU Corpus is the only corpus containing about 140 Chinese language messages, but these mix English words, as may often be the case in Hong Kong. Strictly speaking, there is no pure, Mandarin Chinese SMS corpus in the public domain.

Another public corpus is 9/11 pager messages released by Wikileaks in 2009¹⁴ with over half million messages. The intercepts cover a 24 hours surrounding the September 11th, 2001 attacks, ranging from exchanges among office departments, to fault reporting of computers as the World Trade Center collapsed. A few research studies have been conducted on this 9/11 corpus. Back et al. (2010) investigated the emotional timeline of the messages and analyzed the negative reaction to 9/11 terrorist attacks. Back et al. (2011) also used automatic algorithms and human judgment to identify 37,606 social messages from the original corpus, and rated the degree of anger in the timeline. Although 37,606 messages is quite a large corpus, most of the intercepts are limited to people's reaction to that terrorism event. Such topically-focused pager messages cannot replace a general collection SMS messages, thus the corpus is not suitable for most SMS related studies.

- **Release Time.** For the seven public SMS corpora mentioned above, all of them were released after the completion of data collection. The static release favors protection of contributors' privacy, since a global and thorough anonymization could be conducted (Fairon and Paumier, 2006; Dürscheid and Stark, 2011). A live release, in which the corpus is continually published and updated during the collection process, faces greater challenge and risk in anonymization.

Due to the individual and private nature of SMS, the resulting collected corpora also contain private details, which may make it easy to discover the identity of the sender or recipient. For these reasons, such resulting corpora also cannot be made public. As mentioned, this creates a vicious cycle, erecting a barrier to SMS research, making SMS seem less significant than

⁹ <http://www.demo.inty.net/app6.html>

¹⁰ http://www.mediensprache.net/archiv/corpora/sms_os_h.pdf

¹¹ http://www0.hku.hk/linguist/research/bodomo/MPC/SMS_glossed.pdf

¹² <http://www.cel.iitkgp.ernet.in/~monojit/sms.html>

¹³ <http://www.comp.nus.edu.sg/~rpnlpir/downloads/corpora/smsCorpus>

¹⁴ <http://mirror.wikileaks.info/wiki/911>

it is for understanding our current era of communication. It is clear that a publicly available, large-scale corpus of SMS could lower this barrier, and make the study of SMS more widely available to scholars of all disciplines.

2.2 Crowdsourcing SMS collection

From the above summary, we can see that a variety of approaches have been employed to collect SMS for study. In collecting any large-scale corpora, it is necessary to distribute the task among a large group. This is aptly illustrated by the sms4science project which involves thousands of contributors. As we aim to create an authoritative SMS corpus to enable comparative studies, it is vital that the corpus also be large. Thus our methodology should also follow this distributive paradigm.

Crowdsourcing, the strategy of distributing a task to a large “crowd” of human workers via some computer-mediated sources, has emerged as a new driver of computation. In tasks where raw compute power cannot succeed, but where an aggregate of human judgments or efforts can, crowdsourcing can be used. It uses the computing medium to connect many workers to a task necessitating human processing. For our particular instance of SMS collection, we can employ crowdsourcing to connect many potential contributors of SMS to a collection framework.

The term “crowdsourcing” actually subsumes several forms (Quinn and Bederson, 2009), of which the Mechanized Labor form is most relevant to our project. This form is defined by its use of a (nominal) monetary to motivate distributed workers do their task. The most notable example of mechanized labor in practice is embodied in Amazon Mechanical Turk (hereafter, MTurk)¹⁷, an online marketplace for employers (a.k.a. requesters) to publish small tasks, and workers (a.k.a. Turkers) to choose and complete the tasks. MTurk has become a popular crowdsourcing platform for its low cost and diverse workforce.

Of late, MTurk has been employed for many uses within scholarly work. We only focus on works concerning data collection, in particular, the collection of language-related data. In 2010, a special workshop was held with the North American Annual meeting of the Association of Computational Linguistics (NAACL), entitled Creating Speech and Language Data With Amazon’s Mechanical Turk. Callison-Burch and Dredze (2010) categorized the data collected in this workshop into six types: Traditional NLP tasks, Speech and Vision, Sentiment, Polarity and Bias, Information Retrieval, Information Extraction, Machine Translation. Though strictly speaking, SMS collection is not subsumed by any of the six types, the success and variety of the corpora created in the workshop as well as in other studies convince us that MTurk is a suitable platform for our project.

3 Methodology

We focus on collecting both English and Chinese SMS messages, for expanding our 2004 English SMS corpus and addressing the extreme scarcity of public Chinese SMS corpus. Our aim is to create a SMS corpus that is: 1) representative for general studies, 2) largely free of transcription errors, 3) accessible to the general public without cost, and 4) useful to

¹⁵ <http://www.treasuremytext.com>

¹⁶ The contributors and collection method are for the 487 messages collected in 2002; later, another 366 messages were collected from 2004-2006 without mentioning the contributors and collection methods.

¹⁷ <http://www.mturk.com>

Table 1: Existing Corpora. An asterisk (*) indicates that the corpus is publicly available.

Researcher(s)	Size	Language(s)	Contributors	Collection Method(s)
Pietrini (2001)	500	Italian	15 to 35 years old	<i>Not mentioned</i>
Schlobinski et al. (2001)*	1,500	Germany	Students	<i>Not mentioned</i>
Shortis (2001)*	202	English	1 student, his peers and family	Transcription
Segerstad (2002)	1,152	Swedish	4 paid and 16 volunteers	Transcription, Forwarding
Kasesniemi and Rautiainen (2002)	7,800	Finnish	Adolescents (13-18 years old)	Transcription
Grinter and Eldridge (2003)	477	English	10 teenagers (15-16 years old)	Transcription
Thurlow and Brown (2003)	544	English	135 freshmen	Transcription
Ogle (2005)	97	English	Nightclubs	Subscribe SMS promotion of nightclubs
Ling (2005)	867	Norwegian	Randomly select 23% of 2003 respondents	Transcription
How and Kan (2005)*	10,117	English	166 university students	Transcription
Fairon and Paumier (2006)*	30,000	French	3,200 contributors	Forwarding
Choudhury et al. (2007)*	1,000	English	Anonymous users in treasuremytext ¹⁵	Search the SMS from the website
Rettie (2007)	278	English	32 contributors	<i>Not mentioned</i>
Ling and Baron (2007)	191	English	25 undergraduates	Transcription
Žic Fuchs and Tudman Vukovic (2008)	6,000	Croatian	University students, family and friends	<i>Not mentioned</i>
Gibbon and Kul (2008)	292	Polish	University students and friends	<i>Not mentioned</i>
Deumert and Oscar Masinyana (2008)	312	English, isiXhosa	22 young adults	Transcription, Forwarding
Hutchby and Tanna (2008)	1250	English	30 young professionals (20-35 years old)	Transcription
Walkowska (2009)	1700	Polish	200 contributors	Forwarding, Software
Herring and Zelenkauskaitė (2009)	1452	Italian	Audiences of a iTV program	Online SMS archives
Tagg (2009)	10,628	English	16 family and friends	Transcription
Elvis (2009)	600	English, French, etc.	72 university students and lecturers	Forwarding
Barasa (2010)	2,730	English, Kiswahili, etc.	84 university students and 37 young professionals	Forwarding
Bach and Gunnarsson (2010)	3,152	Swedish, English, etc.	11 contributors	Software
Bodomo (2010)*	853	English, Chinese	87 youngsters ¹⁶	Transcription
Liu and Wang (2010)	85,870	Chinese	Real volunteers	<i>Not mentioned</i>
Sotillo (2010)	6,629	English	59 participants	Software
Dürscheid and Stark (2011)*	23,987	Germany, French, etc	2,627 volunteers	Forwarding
Lexander (2011)	496	French	15 young people	Transcription
Elizondo (2011)	357	English	12 volunteers	Transcription

serve as a reference dataset. Several strategies were used in our collection process to achieve these goals.

First, we did not restrict our collection to any specific topics, to encourage diversity among the messages. Also we did not limit to known contributors, but instead tried to diversify contributor backgrounds to fulfill the first aim of making contributor demographics similar to the general texting population. We used three different technical methods to collect SMS: 1) simple transcription of an SMS into a collection web site, 2) exporting of SMS directly from phone to a file for submission, and 3) uploading lists of SMS as an email draft, for editing and eventual submission via email initiated by the contributor. The latter two collection strategies also favor the collection of whole SMS streams during an interval, favoring an unbiased collection of messages. They also collect the messages as-is from the phone's memory, minimizing the chance of transcription or entry errors, satisfying the second aim. To achieve the third aim, we created a program (discussed below) to automatically replace any identifiers and sensitive data with placeholders and to encrypt identifiable metadata with each SMS. With these minor modifications, contributor's privacy issues are mollified and allow us to release the corpus to the general public. Finally, to ensure that the corpus satisfies our fourth aim of being a viable reference corpus, we release archived, static versions of our continually-growing corpus on a monthly basis. In the following, we present these strategies in more detail.

3.1 SMS Collection Requirements

We did not restrict contributors to send only SMS on certain topics. This helps to keep the collected messages representative of actual content (Barasa, 2010), and diversify the corpus in content. Moreover, we required contributors to fill out a demographic survey about their background (e.g., age, gender, city, country), texting habits (input method, number of SMS sent daily, years of using SMS) and information about their phones (brand, model and whether it is a smartphone or not). Such answers form a profile associated with the bulk of the SMSes collected in our corpus, which we feel can facilitate sociolinguistics studies.

We did, however, require that the submitted messages be personal, sent messages only. The "sent-message" restriction is required for two important reasons. Ethically speaking, the submission of received messages is disallowed as the consent of the sender is not guaranteed, and may violate the trust and rights of the original sender. Technically speaking, as we also aim to have as complete demographics on the SMSes collected, we would also be unable to contact the senders to have them complete the same demographic survey, which makes received messages even less appealing to collect. The "personal" restriction means the messages are typed by the contributors themselves and not of artificial or commercial nature, or chain messages to be forwarded (e.g., blessings, jokes, quotes) that may be available on the Internet.

3.2 Source of Contributors

We aim to create a corpus which reflects the general characteristics of English and Chinese SMS messages, to be used for a wide variety of studies. Therefore, contributors are expected to have diverse backgrounds, of a wide range of ages, and living in various geographic location. As crowdsourcing methods pull from a variety of sources, we deemed this strategy as suitable for SMS collection.

Probably the most well known crowdsourcing platform is Amazon’s Mechanical Turk (henceforth, MTurk), which allows users to publish tasks and for the members of the general public to do the tasks, usually for a nominal fee. The use of MTurk as a crowdsourcing technique has been widely documented in the computer science literature. It is also an ideal place for conducting our English SMS collection. We also published a few tasks in another mechanized labor site, ShortTask¹⁸, to diversify the background of contributors. Considering its similarity to MTurk and the limited usage in our current collection methods, we do not discuss it further in this paper.

A demographic survey of MTurk workers (known colloquially as Turkers) conducted by (Ipeirotis, 2010a) reveals that the respondents are from 66 countries with a wide distribution in age and education levels, but that the majority of them are from English-speaking countries (46.8% American and 34.0% Indian). However, the study also suggests the scarcity of Chinese workers, which has also been validated by researchers – (Gao and Vogel, 2010; Resnik et al., 2010) who have pointed out that there are few Chinese speaking Turkers and thus difficult to recruit. We also performed a pilot study in MTurk, publishing two batches of tasks to collect Chinese SMS messages, but we received few submissions, validating the earlier reports of shortage of Chinese workers. So while MTurk is a good platform for collecting English SMS, and we have to find a more suitable platform for gathering Chinese SMS.

In China, the same crowdsourcing form of mechanized labor goes by the name of “witkey” (威客, *Wēi Kè* in pinyin), short for “key of wisdom”, described as using the wisdom of the masses to solve problems. Among such Chinese websites, Zhubajie¹⁹ currently stands out for its dominant market share (over 50%) and huge workforce (over 50 million)²⁰. Zhubajie also categorizes tasks within its own ontology, and one specific category relates to SMS (more details in section 5). Therefore, we chose Zhubajie as the crowdsourcing platform for collecting Chinese SMS.

Besides anonymous workers in MTurk, ShortTask and Zhubajie, we also exploit our local potential contributors in Singapore. English and Chinese are two of the official languages of Singapore, making it an ideal place to recruit contributors for our corpus collection. We recruited contributors by emailing students in our department. They were requested to submit either English or Chinese SMS. Participants from all three above sources were reimbursed a small sum of money for their contributions.

Finally, we also wanted to explore whether people would be willing to contribute SMSes purely for the sake of science (without remuneration). To test this, we sent email invitations to Internet communities of linguists and mobile phone owners. These communities comprised of the well-known *corpora-list*²¹ (an international mailing list on text corpora for research and commercial study), *corpus4u* (a Chinese corpora forum), *52nlp*²² (a Chinese collaborative blog in natural language processing²³), and two Chinese popular mobile phone forums – *hiapk*²⁴ and *gfan*²⁵.

¹⁸ <http://www.shorttask.com>

¹⁹ <http://www.zhubajie.com>

²⁰ According to the China Witkey Industrial White Paper conducted by iResearch <http://www.iresearch.com.cn>

²¹ Corpora@uib.no

²² <http://www.corpus4u.org>

²³ <http://www.52nlp.cn>

²⁴ <http://bbs.hiapk.com>

²⁵ <http://bbs.gfan.com>

3.3 Technical methods

Our collection methods can be categorized into three separate methods of collection. We want our methods to be simple and convenient for the potential contributor and allow us to collect SMS accurately without transcription errors.

- **Web-based Transcription.** The simplest collection method is transcribing messages from phone. We designed a web page for contributors to input their messages. Contributors were asked to preserve the original spelling, spaces and omissions of SMS, and standardized emoticons by following a transcription code table of our design (e.g., any simple smiling emoticon should be rendered as “:”)”).

As it is simple to implement, we adopted this transcription method as the collection method we used in our pilot, when we restarted our collection in 2010. We published a series of small tasks in MTurk to collect Chinese and English SMS, to test the waters and refine problems with our instruction set. However, when reviewing the submitted messages before Turker payment, we found a serious problem: a high rate of cheating. Some of the English Turkers had just typed messages like blessings, jokes, friendship, quote that were verbatim copies of ones that were publicly available in some SMS websites. These messages would not be representative of personally-sent messages, as required in the task’s documentation. For the Chinese SMS, it was apparent that some English speakers pretended qualify as Chinese speakers, copying Chinese sentences from Internet websites or completing the task without actually submitting any content. For both languages, we spent a non-trivial amount manpower (about 3.5 hours for 70 English submissions, and half an hour for 29 Chinese submissions) to inspect such messages, to validate the submissions as original, checking against identical or very similar messages publicly available the web. For our pilot tasks, our rejection rate of English and Chinese messages was 42.9% and 31.0%, respectively – clearly suboptimal considering the time and effort needed to review submitted SMSes and the potential ill-will generated with Turkers who performed our tasks but whom we deemed as cheating.

A final problem is that transcription is prone to typos and deliberate corrections, and discourages contributors from inputting a lot of messages, since the re-typing is tedious. From these pilot tasks, we learned that we needed better collection methods that ensured message accuracy and demanded less validation.

- **SMS Export.** With supporting software, some mobile devices can export received or sent SMS as files in various formats such as TXT, CSV, XML, HTML. This capability allows us to define this second collection method, SMS Exporting. It involves two steps. First, contributors export SMS from phone as a readable archive, and optionally, censor and delete SMS that they do not want to contribute. Second, contributors upload the archive and take a web-based demographic survey. We recruited contributors via both crowdsourcing websites and by regular, email invitations. Our unified (for both emailed invitations and the crowdsourcing tasks) description asked contributors to participate if they can export messages as a readable file (e.g., CSV, XLS). While such exporting capabilities are becoming more prevalent, not all phone models have such software. Even when available, it is not always free nor easy to use. Noting these difficulties, we thus prepared notes to ease contributors’ potential difficulties for popular platforms. Demographics from our web-based transcription task fielded in MTurk shows that 60% of English SMS workers and 47% of Chinese SMS workers were Nokia owners. This phenomenon is in accord with Nokia’s large market share and penetration in China and India (74% of English SMS workers in the pilot task are from India). Fortunately, Nokia

provides the Nokia PC Suite²⁶, a free software package for SMS export and backup via computer, which works on most Nokia models and meets our requirements. In the task description, we therefore linked to the download site for Nokia PC Suite and we offered a webpage-based tutorial on how to export SMS using the software.

Besides the advantage of high accuracy, and ease of batch submissions of SMS as mentioned in Section 2, SMS Export greatly helps us in validation. Since the archive has a specified format – which includes the telephone numbers of the sender and receiver, the send timestamp of the message – it significantly lowers the barrier for submitting valid data and significantly raises the barrier for submitting false data. For this reason, we expend significantly less effort in validating SMS submitted by this process.

- **SMS Upload.** With the growing popularity of smartphones, which have added functionality, we felt it would be a good idea to implement mobile applications (“apps”) that can contribute SMS directly. At the current juncture, we have implemented an app for the Android platform. Inspired by another app, SMS Backup, which is an open-source Android app for backing up SMS to Gmail²⁷, we adapted the code to create a new app, which we called *SMS Collection for Corpus*, as a pilot software for smartphones. We have released it as a free application in Google’s Android Market²⁸. Figure 1 shows a snapshot of our app.

SMS Collection for Corpus works by uploading sent SMSes from the Android device to the user’s Gmail²⁹ as a draft email. To allow the user to censor and delete message that she does not deem suitable for the corpus, the app purposely does not send the messages directly to our collection web site. We do not receive the SMSes for the corpus until contributors act to send out the draft email to us. The app also automatically anonymizes the metadata (telephone numbers) and replaces sensitive identifiers with placeholders. The details of the anonymization process is described later in this section.

As with the SMS Export collection method, it reduces the possibility of cheating and preserves the originality of messages. One advantage over SMS Export is its convenience; as there is no need to connect to a computer. Most importantly, its automatic anonymization makes contributors more confident about our strategy in privacy protection. For SMS collected in the other two methods, we employ a similar anonymization process, but after receiving the original SMS; in this method the anonymization procedure is run on the client smartphone, even before it reaches our collection server.

To the best of our knowledge, *SMS Collection for Corpus* was the first application designed to collect a corpus from original sources. It is also easy to adapt the software to support internationalization, so that the user interface can support new languages for potential submitters in other languages. In July 2011, we did exactly this, we extended the UI (user interface) to support prompts in Dutch, to facilitate the SoNaR³⁰ project language corpus project, to assist them to gather SMS in Netherlands.

²⁶ Currently being replaced by Nokia Suite <http://www.comms.ovi.com/m/p/ovi/suite/English>

²⁷ <http://mail.google.com>

²⁸ <https://market.android.com/search?q=pname:edu.nus.sms.collection>

²⁹ Hence a Gmail account is a prerequisite to this collection method.

³⁰ <http://www.sonarproject.nl>

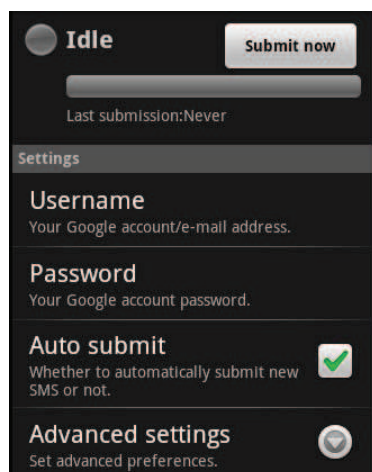


Fig. 1: A screen capture of the *SMS Collection for Corpus* mobile application.

3.4 Anonymization

Since SMS often contains both personal and confidential information, such as telephone numbers and email addresses, we need to anonymize these data when included in submitted SMS. We need to do so systematically in order to guarantee privacy when publishing the corpus, as we want to make the messages publicly available without restriction on access or use.

For messages collected by SMS Export and SMS Upload, the SMS metadata – telephone number of sender and receiver, and send time – is also collected. However, for the sender and recipient SMS metadata, we need to replace the original data with a unique identifier for each phone number so that privacy can be maintained, while preserving the fact that multiple messages linked to the original, same source are attributed correctly in the anonymized versions. To solve this problem, we adopt DES encryption to create a one-way enciphering of the phone numbers, which replace the originals in the corpus.

For the SMS message body, sensitive data include dates, times, decimal amounts, and numbers with more than one digit (telephone numbers, bank accounts, street numbers, etc.), email addresses, URLs, and IP addresses. Privacy for these types of data is paramount, and as such, we adopt a stricter standard in dealing with sensitive data in the message itself. Such information is programmatically captured using regular expressions and replaced by the corresponding semantic placeholders, as shown in Table 2. For example, any detected email address will be replaced by the code $\langle EMAIL \rangle$. This process gives a level of protection against publishing sensitive data. While we remove such confidential information, in general it is impossible to guarantee a contributor’s privacy with only a simple set of textual regular expressions. In particular, as person names are varied, language-specific and often confusable with common words, we do not try to remove or replace personal names.

All contributors were informed about the intended publishing of the resultant corpus, its public availability and the above anonymization procedure. This process also aided our internal review board application for exemption, as it was deemed that through this method, that our collection procedure did not collect personally identifiable information and was granted exemption from full review. However, the contributors may still not be entirely

clear about the automatic anonymization procedure after reading the description. To eliminate their uncertainty and skepticism, we need a straightforward and compelling way to show the anonymization in action. As we mentioned before, our Android app integrates the anonymization process internally, so potential submissions can be previewed as a draft email before sending the SMS batch to the collection server. This manner allows the actual collection data to be previewed, and more likely to convince the contributor of the veracity of the project and collection process.

Inspired by this, we created and deployed the website for the corpus project in January 2011, at the very beginning of our data collection process. The website allows users to browse the current version of the corpus. In calls to contributors, we also link to this live website so that potential contributors can view the scope, volume and content of the current corpus. We feel this is a strong factor in both lowering the anxiety and reluctance of potential submitters and raising awareness of the corpus in general.

Table 2: Replacement Codes

Original Content	Example	Replaced Code
Email Address	name@gmail.com	<i><EMAIL></i>
URL	http://www.google.com	<i><URL></i>
IP Address	127.0.0.1	<i><IP></i>
Time	12:30	<i><TIME></i>
Date	19/01/2011	<i><DATE></i>
Decimal	21.3	<i><DECIMAL></i>
Integer over 1 Digit Long	4000	<i><#></i>
Hyphen-Delimited Number	12-4234-212	<i><#></i>
Alphanumeric Number	U2003322X	<i>U<#>X</i>

3.5 Live Corpus

A few words about the notion of a live corpus. We feel that a live corpus is a emerging concept, in which the corpus grows, is maintained and released on regular, short intervals. A truly live corpus connotes that as soon as a new text is created, it becomes part of the distributed corpus. Such an interpretation can cause replicability problems, as different researchers may use different versions of corpus. Due to this problem, we have chosen to release a new version of the corpus on a regular, monthly basis. This strategy of having regular updates promotes interested parties to stay up to date with the corpus developments, while allowing the easy identification of a particular version, for papers that wish to use the corpus for comparative benchmarking. The release cycle further helps to demonstrate the trend of our gradual achievement in SMS collection, which, in turn, also may spur more contributors to help in our project. It also allows us to batch corpus administrative duties, such as proofchecking submitted SMS and re-computing demographic statistics, which we describe later.

4 Properties and Statistics

Given the variety of methods in our current corpus collection, and its previous history within another former project within our group, it is worthwhile to describe some properties of the resultant SMS collection thus far.

The original corpus, as collected and documented in How and Kan (2005), was collected by an honors year project student, Yijue How, over the course of her project from the fall of 2003 to the spring of 2004. The main collection method was by SMS transcription to a publicly-accessible website, largely from volunteers that authors contacted directly, hence most volunteers were Singaporeans in the young adult age range. A few contributors gave a large set of messages directly from the phones, foregoing the transcription process. This led to a distinctly bimodal message distribution of having a small “head” of few contributors that submitted many messages that represented depth in the collection, as well as a long “tail” of many contributors that submitted less than 100 messages (The transcription website allowed the submission of 10 messages at a go). Each contributor was assigned an identifier such that the number of messages by each contributor could be tracked. Further details about the demographics of the collection are available from How’s complete thesis (How, 2004).

We embarked on our current SMS collection project in October 2010. At the time of writing (October 2011), we have collected almost 60,000 messages, with the number still growing. In this remainder of section, we give statistics on the current corpus, the demographics of contributors, furnish a cost comparison of the major three sources we used and wrap up with a discussion on matters related to the corpus release.

4.1 Specification

As of October 2011, our corpus contains 28,724 English messages and 29,100 Chinese messages. In total, 116 contributors contributed English SMS and on average, each individual submitted 247.6 messages. In comparison, the total number of Chinese contributors is 515, with an average contribution rate 56.5 messages per person. Detailed histograms showing the number of messages contributed per contributor are given in Figure 2. Similar to the previous project, both histograms show a peak at the very left side, meaning that only a small proportion of people contributed the bulk of the messages – “the short head”. Specifically, 54.3% of English contributors submitted less than 30 messages. This figure is 75.7% for Chinese contributors, which explains why the per contributor Chinese SMS figure is much less than its English counterpart.

The cause of this difference is related to our collection methods. As discussed previously, due to its simplicity, Web-based Transcription is an effective way to obtain mass participation but makes it difficult to collect large amounts of SMS from a single contributor, while both the SMS Export and SMS Upload methods have the opposite characteristic. We fixed the number of SMS per submission in our Web-based Transcription method to 2 or 5 English messages, and 10 or 20 Chinese messages. A small number was used in the initial experiment for exploring a good ratio between monetary reward and workload (number of messages). Using MTurk, we published two batches of tasks to recruit 40 workers to follow our Web-based Transcription to collect English SMS. Unfortunately, due to the resulting high level of cheating and effort expended in verification, we felt the utility of this method was not tenable, so we stopped using this collection method for English SMS. In contrast, the Web-based Transcription was much more effective in Zhubajie, perhaps due to the unavailability of sources to cheat on the task. Up to now, we have retained the use of

Web-based Transcription in Zhubajie for the resulting high-quality SMS. This leads to the ascribed difference in demographics in recruiting more Chinese contributors with a resulting smaller per capita figure.

Table 3 demonstrates the number of messages collected by each of our methods. We see that 98.3% (28,244) of English messages and 45.9% (13,347) of Chinese messages were collected by SMS Export and SMS Upload methods, which are free of typos and contain metadata (ownerships of sender and receiver, and the timestamp of when it was sent). Table 4 then shows the number of SMS and contributors per source: for the English SMS 39.3% (11,275) were from workers in MTurk, 58.1% (16,701) were from local contributors, 1.0% (280) were from workers in ShortTask and the remaining 1.6% (468) were from the Internet community. For the Chinese SMS, workers from Zhubajie contributed 81.7% (23,789) of the SMS, local and Internet contributors submitted 12.2% (3,544) and 5.9% (1,712), respectively. Currently, only 55 Chinese SMS were contributed by users from MTurk, about 0.2%.

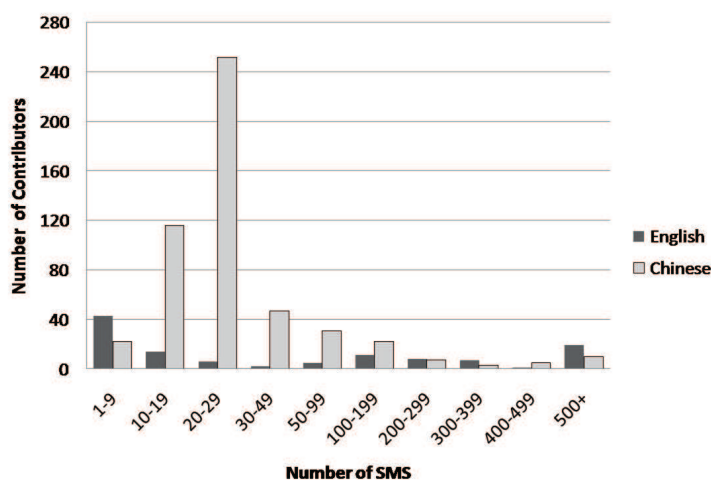


Fig. 2: Contributors and SMS Distribution

Table 3: Number of SMS by Collection Method

Method	English SMS	Chinese SMS
Web-based Transcription	480	15,753
SMS Export	11,104	12,344
SMS Upload	17,140	1,003

Table 4: Number of SMS and Contributors by Source

Source	English SMS	English Contributors	Chinese SMS	Chinese Contributors
MTurk	11,275	75	55	19
ShortTask	280	17	0	0
Zhubajie	0	0	23,789	483
Local	16,701	20	3,544	10
Internet Community	468	4	1,712	3
Total	28,724	116	29,100	515

4.2 Demographics

Aside from submitting SMS, all contributors were required to fill out an online demographic survey about their background (e.g., age, gender, country, native speaker or not, etc.), texting habits (input method, number of SMS sent daily, years of experience using SMS) and their phone (brand, model, smartphone or not). Such answers form a user profile for the contributor which is linked to each of their contributed SMS. We accept and report the data for the demographic survey as-is, assuming that contributors answered the questions to the best of their knowledge.

99.5% of English messages and 93.8% of Chinese messages thus have associated user profiles. The incompleteness arises from the separation of submitting SMS and filling out the survey in the two collection modes of SMS Export and SMS Upload. Some contributors submitted the messages but later did not do the survey. The phenomenon was more prevalent in the Chinese Zhubajie. During our initial usage pilots of Zhubajie, we approved contributors' SMS immediately, and trusted them to do the survey later on. To stem this problem, we later changed our protocol to only approve the task after receiving both SMSes and the demographic survey. We also had updated the survey once, adding some questions to reveal more detail on some aspects. The user profiles formed from the first version of the survey thus lacks answers to a few questions. To make all sets of the demographic data comparable, we inserted "unknown" values to these missing questions as well as to questions that were skipped by contributors.

While it is not possible to conclusively say anything about the demographics of SMS senders in general, our demographic survey allows us limited insight into the characteristics of our corpus' contributors. The confounding factor is that our contributors come largely from crowdsourcing sources, so both the self-selection of participating in crowdsourcing and of SMS use contribute to the demographic patterns we discuss below.

We report both the country of origin, gender and age of contributors, subdivided by the English or Chinese portion of the current corpus. Our English SMS contributors are from 15 countries (in decreasing order of number of contributors): India, USA, Singapore, UK, Pakistan, Bangladesh, Malaysia, China, Sri Lanka, Canada, France, Serbia, Spain, Macedonia and Philippines. 64.7% of them are English native speakers. The top three countries are Singapore (46.9% of SMS), India (28.2%) and USA (13.5%). Our Chinese SMS contributors are from 4 countries: China, Singapore, Malaysia and Taiwan. However, the messages are overwhelming from China: China mainlanders contributed 99% of the messages, resulting in 99.8% of messages originating from native speakers. As for gender, for the English portion of the corpus, 16.1% come from females, 71.1% from males, and the remaining 12.8% is unknown. For the Chinese portion, 34.3% come from females, 59.4% come from males, and 6.3% is unknown. The age distribution shows that the majority of contributors in both portions of the corpus are young adults, as displayed in Figure 3. In particular, contribu-

tors aged at 21–25, taking up 39.7% of English and 56.7% of Chinese SMS contributors, respectively, make the biggest contribution to our corpus, submitting 56.9% of English and 66.0% of Chinese SMS respectively. This may be reflective of the demographics of crowd-sourcing workers in both MTurk and Zhubajie (Ipeirotis, 2010a; iResearch, 2010). There is an even higher skew towards the 16–20 age group among English contributors than the Chinese counterpart, largely due to the fact that 58.1% English SMS originate from local contributors, namely the students in our university.

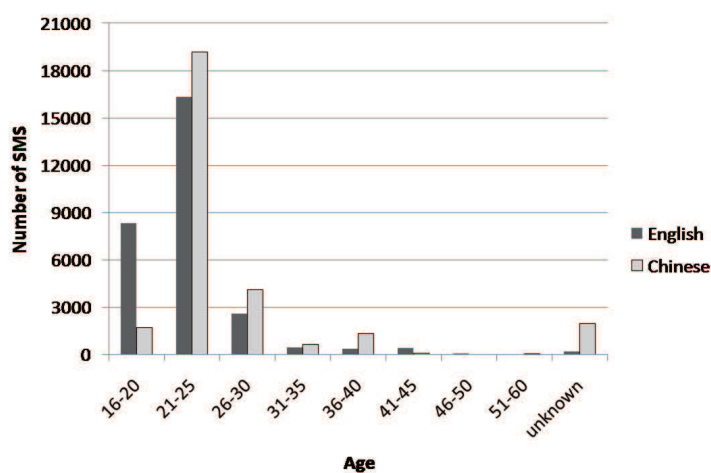


Fig. 3: Age Distribution by SMS

Our survey also reveals other pertinent details on the texting habits and phone models of contributors. We display the distribution of contributors' years of using SMS in Figure 4. The largest English SMS portion lies in 5–10 years (44.8% of contributors), and the second largest portion is 3–5 years (31.9%). Similarly, most Chinese contributors have used SMS for 3–5 years (31.3%) and 5–10 years (30.7%). This phenomenon is in accord with the age distribution; that young adults represent the majority of the contributors. We may also posit that more of our Chinese contributors have acquired their SMS-capable phone more recently than our English contributors, as we see a smaller proportion of users in the 5–10 year range.

The distribution of the frequency of sending SMS is presented in Figure 5. We observe an interesting phenomenon that there is a gradually increasing trend – from 18.0% (2–5), 18.1% (5–10), to 31.0% (10–50) – for English contributors, while for Chinese contributors it decreases – from 32.2% (2–5), 26.0% (5–10), to 22.1% (10–50). Moreover, for the English portion, 17.2% of contributor send more than 50 SMS everyday. We posit that the larger proportion of English contributors who SMS more than 50 times a day may indicate that some use it to carry on conversations (thus needing more messages) rather than for sending one-off messages.

Input method differences were also revealed in our survey. Three common input methods, multi-tap, predictive and full keyboard, account for 41.4%, 30.2% and 17.2% of English SMS contributors respectively. The remaining 10.3% of contributors used other input methods. Chinese input methods also largely consist of three input methods, pinyin, wubi and

bihua; these account for 86.0%, 3.9% and 4.3% of contributors' usage. As displayed in Figure 6, the majority of contributors own a Nokia phone, which accounts for 48.3% of English SMS contributors and 49.7% of Chinese SMS contributors. However, these figures cannot fairly present the general popularity of phone brands, for the reason that we only provide links to Nokia utility software for SMS Export collection method. In addition, 37.1% of English SMS contributors, and 44.9% of Chinese SMS contributors own a smartphone. This question was not included in the first version of survey used in MTurk, which leads to smartphone information is unknown for 48.3% of English SMS contributors and 7.8% of Chinese SMS contributors.

For more in-depth analysis beyond the scope of our article, we invite you to visit the corpus website, where the full, per question answers for our demographic data is available.

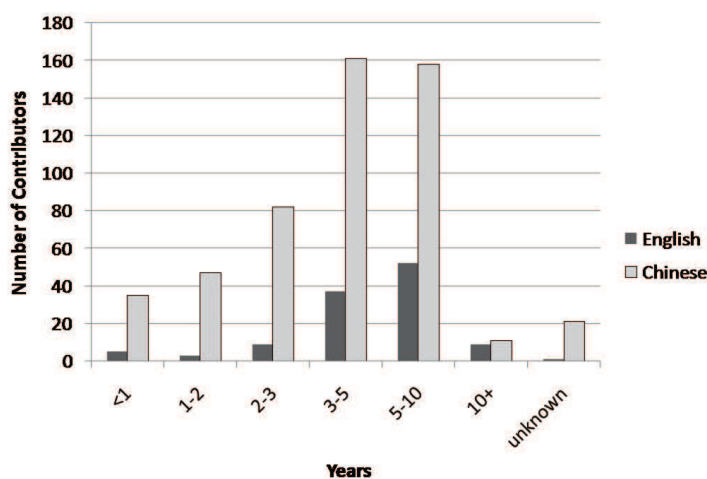


Fig. 4: Contributors' Experience in Using SMS

4.3 Cost

As MTurk, ShortTask and Zhubajie are crowdsourcing sites where participants are motivated by profit, we compensated contributors monetarily. The same was true for the local collections that we ran. For the calls for participation via the Internet to linguistic, text corpus and phone manufacturer's communities, we felt that their self-motivation to see the corpus' success would be a strong motivator to participate. Thus for these communities, we did not provide any compensations.

Table 5 shows the reward scheme used in our MTurk collection runs using the SMS Export and SMS Upload methodologies. For example, 400 messages will be rewarded with \$4.50 in total with \$4.00 base payment and \$0.50 bonus. In ShortTask, we only published tasks using Web-based Transcription method, with the reward of \$0.08 for 10 messages per submission. Since Zhubajie was a new venue for crowdsourcing, we tuned our rewards scheme based on a pilot (as shown in Tables 6 and 7). Our pilot showed that workers were

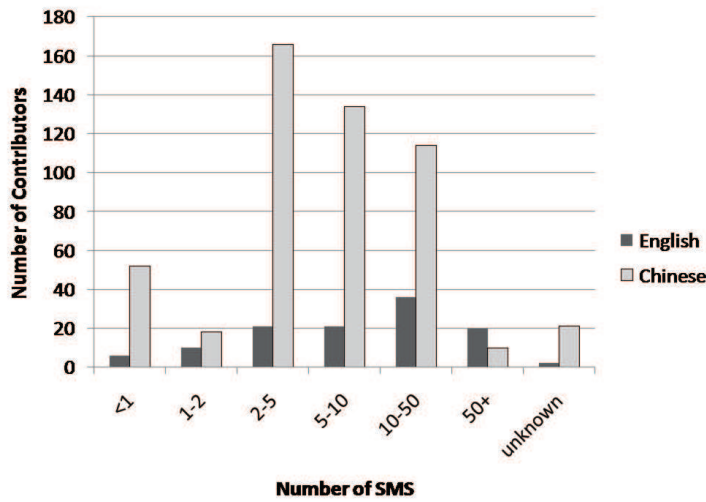


Fig. 5: Contributors' Frequency of Sending SMS Daily

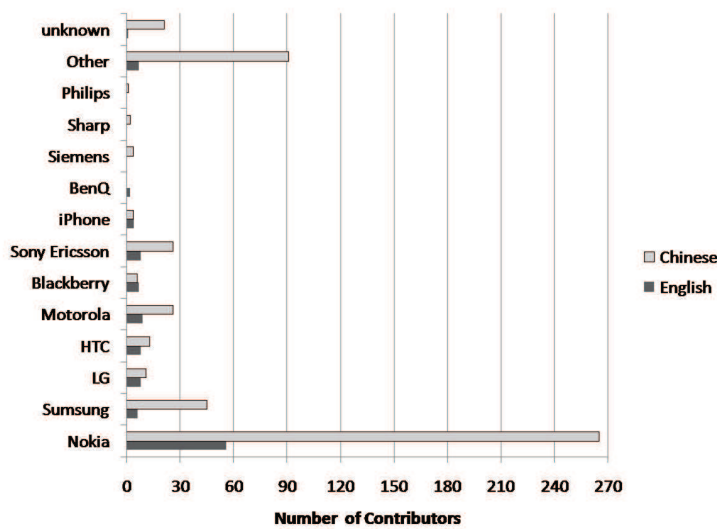


Fig. 6: Contributors' Phone Brand

very eager to participate, thus we decreased the reward amount in our subsequent runs, which did not dampen workers' enthusiasm for completing the contribution tasks. For the four batches of English (2 batches) and Chinese (remaining two batches) SMS Web-based Transcription, we instead aimed for breadth of participants. In each task, we recruited 20 workers with \$0.10 as the reward for individual workers. Finally, we also recruited contributors locally, whose reward scheme is displayed in Table 8.

Since the labor cost of collecting additional SMS over the first few is small (arguably even negligible in the Upload and Export methodologies), we incentivize additional submitted messages with a bonus reward, which is based on the number of messages that exceed the base range. For all reward schemes, the bonus amount diminishes with the amount of additional messages submitted, with a maximum payment capped to allow us a measure of budgetary control. Table 9 shows the cost comparison between sources. We spent 92.30 US dollars in MTurk, 2.94 US dollars in ShortTask, 868.50 Chinese yuan in Zhubajie (all inclusive of commission fees) and 340.00 Singapore dollars for our local collection. Standardizing all currency amounts to US dollars³¹ allows us to compute the cost per message for a clear comparison. In a nutshell, local collection is the most expensive method, while crowdsourcing remains an effective and economical method to collect our corpus data. We also note that Zhubajie is a little cheaper than MTurk, but that it may only be applicable to certain languages (i.e., Chinese). Due to our very limited usage of ShortTask, it doesn't make much sense to compare cost in ShortTask with other sources.

Table 5: Reward Scheme in MTurk

Total Number	Base Reward	Bonus
10–400	0.10	1/100 Msg
401–1000	4.00	1/200 Msg
≥ 1000	7.00	0

Table 6: Reward Scheme 1 in Zhubajie

Total Number	Base Reward	Bonus
10–100	1.00	1/10 Msg
101–400	10.00	1/20 Msg
401–1000	25.00	1/40 Msg
≥ 1000	40.00	0

Table 7: Reward Scheme 2 in Zhubajie

Total Number	Base Reward	Bonus
20–100	1.00	1/20 Msg
101–400	5.00	1/25 Msg
401–1000	17.00	1/40 Msg
≥ 1000	32.00	0

4.4 Towards a publicly-available live corpus

Our corpus, consisting of both messages and associated user profiles, has been released publicly since February 2011³². To achieve our goal of making an accessible dataset, we

³¹ On 23 October 2011, 1 SGD = 0.7848 USD, 1 CNY = 0.1567 USD.

³² <http://wing.comp.nus.edu.sg/SMSCorpus>

Table 8: Reward Scheme for Local Collection

Total Number	Base Reward	Bonus
20–50	2.00	1/10 Msg
51–200	5.00	1/30 Msg
201–600	10.00	1/40 Msg
≥ 600	20.00	0

Table 9: Cost Comparison

Source	Total Num	Total Cost	Cost Per Msg
MTurk	11,330	USD 92.30	USD 0.00815
ShortTask	280	USD 2.94	USD 0.0105
Zhubajie	23,789	CNY 868.50	CNY 0.0365 (~USD 0.0057)
Local	20,245	SGD 340.0	SGD 0.0168 (~USD 0.0132)

have pursued an open license, public domain development methodology that involved first the convincing and later the blessing of our university’s intellectual property department. For the aim of making a general purpose dataset, we have tried to incorporate a balanced approach for user profiling; by requiring contributors to answer a set of demographics and including them with the dataset. So as to make the corpus as large as possible, we incorporate all messages that we collected through all of the methodologies used, although this means varying levels of quality among subportions of the corpus (e.g., some SMS may not have an associated user profile).

To make the corpus convenient for researchers to access, we also pioneer the distribution of the corpus both as an XML file as well as a database dump in MySQL. Potential SMS researchers or contributors can also browse and download the corpus on the directly on the corpus website, and access dataset statistics, all without the need to handle the raw corpus files or compute the statistics themselves. Website access also shows the effect of the anonymization processes discussed earlier, so that potential contributors can feel more secure knowing how their messages will likely appear.

Our statistics help prospective users grasp a general understanding about the demographic and representativeness of our corpora. The corpus as well as statistics will be updated on a monthly basis, since our collection is still in progress. Moreover, the SMS can be directly browsed on our website, which provides a convenient way to learn about our corpus without the need to process raw files and helps potential contributors to understand our anonymization strategy by viewing other’s messages.

5 Discussion

We now comment on three open questions surrounding the crowdsourcing of our public corpus of SMS. First, what do workers think about contributing SMS to a public corpus? Second, how does the Chinese crowdsourcing site of Zhubajie compare with Amazon’s Mechanical Turk? Third, as some crowdsourcing is motivated by altruism, how possible is it to collect SMS without offering any monetary reward?

5.1 Reactions to our Collection Efforts

The corpus was collected under our university's institutional review board (IRB) exemption policy and important identifiers in the corpus have been replaced by placeholder tokens for deidentification purposes. However, our experience through on this project over the last year has shown us that the privacy issues surrounding the collection of SMS is still very much a concern. Even among our research group, members were largely unwilling to donate SMS even with the safeguards in place. This may have been partially due to fact that the authors need to manually review the submitted SMS, and that the review process may identify the contributor. This fear was further validated in our local collection drive, where potential contributors worried that their friends may review the corpus and identify their messages, especially through the mention of certain names in SMS (Personal names are not replaced by any code as given in 2, as many personal names are also common words as well).

Privacy concerns were also paramount in our crowdsourcing work with Amazon Mechanical Turk, and ultimately caused our account with MTurk to be closed. Amazon sent us several notices that our tasks violated their terms of service. Though private correspondence with Panagiotis Ipeiritis, whose research involves detecting spam in MTurk, we found out our tasks were routinely classified by turkers as a spam or phishing task, despite our attempts to give credibility to the project through the creation of the corpus webpage and browsing interface³³. Unfortunately, even with repeated attempts to contact Amazon to clarify the nature of our notice of breach of service, our MTurk account was suspended without further detail from Amazon.

Similar concerns surfaced on our calls for SMS contribution in the Chinese realm. Notably on the mobile phone forums that we posted our call for participation, we encountered a few skeptic replies. For these forums, we had advertised our Android SMS uploader application, with the appropriate links to an explanation of the project and our corpus' web page. Several posters voiced their concern that the software might be malware looking to steal private information (especially given the inclusive permissions set that our application needs access to). These were valid concerns as some previous mobile application recommendations did turn out to be malware, so readers were being cautious before installing any software.

5.2 Zhubajie compared to MTurk

Zhubajie is one of a growing number of middleware websites in China offering crowd-sourced labor. Forecasted online transactions on the site are expected to surpass 500 million CNY (~78 million USD) in 2011 alone³⁴.

As discussed, we found Zhubajie to be a good platform to recruit Chinese contributors. However, unlikely its western counterparts, Zhubajie, as well as other Chinese "witkey" websites, has not been widely exploited for research data collection in computer science community. Most exiting academic work focus on the business and economic research, studying the user behavior (Yang et al., 2008; DiPalantino et al., 2011; Sun et al., 2011), analyzing the participation structure (Jiang Yang, 2008), exploring the anti-cheating mechanism (Piao et al., 2009), and investigating the business model (Li and Hongjuan, 2011).

³³ In fact, these were some of Ipeiritis' suggestions to ameliorate the problem, so credit is due to him.

³⁴ <http://economictimes.indiatimes.com/tech/internet/idg-backed-chinese-website-zhubajie-to-list-in-us-in-3-years/articleshow/9478731.cms/>

For these reasons, we feel it would be useful to give a more comprehensive overview of Zhubajie, focusing on five aspects: its conceptualization, characteristics of typical tasks, cost, completion time and result quality. We compare Zhubajie against the now familiar Amazon Mechanical Turk (MTurk) when appropriate.

- **Concepts.** While both Zhubajie and MTurk can be characterized as mechanized labor, to be more accurate, Zhubajie’s form of crowdsourcing originates from “witkey” – an abbreviation of the phrase “the key of wisdom”. The concept of Witkey was put forward by Liu in 2005, and later published in Liu et al. (2007), where its core concept was to trade knowledge, experience and skill as merchandise.
- **Tasks.** MTurk focuses on tasks that take a small or moderate amount of time to complete, while most tasks of Zhubajie require expertise and can take longer to complete. Designing logos, software development and revising resumé are typical Zhubajie tasks. Zhubajie also classifies tasks into a detailed hierarchical classification system with major 18 top categories, and 6–22 secondary categories per top-level category. It requires requesters to specify a secondary category for each task. This is unlike MTurk, which eschews task classification altogether. Zhubajie’s detailed browsable task hierarchy reflects its Chinese base, as the Chinese population often prefers selection and browsing over searching (as browsing only requires clicking but searching requires inputting Chinese characters, which is still somewhat difficult)³⁵. This task classification leads to different service characteristics in Zhubajie and MTurk. MTurk provides keyword search and 12 different sorting options for results display (newest/oldest tasks, most/fewest available tasks, highest/lowest reward, etc.). The survey results of Chilton et al. (2010) shows that the newest and most available tasks are the most popular sorting strategies employed by workers, and that first two pages of result listings are most important. Ipeirotis (2010b) pointed out that if a task is not executed quickly enough, it will fall off these two preferred result listings and is likely to be uncompleted and forgotten. This is in accord with our experience in trying to recruit workers. In Zhubajie, even 10 days after publishing the task, we still received new submissions from workers. This is contrary to our experience with MTurk, where we did not receive many new submissions after the first two days. Due to the detailed task hierarchy in Zhubajie, potential workers can easily target specific tasks matching their expertise and interests, ameliorating the recency-listing concerns prevalent in MTurk. A few outstanding workers, based on reputation and total earnings, are also featured as top talents for each task category. Requesters can invite and recruit talents to fulfill the task. These properties all help aid matching workers to tasks in comparison to MTurk.
- **Cost.** The demand of expertise in Zhubajie also impacts the payment distributions in two websites. In MTurk, the lowest payment is just USD \$0.01 and 90% of tasks pay less than \$0.10 (Ipeirotis, 2010b). Compared to the tiny rewards offered in MTurk, the rewards in Zhubajie are significantly higher, with about \$0.15 (CNY 1.00) as the lowest reward and about \$182 (CNY 1181) as the average reward for the year 2010. Also, though both services make profit by collecting commission fees, they differ as to whom the commission is charged from: MTurk charges the requester 10%, but Zhubajie charges the worker 20% commission. Furthermore, In Zhubajie, task rewards come in two flavors: they can be set by requesters or they can be bid on by workers. In Zhubajie, these are referred to as *contract tasks* and *contest tasks*, respectively. In this sense, our task

³⁵ <http://www.smashingmagazine.com/2010/03/15/showcase-of-web-design-in-china-from-imitation-to-innovation-and-user-centered-design/>

- and MTurk tasks in general – are thus contract tasks. For our SMS collection thus far, Zhubajie has turned out to be more economical by 30.1%; we spent \$0.0057 and \$0.00815 per message in Zhubajie and MTurk, respectively.
- **Completion Time.** Here we look at the task completion time with respect to collection methodology. With the SMS Upload method, it took 2 full days to receive 3 English submissions via MTurk; and worse, there were no submissions at all from Zhubajie. This may be explained by the current low popularity of Android smartphones among Chinese SMS contributors. In contrast, under the SMS Export collection method, we received 16 Chinese submissions from Zhubajie in 40 days, and 27 English submissions from MTurk in 50 days. The collection in this method was slow in both platforms. Web-based Transcription offers the most telling demographic difference. Our MTurk tasks took 2 days to complete, collecting 40 valid English submissions and 20 days for 20 valid Chinese submissions (each submission having 2 or 5 individual SMSes). In contrast, the same Chinese SMS task, when published to Zhubajie, usually took less than 30 minutes to complete to collect for 20 submissions. We ascribe the quick completion in Zhubajie to two reasons. First, Zhubajie has a specific task category for SMS tasks – the *creative greetings* category. This category typically asks workers to compose a creative SMS and send it to bless a designated recipient (i.e., write a poem to wish someone to get well soon), as it is uplifting in China to receive lots of blessing from the general public. It is also a relatively popular category among workers for its short completion time and low requirements for expertise. Second, compared to other tasks in the creative blessing category, our task is easier, faster and more profitable. Other tasks require workers to design or craft a creative blessing and send it to an actual recipient which incurs cost, but the payment is usually identical to ours.
- **Quality** has emerged as a key concern with crowdsourcing, and it is clear that this is a concern for our task as well. MTurk employs several strategies to help requesters control for quality: a requester can require certain qualifications based on the worker’s location and approval rate, publishing a qualification test prior to real task and blocking certain poor workers from a task. To attract the maximal number of potential contributors, we did not set any qualifications in MTurk. Zhubajie does not provide built-in quality control system. Tasks, when completed in either MTurk or Zhubajie, can be rejected by the requester if it does not meet their criteria for a successful task. Table 10 shows our approval rate of completed tasks for each collection method in the two crowdsourcing websites.

As we have previously described the problems with Web-based Transcription (in that contributors can enter anything they want, including SMS copied from other SMS sites on the web), we expected this poorly-performing methodology to have the highest rejection rate. Surprising, in fact, it was quite the opposite: Web-based Transcription tasks enjoyed a higher approval rate than the other methods, across both sites. We believe the difference in financial incentives of the methodologies explains this. While the payment for Web-based Transcription was only US \$0.10 in MTurk and CNY 1.00 in Zhubajie, the payment of the other two methods can be as high as US \$7.00 in MTurk and CNY 40.00 in Zhubajie. Intrigued by the high reward, some workers attempted to cheat on these higher-yield methods. This validates findings by Mason and Watts (2009), who states that increased financial compensation may not improve task quality, and sometimes may even result in poorer quality.

SMS Upload approval rates were also relatively better than those for SMS Export. Workers using SMS Upload needed to type a unique code generated by the mobile application, which may discourage errant workers from cheating since they would have not known

how to generate the correct code without doing the task through the application. In contrast, the SMS Export method allowed contributors to upload any files (even those not containing SMS at all), making it easier for potential cheaters to try their luck.

Finally, we judged the overall quality of work done by Zhubajie workers to be much higher than that of MTurk. We attribute this to the open worker reputation system of Zhubajie. In MTurk, the worker’s approval rate is the sole figure to judge whether a worker’s work is good or bad. Zhubajie stores comments on workers as well as calculating a positive comment rate (similar to MTurk’s approval rate) and a reputation rank which is based on earned income. In some cases, if many workers compete for one task, the requester can pick over the potential, qualified workers based on these positive comment and reputation rank. Finally, Zhubajie’s administrators will warn serious cheaters and even lock their account. MTurk metes out no official punishment for cheaters (unlike our experience for requesters), and requesters have to manually blacklist poor workers in their tasks.

Table 10: Approval Rate Comparison

Collection Method	MTurk	Zhubajie
Web-based Transcription	62.50%	85.03%
SMS Export	16.58%	57.14%
SMS Upload	42.86%	No submissions

5.3 Altruism as a Possible Motivator

Mechanized labor is just one possible form of crowdsourcing that can result in workers performing a task. There have been a number of surveys on crowdsourcing, including a recent survey on finding optimal the method for crowdsourcing corpora and annotations Wang et al. (2011). Are other, non-profit oriented approaches feasible for collecting sensitive data? Could altruistic motivational factors work?

To answer this question, we emailed calls for participation to the natural language and corpora community³⁶ for voluntary, non-compensated contributions of SMS. This was a part of our methodology from the beginning as described earlier. Unfortunately, the results were not promising. As shown in Table 4 of Section 4, we received only 5 anonymous contributions, totalling 149 English and 236 Chinese SMS, respectively by these methods³⁷. Compared to the rest of the for-reward collection methods, this method was a failure, and we do not recommend this method for collection in its current guise.

Our findings are contrary to the sms4science project, which succeeded in gathering a large number of messages through pure voluntary contribution. Though a small portion of contributors were randomly selected by lottery to win prizes³⁸, we still deem their collection method as a purely voluntary contribution, as there is no monetary compensation. However, we note two key differences between our call and theirs. The sms4science project obtained support from phone operators, to make it free for potential contributors to forward their

³⁶ via the Corpora List, corpus4u forum, and the (Chinese) 52nlp blog.

³⁷ From additional personal contacts, we obtained an additional 319 English and 1476 and Chinese SMS respectively.

³⁸ <http://www.smspouurlascience.be/index.php?page=14>

SMS to a service number. This lowers the difficulty of contributing messages as no software installation or tedious export is necessary (but note it does destroy some message meta-data that we can collect through our other methods). Probably more important was that the sms4science project conducted large-scale publicity; its call for participation was broadcast in the main national media including press, radio, television (Fairon and Paumier, 2006; Dürscheid and Stark, 2011). For example, the Belgium project was reported in five newspapers and six websites within two weeks³⁹. For our project, due to the limited publicity vehicles and technical constraints, attracting people to contribute SMS only for the sake of science was difficult.

Our appeal to the research community did not yield many SMS for the corpus, but did give us further convictions that we were performing a necessary and useful task. Several researchers supported our project by writing words of encouragement and sharing their personal difficulties with gathering SMS for research.

6 Conclusion

In order to enlarge our 2004 SMS corpus and keep up with the current technology trends, we resurrected our SMS collection project in October 2010 as a live corpus for both English and Mandarin Chinese SMS. Our aim in this revised collection are threefold: to make the corpus 1) representative for general studies; 2) accurate with fewer transcription errors; 3) released to the general domain, copyright-free for unlimited use; 4) useful to serve as a reference dataset. To achieve these four goals, we adopt crowdsourcing strategies to recruit contributors from a wide spectrum of sources, using a battery of methodologies to collect the SMS. As SMS often contains sensitive personal data, privacy and anonymization issues have been paramount and have influenced the resulting design of the collection methods and the corpus data itself.

We are very encouraged by the results so far. As of the October 2011 version of the corpus, we have collected 28,724 English SMS and 29,100 Chinese SMS, with a cost of 497 U.S. dollar equivalent and approximately 300 human hours of time (inclusive of the Android app implementation, website creation and update). As the project is a live corpus project, all of these figures are growing as the collection is a continuing effort. To the best of our knowledge, our corpus is the largest English and Chinese SMS corpus in the public domain. We hope our corpus will address the lack of publicly-available SMS corpora, and enable comparative SMS related studies.

A novel aspect of our collection is the implementation of mobile phone applications for collection. We adapted an SMS backup software to also serve as a platform for contributing SMS. It is the first application for such purpose and is easily adapted for other SMS collection purposes. We report on the use of the first use of Chinese crowdsourcing (also known as “Witkey”) for collecting corpora and have discussed the significant differences between Chinese and traditional crowdsourcing in the English-speaking world, as embodied by Amazon’s Mechanical Turk. Finally, we explored the possibility of calling for SMS contribution without compensation, but found that altruistic motivation is not sufficient for collecting such data. Rather, our lessons learned indicate that large-scale publicity is the key to success.

We continue to enlarge our SMS collection, as part of our interpretation of what a live corpus project means. Given the importance of SMS in carrying personal communication in

³⁹ <http://www.smspouurlascience.be/index.php?page=16>

our society, and the low-cost methods we have found to collect message contents (suitably scrubbed) and demographic data, we are encouraged to continue to fund this work internally, to encompass more languages and a wider population of users. We also plan to explore other SMS collection methods, such as an iOS (i.e., iPhone, iPad) application, and benchmark their efficacy against the methods we have analyzed in this article.

As for downstream use, with further funding, we may annotate the corpus (either automatically or manually) for part-of-speech, translation to other languages, or other semantic markup. The resulting corpus may then be used in other natural language studies and applications (e.g., machine translation). Other downstream projects that we know of may also make their annotations and additional collection of SMS available as collaborative or sister projects to our NUS SMS corpus.

7 Data

The corpus described in this paper is publicly available at our corpus website (<http://wing.comp.nus.edu.sg/SMSCorpus>).

Acknowledgements We would like to thank many of our colleagues who have made valuable suggestions on the SMS collection, including Jesse Prabawa Gozali, Ziheng Lin, Jun-Ping Ng, Yee Fan Tan, Aobo Wang and Jin Zhao.

References

- Bach, C. and J. Gunnarsson (2010, June). Extraction of trends in SMS text. Master's thesis, Lund University.
- Back, M. D., A. C. Kufner, and B. Egloff (2010). The emotional timeline of september 11, 2001. *Psychological Science* 21(10), 1417–1419.
- Back, M. D., A. C. P. Kufner, and B. Egloff (2011). “automatic or the people?”: Anger on september 11, 2001, and lessons learned for the analysis of large digital data sets. *Psychological Science*.
- Barasa, S. (2010). *Language, mobile phones and internet: a study of SMS texting, email, IM and SNS chats in computer mediated communication (CMC) in Kenya*. Ph. D. thesis, Leiden University.
- Bodomo, A. B. (2010). *The Grammar of Mobile Phone Written Language*, Chapter 7, pp. 110–198. IGI Global.
- Callison-Burch, C. and M. Dredze (2010). Creating speech and language data with amazon's mechanical turk. In *Proceedings of the NAACL HLT 2010 Workshop on Creating Speech and Language Data with Amazon's Mechanical Turk*, CSLDAMT '10, Stroudsburg, PA, USA, pp. 1–12. Association for Computational Linguistics.
- Chilton, L. B., J. J. Horton, R. C. Miller, and S. Azenkot (2010). Task search in a human computation market. In *Proceedings of the ACM SIGKDD Workshop on Human Computation*, HCOMP '10, New York, NY, USA, pp. 1–9. ACM.
- Choudhury, M., R. Saraf, V. Jain, S. Sarkar, and A. Basu (2007). Investigation and modeling of the structure of texting language. In *In Proceedings of the IJCAI-Workshop on Analytics for Noisy Unstructured Text Data*, pp. 63–70.
- Crystal, D. (2008). *Txtng: the Gr8 Db8*. Oxford University Press.

- Deumert, A. and S. Oscar Masinyana (2008, April). Mobile language choices—the use of english and isixhosa in text messages (sms): Evidence from a bilingual south african sample. *English World-Wide* 29(2), 117–147.
- DiPalantino, D., T. Karagiannis, and M. Vojnovic (2011). Individual and collective user behavior in crowdsourcing services. Technical report, Microsoft Research.
- Dürscheid, C. and E. Stark (2011). *SMS4science: An International Corpus-Based Texting Project and the Specific Challenges for Multilingual Switzerland*, Chapter 5. Oxford University Press.
- Elizondo, J. (2011). *Not 2 Cryptic 2 DCode: Paralinguistic Restitution, Deletion, and Non-standard Orthography in Text Messages*. Ph. D. thesis, Swarthmore College.
- Elvis, F. W. (2009). The sociolinguistics of mobile phone sms usage in cameroon and nigeria. *The International Journal of Language Society and Culture*, 25–40.
- Fairon, C. and S. Paumier (2006). A translated corpus of 30,000 French SMS. In *Proceedings of Language Resources and Evaluation*.
- Gao, Q. and S. Vogel (2010). Consensus versus expertise: a case study of word alignment with mechanical turk. In *Proceedings of the NAACL HLT 2010 Workshop on Creating Speech and Language Data with Amazon’s Mechanical Turk*, CSLDAMT ’10, Stroudsburg, PA, USA, pp. 30–34. Association for Computational Linguistics.
- Gibbon, D. and M. Kul (2008). Economy strategies in restricted communication channels: a study of polish short text messages. In *Proceedings of 5. Internationale Tagung Perspektiven der Jugendspracheforschung*.
- Grinter, R. and M. Eldridge (2003). Wan2tlk?: everyday text messaging. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pp. 441–448. ACM.
- Herring, S. and A. Zelenkauskaitė (2009). Symbolic Capital in a Virtual Heterosexual Market: Abbreviation and Insertion in Italian iTV SMS. *Written Communication* 26(1), 27.
- How, Y. (2004). Analysis of sms efficiency. Undergraduate thesis, National University of Singapore.
- How, Y. and M. Kan (2005). Optimizing predictive text entry for short message service on mobile phones. In *Proceedings of HCI*. Lawrence Erlbaum Associates.
- Hutchby, I. and V. Tanna (2008). Aspects of sequential organization in text message exchange. *Discourse & Communication* 2(2), 143–164.
- Ipeirotis, P. (2010a). Demographics of mechanical turk. *New York University, Working Paper No: CEDER-10-01*.
- Ipeirotis, P. G. (2010b, December). Analyzing the amazon mechanical turk marketplace. *XRDS* 17, 16–21.
- iResearch (2010, Nov). 2010 china witkey industrial white paper. White paper, iResearch Consulting Group.
- Jiang Yang, Lada A. Adamic, M. S. A. (2008). Competing to share expertise: the taskcn knowledge sharing community. In *Proceeding of the International AAAI Conference on Weblogs and Social Media*.
- Jonsson, H., P. Nugues, C. Bach, and J. Gunnarsson (2010). Text mining of personal communication. In *2010 14th International Conference on Intelligence in Next Generation Networks*, pp. 1–5. IEEE.
- Ju, Y. and T. Paek (2009). A voice search approach to replying to SMS messages in automobiles. In *Proc. of Interspeech*, pp. 1–4. Citeseer.
- Kasesniemi, E.-L. and P. Rautiainen (2002). Mobile culture of children and teenagers in finland. In *Perpetual contact*, New York, NY, USA, pp. 170–192. Cambridge University Press.
- Lexander, K. V. (2011). Names U ma puce : multilingual texting in Senegal. Working paper.

- Li, Z. and Z. Hongjuan (2011, june). Research of crowdsourcing model based on case study. In *Service Systems and Service Management (ICSSSM), 2011 8th International Conference on*, pp. 1–5.
- Ling, R. (2005). The sociolinguistics of sms: An analysis of sms use by a random sample of norwegians. *Mobile communications engineering: theory and applications*, 335–349.
- Ling, R. and N. S. Baron (2007). Text messaging and im. *Journal of Language and Social Psychology* 26(3), 291–298.
- Liu, F., L. Zhang, and J. Gu (2007). The application of knowledge management in the internet—witkey mode in china. *International journal of knowledge and systems sciences* 4(4), 32–41.
- Liu, W. and T. Wang (2010). Index-based online text classification for sms spam filtering. *Journal of Computers* 5(6), 844–851.
- Mason, W. and D. J. Watts (2009). Financial incentives and the "performance of crowds". In *Proceedings of the ACM SIGKDD Workshop on Human Computation, HCOMP '09*, New York, NY, USA, pp. 77–85. ACM.
- Ogle, T. (2005, May). Creative Uses of Information Extracted from SMS Messages. Undergraduate thesis, The University of Sheffield.
- Petrović, S., M. Osborne, and V. Lavrenko (2010). The edinburgh twitter corpus. In *Proceedings of the NAACL HLT 2010 Workshop on Computational Linguistics in a World of Social Media, WSA '10*, Stroudsburg, PA, USA, pp. 25–26. Association for Computational Linguistics.
- Piao, C., X. Han, and X. Jing (2009). Research on web2.0-based anti-cheating mechanism for witkey e-commerce. In *Electronic Commerce and Security, 2009. ISECS '09. Second International Symposium on*, Volume 2, pp. 474–478.
- Pietrini, D. (2001). X'6 :-(?": The sms and the triumph of informality and ludic writing. *Italienisch* 46, 92–101.
- Quinn, A. J. and B. B. Bederson (2009). A taxonomy of distributed human computation. Technical report, Univ. of Maryland, College Park.
- Resnik, P., O. Buzek, C. Hu, Y. Kronrod, A. Quinn, and B. B. Bederson (2010). Improving translation via targeted paraphrasing. In *Proceedings of the 2010 Conference on Empirical Methods in Natural Language Processing, EMNLP '10*, Stroudsburg, PA, USA, pp. 127–137. Association for Computational Linguistics.
- Rettie, R. (2007). Texters not talkers: Phone call aversion among mobile phone users. *PsychNology Journal* 5(1), 33–57.
- Schlobinski, P., N. Fortmann, O. Groß, F. Hogg, F. Horstmann, and R. Theel (2001). Simsen. eine pilotstudie zu sprachlichen und kommunikativen aspekten in der sms-kommunikation. *Networx*.
- Segerstad, Y. (2002). *Use and Adaptation of Written Language to the Conditions of Computer-Mediated Communication Use and Adaptation of Written Language to the Conditions of Computer-Mediated Communication*. Ph. D. thesis, University of Gothenburg.
- Shortis, T. (2001). 'new literacies' and emerging forms: text messaging on mobile phones. In *International Literacy and Research Network Conference on Learning*.
- Sotillo, S. (2010, May). *SMS Texting Practices and Communicative Intention*, Chapter 16, pp. 252–265. Hershey: IGI Global.
- Sun, Y., N. Wang, and Z. Peng (2011). Working for one penny: Understanding why people would like to participate in online tasks with low payment. *Computers in Human Behavior* 27(2), 1033–1041.

- Tagg, C. (2009). *A Corpus Linguistics Study of SMS Text Messaging*. Ph. D. thesis, University of Birmingham.
- Thurlow, C. and A. Brown (2003). Generation Txt? The sociolinguistics of young people's text-messaging. *Discourse Analysis Online* 1(1), 30.
- Walkowska, J. (2009). Gathering and Analysis of a Corpus of Polish SMS Dialogues. *Challenging Problems of Science. Computer Science. Recent Advances in Intelligent Information Systems*, 145–157.
- Wang, A., C. D. V. Hoang, and M.-Y. Kan (2011). Perspectives on crowdsourcing annotations for natural language processing. *Language Resources and Evaluation*.
- Yang, J., L. A. Adamic, and M. S. Ackerman (2008). Crowdsourcing and knowledge sharing: strategic user behavior on taskcn. In *Proceedings of the 9th ACM conference on Electronic commerce*, EC '08, New York, NY, USA, pp. 246–255. ACM.
- Žic Fuchs, M. and N. Tudman Vukovic (2008). Communication technologies and their influence on language: Reshuffling tenses in Croatian SMS text messaging. *Jezikoslovlje* 2(9.1-2), 109–122.