

Readability of Hearing Related Internet Information in Traditional Chinese

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Abstract

Hearing impairment is a prevalent issue that affects many people. However, the prevalence and consequences of hearing impairment may be prevented or managed through proper understanding of health information (El Dib & Mathew, 2012; Tsukada & Sakakibara, 2008). Now, with the advances in technology, the Internet has become a popular and convenient source for health information (Fox, 2006; Siow et al., 2003; Y. Y. Yan, 2010). Despite the convenience that is brought about by the Internet, the majority of health information can be too difficult to understand (Friedman & Hoffman-Goetz, 2006; Laplante-Levésque & Thorén, 2015). To examine this issue, readability scores have often been used to assess the reading difficulty of health information. Readability scores are calculated by readability formulas, based on measuring quantifiable textual features that contribute to reading difficulty (Dubay, 2004). For online hearing health information, most of the focus has been centered on English websites and have found them to be written at levels too difficult for the general public (Laplante-Levésque & Thorén, 2015; Svider et al., 2013). However, there are no studies on Chinese online hearing health information and yet Chinese has the largest number of native speakers in the world (Paul, 2016). Due to the limited Chinese readability formulas available, this study focused on Traditional Chinese online hearing health information using the Jing (Jing 荆, 1995) and CRIE 1.0 (Sung et al., 2016) readability formulas. A panel of 39 people with no expertise in the hearing health profession and who spoke Mandarin as their primary language, were recruited to identify keywords for the Internet search. Keywords that were mentioned more than once and returned relevant results were 耳朵 (ear), 聽力 (hearing), 助聽器 (hearing aids), 重聽 (hard of hearing), 聽不清楚 (can't hear properly). These keywords were entered into google.com.tw (Google Taiwan) and google.com.hk (Google Hong Kong) to obtain websites for readability analysis. After matching against the inclusion and exclusion criteria, 31 websites were included in the

readability analysis. Health information is recommended to be written at the 6th reading grade level and according to the CRIE 1.0 formula, 25% of the websites had a reading grade level greater than 6. However, according to the Jing formula, 81% of the websites had a reading grade level greater than 6. When websites were sorted according to organization type, there was not a significant difference in reading grade level between the different type of organizations. Readability can be improved primarily by reducing the length of the paragraph and using more common characters and words. Future directions include performing readability analysis for online hearing health information written in Simplified Chinese, as the majority of Chinese speakers use Simplified Chinese. This is currently not feasible as there are no reliable readability formulas for Simplified Chinese. Also, to supplement the findings from this study, the websites should be assessed for their suitability and quality.

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List of abbreviations

Artificial Neural Network (ANN)

American Speech-Language-Hearing Association (ASHA)

Chinese Readability Index Explorer (CRIE)

Chinese Knowledge and Information Processing (CKIP)

Disability Adjusted Life Years (DALYs)

Health on the Net (HON)

Health On the Net Code of Conduct (HONcode)

Hearing Impairment (HI)

Hypertext Markup Language (HTML)

Part-of-Speech (POS)

Readability Analyzer System (R.A.S.)

Reading Grade Level (RGL)

Suitability Assessment of Materials (SAM)

Simplified Chinese (SC)

Suitability of Assessment of Materials (SAM)

Traditional Chinese (TC)

Tympanic Membrane (TM)

Uniform Resource Locator (URL)

United States (U.S.)

Word Extractor for Chinese Analysis (WECA_n)

World Health Organization (WHO)

1 Introduction

1.1 Thesis overview

Hearing impairment (HI) is a prevalent disability and is the most common sensory deficit (Mathers, 2003; Stevens et al., 2013). Some of the consequences of HI include social isolation, emotional distress and depression (American Speech-Language-Hearing Association [ASHA], 2016; Hsu et al., 2016; Tyler, Tye-Murray, & Gantz, 1991). Hearing impairment not only impacts the individual but also their frequent communication partners (Arlinger, 2003). However, the prevalence and consequences of HI may be prevented or managed through proper understanding of health information. Proper understanding and utilization of health information leads to behavioral changes (Becker, 1974; Mirowsky & Ross, 1998) resulting in prevention of, or intervention for, HI. With the advances in technology, the Internet has become a popular source for health information (Zickuhr, 2010). The Internet offers a unique platform for health care providers to dispense, and for consumers to retrieve, health information (Cline & Haynes, 2001; Eng et al., 1998).

Despite the convenience that is brought about by the Internet, the quality of online health information is concerning. Particularly, the majority of health information can be too difficult to understand (Atcherson et al., 2014). Readability scores have often been used to assess the reading difficulty of text (Doak, Doak, & Root, 1996b; DuBay, 2004). They are calculated by readability formulas, based on measuring quantifiable textual features that contribute to reading difficulty (DuBay, 2004; Flesch, 1948). Readability research originated from the United States (U.S.) and was originally designed for the English language (Flesch, 1948). Researchers have since developed readability formulas for other languages, including Chinese (Lau, 2006). Readability analysis is all the more important for the Chinese language as it has the greatest

number of native speakers in the world (Paul, 2016). While there are many Chinese dialects within the umbrella term “Chinese language”, all Chinese dialects people share the same writing system (J. Chang, 1987). There are two forms of written Chinese, Simplified Chinese (SC) and Traditional Chinese (TC) (J. Chang, 1987). Their difference lies predominantly in their characters (Bökset, 2006). SC has less strokes in its characters while TC characters maintain their original complicated form (Bökset, 2006). TC is visually more complicated as it has more strokes in its characters (Jordan, 2002b). Chinese readability research has lagged behind that of other languages and there are only a few readability studies available (Lau, 2006; Sung, T.H. Chang, W.C. Lin, Hsieh, & K.E. Chang, 2016). Readability analysis for written Chinese is different to English due to the uniqueness of the Chinese language. It is unique in how characters are written and how words and sentences are composed (J. Chang, 1987; Lau, 2006). In order to develop readability formulas, researchers have to first identify the important features of written Chinese that contribute to reading difficulty (Lau, 2006; S. Yang, 1970). To date, most of the Chinese readability formulas were developed using TC (Jeng, 2001; Sung et al., 2016; S. Yang, 1970; 溪. 荆, 1995). As such, this study aimed to determine the readability of Chinese websites written in TC that were related to hearing or hearing impairment.

1.2 Overview of hearing impairment

The ability to hear is central to communicating with the world around us, to understand and interact with our environment. Yet, HI is a pervasive issue and the prevalence has been ever-increasing. It is the third leading cause of disability and the most common sensory deficit (Mathers, 2003; Stevens et al., 2013).

1.2.1 Causes and types of hearing impairment

There are mainly three different types of HI: conductive, sensorineural, and mixed (Steiger, 2015). Conductive hearing impairment is a term ascribed to a compromise in structural integrity or pathology affecting the outer and/or middle ear (Steiger, 2015). The outer ear is responsible for channeling sound pressure waves into the ear canal and onto the tympanic membrane (TM) (Moller, 2006, p. 20). The pressure waves cause the TM to vibrate and the ossicles connected to the TM subsequently vibrate according to the original sound pressure wave (Moller, 2006, p. 22). The ossicles, from distal to medial, are the malleus, incus and stapes (Steiger, 2015). They, along with the TM, are responsible for the conversion of sound pressure to mechanical vibrations (Steiger, 2015). As the TM vibrates due to sound pressure, the vibration is passed along the malleus to the stapes (Moore, 2013, p. 24). The stapes then transfers the mechanical vibrations to the inner ear via the oval window (Moller, 2006, p. 22). If any point along this conductive system becomes compromised, the result is an impairment in hearing and is thus known as a conductive HI (Steiger, 2015). Some of the causes of conductive HI include compacted cerumen preventing sound waves from entering the ear canal (Alberti, 2001b, p. 64), perforation of the TM that affect its vibrations (Alberti, 2001b, p. 64), or fluid filling the middle ear and impeding the normal vibration of the ossicles (Alberti, 2001b, p. 64-65). Some other causes may be due to structural damage to the ossicles themselves (Alberti, 2001b, p. 65-66). Conductive HI is often a temporary HI, indicating there are interventions that may be able to restore hearing to a normal level. These often come in the way of corrective surgery (Briggs & Luxford, 1994) or hearing aids (Hol, Snik, Mylanus, & Cremers, 2005; Tjellström, Lindström, Hallén, Albrektsson, & Brånemark, 1981).

Sensorineural HI refers to a compromise in the integrity of the inner ear and the neural connections from the peripheral auditory system to the auditory centers in the brain (Alberti, 2001b, p. 66; Moore, 2013, p. 62). As the stapes impinges on the oval window of the cochlea, the stapes' vibration is transferred into the fluid within the cochlea (Moller, 2006, p. 48). The displacement of the fluid causes displacement of the basilar membrane which then triggers a series of chemical events within the hair cells situated on the basilar membrane (Alberti, 2001a, p. 58). The chemical events then are able to activate neural firing of the neural connections that innervate the basilar membrane hair cells (Moore, 2013, p. 38). It is this neural firing that creates a 'picture' of the original sound pressure wave, as electrical signals and are decoded by central auditory structures in the brain (Moore, 2013, p. 38). Any lesion in the inner ear or the neural connections can contribute to a sensorineural HI (Alberti, 2001b, p. 66). Some of the causes of sensorineural HI include: excessive noise exposure, bacterial infections, ototoxic medication, antibiotics, chemotherapies or presbycusis (loss of hearing due to old age) (Alberti, 2001b, p. 66-69). Unlike conductive HI, sensorineural HI is usually permanent and currently there are no known cures for sensorineural HI (Coplan, 1987). There are however, interventions such as hearing aids (Kennedy et al., 2006), which may alleviate many of the communication difficulties that are brought about by HI.

1.2.2 Prevalence of hearing impairment

Hearing impairment is a major contributor to communication disorders and affects people's ability to function in their everyday lives. Currently, there is a large number of people living with HI globally.

1.2.2.1 Global prevalence of hearing impairment

The Global Burden of Disease Project estimated that HI is the third-leading cause of disability (Stevens et al., 2013). It is the most common sensory deficit and can affect everyone from the newborn to the elderly (Mathers, 2003). The global prevalence of HI has seen a significant increase over the years. In 1995, there were 120 million people, or 2.1% of the world population, with a disabling HI (Smith, 1998). In 2001, there were 250 million people with disabling HI, which is about 4% of the world population (Mathers, 2003). In 2012, this number increased even further to 360 million people; about 5% of the world population (WHO, 2012). A disabling HI in adults is defined as a permanent, unaided hearing threshold in the better year of 41 dB or worse (WHO, 2001). Out of the 360 million people who experience a disabling hearing loss, 91% are adults, among which 56% are males and 44% are females (WHO, 2012). When stratified by age, the prevalence is greatest in people above 65 years of age. In this age group, 33% of the people have a disabling hearing loss (WHO, 2012).

1.2.2.2 Prevalence of hearing impairment in Chinese-speaking populations

Hearing impairment is regarded as a communication disorder as it hinders the effective use of spoken language. Considering how many Chinese speakers there are, it is concerning that there are very few data on the prevalence of HI in Chinese-speaking populations. Chinese is an umbrella term for all the Chinese dialects that are spoken amongst people of Chinese ethnicity (Jordan, 2002a). Chinese, including dialects, has the most number of native speakers in the world, estimated to be 1.3 billion people (Paul, 2016). The most common dialect, Mandarin Chinese, is listed as the official spoken language of China, Taiwan and Singapore. The estimated number of native Mandarin speakers is 889 million people (Paul, 2016). Another common dialect is Cantonese which is spoken by local provinces such as Canton and Hong Kong. Although the

Chinese dialects are mutually unintelligible, as speakers of different Chinese dialects may not understand one another, the writing system is the same. All Chinese people share a unifying written language (Bökset, 2006; J. Chang, 1987). Written Chinese has two forms, SC and TC. With the exception of Hong Kong and Taiwan which use TC, SC is universally used elsewhere among Chinese-speaking populations (Jordan, 2002b).

In China the reported overall prevalence of HI was 2.11%, and in adults 60 years of age and above, it was 11.04% (X. B. Sun, Wei, Yu, Wang, & Liang, 2008). In Taiwan the adult prevalence was higher with 17.1% and in adults over 65 years of age, it was 27.2% (H. P. Chang & Chou, 2007; C. Y. Lin et al., 2007). For Singapore, the overall prevalence was 14.5% and estimated to be 18% in people over 65 years of age (Pineiro, 2015). In Hong Kong, the overall prevalence was 1.3% and in adults over 60 years of age it was 6.1% (Center for Health Protection, 2011).

1.2.3 Impact of hearing impairment

Hearing impairment can impose a negative impact on the person with HI, as well as their frequent communication partners. This is irrespective of age of onset and presents a large burden to those affected.

1.2.3.1 Impact on person with hearing impairment

Children with HI often present with delayed speech and language development which in turn, are linked to learning difficulties and scholastic underachievement (Tyler et al., 1991; Zargi & Boltezar, 1992). Communication difficulties caused by HI may also lead to social isolation, self-devaluation and lesser vocational attainment (ASHA, 2016; Tyler et al., 1991). Adults with a late onset of HI are not immune to the negative effects of hearing loss as well. Difficulties in recognizing speech, asking for word or phrase repetition—despite this potentially failing to

reconcile understanding—are situations people with HI encounter regularly (Arlinger, 2003). They often experience social isolation, self-doubt and vocational problems (Arlinger, 2003). Furthermore, hearing loss in the elderly is associated with: activity limitation (Solheim, Kvaerner, & Falkenberg, 2011), increased risk of depression (Hsu et al., 2016), dementia and cognitive decline (Arlinger, 2003; F. R. Lin et al., 2011).

1.2.3.2 Impact on frequent communication partners

HI can affect communication with other people and it is the frequent communication partners who will be affected the most (Arlinger, 2003). Frequent communication partners can be parents, spouses, immediate family, colleagues, friends and peers (Kamil & Lin, 2015). They have to put in more effort to communicate with the person with HI, via: speaking slower and articulating clearly, making sure they are facing the person with HI when conversing, obtaining their attention before speaking to them and often serving as their ‘ears’ in noisy situations. As a consequence, frequent communication partners may reduce their contact and the person with HI will become more isolated (Arlinger, 2003).

Parents of children with HI report increased anxiety, stress regarding the child’s education and safety, anxiety over the child’s future and worry about the disadvantages the child may face (Meinzen-Derr, Lim, Choo, Buyniski, & Wiley, 2008). In the elderly population it has been found that spouses of people with HI experience a restricted social life, an increased burden of communication, poorer quality of life and less relationship satisfaction (Kamil & Lin, 2015).

1.3 Importance of health information

The importance of health information cannot be overstated. It has the ability to empower patients (Bader, 1998) and lead to improvements in health outcomes (Connell, Turner, & Mason, 1985; Farquhar et al., 1977; Reichard, 1996). Also, with proper understanding of health

information, people have become increasingly involved with managing their own health (Bader, 1998). A World Health Organization (WHO) report on the major risks to health (Rogers, 2002), highlights how patients may be empowered by health information which leads to improvements in health outcomes. The top 10 risk factors in terms of attributable disability adjusted life years (DALYs) were found to be intricately linked to lifestyle behaviors. DALYs refer to the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability (Feinstein, 2006). Importantly, the risk factors had a significant, causal relationship with education. It was found that people with higher education had lower risk factors, an effect that was mediated by having a healthy lifestyle (Mirowsky & Ross, 1998). The researchers concluded that education leads to development of a person's sense of control, and a sense of control leads to the development of a healthy lifestyle (Mirowsky & Ross, 1998). This led to the conclusion that effective utilization of health information can lead to increases in health and well-being. With this view in mind—that health information leads to patient empowerment, which in turn results in improvements in health—the importance of health information relating to HI can then be appreciated. Many causes of HI can be prevented and HI itself may be managed with appropriate measures. A WHO report (Kaplan, 2013) stated that the key measures needed to help reduce the burden of HI included: prevention of excessive exposure to noise, prevention of infectious diseases through vaccination, hearing screening programs, and raising awareness among users, of the risks of ototoxic medications. These preventive measures can be achieved in part, through effective dissemination of public health information.

The following section will describe the uses of health information, the outcome of utilizing health information and how health information may be sought.

1.3.1 Use of health information

Health information can be utilized by both health providers and individuals seeking help. For health providers, in addition to preventing health conditions as discussed in the previous section, health information may be given to the patient to educate them about their health condition or its treatment. This is beneficial when a physician is not immediately available (Bader, 1998) or to simply reinforce the information given during a consultation (S. Rees & Williams, 2009). Health information can also be sought by patients to make a decision regarding their health or to discuss with their health care provider (Liszka, Steyer, & Hueston, 2006). In a survey of patient use of Internet health information (Diaz et al., 2002), patients indicated they had sought information on drug side effects or complications of medical therapy, second opinions on medical conditions and information on complementary or alternative medicine. Some patients also used the information they found to consult with their doctors. Health information may also be used by policy makers to implement strategies to combat diseases (Wessex Universal Neonatal Hearing Screen Trial Group, 1998).

1.3.2 Outcomes of health information

The effects of health information can be substantially positive. In a study evaluating the effects of school health education programs, it was found that the effectiveness of school health programs was strongly related to the level of implementation (Connell et al., 1985). Positive effects were seen in all measured outcomes, including overall health knowledge and health practices (Connell et al., 1985). Another study determining whether health education could reduce the risk of cardiovascular disease found that compared to controls, the promotion of cardiovascular health led to a substantial and significant decrease in the risk of cardiovascular disease (Farquhar et al., 1977).

One of the key measures called for to reduce the burden of HI, was the prevention of excessive noise exposure (Kaplan, 2013). Excessive noise exposure can be protected against through the use of hearing protection or the reduction of noise levels. A systematic review found that people exposed to hearing loss prevention programs were more likely to wear hearing protection than those who had not been exposed to hearing loss health information (El Dib & Mathew, 2012). In a Japanese study educating factory workers about the effectiveness of hearing protection, it was found that the number of workers wearing hearing protection increased from 46% to 66% afterwards (Tsukada & Sakakibara, 2008). Two other studies found that with provision of instruction and information on hearing protection, hearing protection adoption (Auchter, 2014) and hearing protection effectiveness (Williams, 2004) increased. With proper knowledge and utilization of health information, anyone can conceivably have the ability to promote better health and well-being (Iverson, Howard, & Penney, 2008).

1.3.3 Types of health information

Health information can be obtained from pamphlets, books, brochures and fact sheets. Other than written text, health information may also be obtained from public health videos, oral information given by health care professionals and from health-related call stations. Recently, more and more people are turning to the Internet for health information (Diaz et al., 2002). The Internet has made information retrieval extremely convenient (Tonsaker, Bartlett, & Trpkov, 2014) and thus, the Internet is a popular source for consumers to seek health information (Fox & Duggan, 2013; Murray et al.).

1.4 Access to online health information

Searching for health information online is ranked as the third most common Internet activity in the U.S. (Zickuhr, 2010). Reasons for the Internet becoming a prevailing and popular

source of health information, include: the development of consumer-oriented health care models, consumers' increased interest of health and well-being, emphasis on self-care and prevention of diseases and cost-reducing efforts from service providers (Cline & Haynes, 2001; Eng et al., 1998). Other reasons include convenience, anonymity or searching for performance reviews of health providers (Cline & Haynes, 2001).

1.4.1 Global access to online health information

There are many Internet users worldwide and many of them have used the Internet to search for health information (Fox & Duggan, 2013). In 2016, there were 3.6 billion Internet users worldwide (Internet World Stats, 2016b). The majority of Internet users were in Asia (50.2%) and Europe (16.7%) (Internet World Stats, 2016b). Although North American users only constituted 8.7% of the total Internet users, their penetration rate was highest at 89% (Internet World Stats, 2016b). Asia and Europe had penetration rates of 45.6% and 73.9% respectively (Internet World Stats, 2016b).

Regarding the prevalence of online health seeking, 8 out of 10 Internet users in the U.S. have searched for medical information online (Fox, 2006). On a typical day, 8 million U.S. adults search online for health information (Fox, 2006). Other countries reporting online health-seeking statistics include Scotland, where 68% of a clinic's patients had searched online for health information (Moreland, French, & Cumming, 2015). In Australia, estimates indicate that more than 21% of the population are online health seekers (Bessell, Silagy, Anderson, Hiller, & Sansom, 2002). In Singapore and Hong Kong, 38% (Siow et al., 2003) and 44% (Y. Y. Yan, 2010) of survey responders indicated they had searched the Internet for health information. Another survey in China found 36% of participants had searched for online health information (Zhang, 2010). There are also a multitude of health related websites. In 2001, there were over

70,000 websites providing health information and this number was expected to increase (Grandinetti, 2000). Health seekers said they used health information to find out about their condition, symptoms of diseases and possible treatment options (Fox, 2006). Some also sought information on behalf of others (Fox, 2006).

1.4.2 Access to online health information in Chinese speaking populations

Asia has the largest number of Internet users in the world and as a whole, has an Internet penetration rate of 45% (Internet World Stats, 2016b). Some of the countries in Asia have high Internet penetration rates. China, has an Internet penetration rate around 50% (Internet World Stats, 2016a) while Taiwan and Hong Kong each have penetration rates greater than 80% (Internet World Stats, 2016a). One survey in Hong Kong found that 44% of respondents had sought online health information (Cao, Zhang, Xu, & Wang, 2016), while in China and Singapore, this number was reported to be around 36% (Siow et al., 2003; Y. Y. Yan, 2010). No data was available for Taiwan, highlighting the lack of research on this topic in Taiwan.

1.5 Quality of online health information

Despite the relative ease of accessing online health information, there remain some issues to be resolved. One of the problems faced by consumers of online health information who have limited medical knowledge, is that they may lack the ability to judge whether the information is accurate and reliable (Atcherson et al., 2014). Anyone can create a website with relative ease and publish anything they want. There is currently no mediator to prevent websites from publishing inaccurate or misleading health information. The consumer is left alone to discern whether the medical information they find is accurate. Furthermore, websites with a commercial motive may seek to capitalize on the vulnerability of people with health conditions by presenting treatment options based on little or no scientific evidence (Cline & Haynes, 2001).

Another problem is that consumers of online medical information may not have the necessary literacy skills to understand and utilize the information even if it is accurate (Atcherson et al., 2014). According to the Pew Research Center (M. Duggan, Fox, S., 2013), 35% of U.S. adults say they have diagnosed themselves from online health info. However only 41% of those who diagnosed themselves online, were accurate about their condition (M. Duggan, Fox, S., 2013). This indicates there are misjudgments when using online health information. The consequences can be serious, depending on the medical condition. Parents of children with HI, may not understand online health information regarding the consequences of uncorrected hearing loss for their children, which in turn, may lead to delay or neglect in seeking treatment for their children. Another example is not understanding medical terminology. Doak, Doak, and Root (1996c) pointed out that people with low literacy skills tended to skip over uncommon words. Medical terminology, can be unfamiliar to the general public and not just those with low literacy skills (Sand-Jecklin, 2007). Some common medications including antibiotics and aspirin are ototoxic and this is indicated on the labels, however people with little medical knowledge may not understand that ototoxic means toxic to hearing. Thus, health information that is burdened with unfamiliar medical terminology, is contrary to its purpose, hindering the utilization of health information.

While there does not exist any tool at present to examine the accuracy and usefulness of online health medical information, there are many guidelines and tools to make websites easier to understand. A common way is to assess the website's readability and suitability.

1.5.1 Readability

Readability is defined as “the ease with which a person can read and understand written materials” (Freda, 2005, p. 152), “what makes some texts easier to understand than others”

(DuBay, 2004, p. 3). A comprehensive definition given by (Dale & Chall, 1949, p. 23) describes it as “the sum total (including all the interactions of all those elements within a given piece of printed material) that affect the success a group of readers have with it. The success is the extent to which they understand it, read it at an optimal speed, and find it interesting.”

Readability formulas are tools developed to quantify the reading difficulty of text, but not tables, charts or word lists (Doak et al., 1996b). Readability formulas are mostly based on measuring quantifiable textual attributes that represent the level of difficulty (Doak et al., 1996b; Friedman & Hoffman-Goetz, 2006). For example, if long sentences are harder to understand than short sentences, a passage containing more long sentences, is harder to read than one containing short sentences. Applying readability formulas to a passage produces a reading grade level (RGL) or readability score. A higher RGL indicates the text is more difficult to read. Readability formulas can be used to indicate whether the material is too difficult for intended audiences (Doak et al., 1996b).

Many websites containing health information have been assessed for their readability and the majority have a RGL higher (more difficult) than recommended. In 2003, the National Assessment of Adult Literacy in the U.S. revealed that the average reading comprehension of adults is at the 7th or 8th grade level (Kutner, Greenberg, Yin, Paulsen, & White, 2006). Thus, researchers have recommended that health information is written at the 5th to 6th RGL (Doak, Doak, & Root, 1996a; Safeer & Keenan, 2005). However, this is far from the case. In a systematic review on the readability of cancer information, (Friedman & Hoffman-Goetz, 2006) found that information was written at grade levels that ranged from grade 6 to 14. (Atcherson et al., 2014) found 85.4% of consumer documents on the American Speech-Language-Hearing Association’s (ASHA) website exceeded the recommended 5th to 6th grade reading level. In a

recent systematic review of the readability of Internet information on hearing, it was found that the mean RGLs from 8 studies, were between 9 to over 14 (Laplante-Levésque & Thorén, 2015).

1.5.2 Suitability

There are factors beyond those measured by readability formulas that also affect reading difficulty and how much health information is absorbed by the reader (Doak et al., 1996b; Shieh & Hosei, 2008). These factors have been described by (Doak et al., 1996b) as the suitability of written material and involve aspects of design and organization. These aspects include font size and typography, color layout, information density, and unfamiliar context (Doak et al., 1996b). There is even more to consider for health-related information such as, clear statement of aims, relevance of information, and outlining the risks and the benefits of treatment (Charnock, 1999). Health-related Internet information is also lacking when assessed against these criteria. A review of 66 hearing-health related websites (Laplante-Levesque, Brannstrom, Andersson, & Lunner, 2012) found that on average, the websites only partially met the assessed criteria on quality.

1.5.3 Health On the Net code of conduct

In addition to readability and suitability measures, some tools have been developed to evaluate the quality of online health information. The most well-known and widely adopted tool is the Health On the Net Code of Conduct (HONcode) (Boyer, Baujard, Geissbuhler, 2011). It is an 8-item code of conduct that addresses: authorship, complementarity, privacy, attribution, justifiability, transparency, financial disclosure, and advertising policy (Boyer, Baujard, Geissbuhler, 2011; HON, 2010). Health-related websites that abide by the HONcode, when approved by the Health on the Net (HON) foundation, are able to display a certification badge (HON, 2010). It was first implemented in 1996 and has been translated into 35 languages (Boyer, Baujard, Geissbuhler, 2011). As of 2010, it has certified over 7,400 websites in 102 countries

(Boyer, Baujard, Geissbuhler, 2011). Furthermore, the French government has adopted the HONcode as the official certification of French health-related websites (Boyer, Baujard, Geissbuhler, 2011).

1.6 Readability analyses

Due to their ease of use, readability analyses have become very popular and are used in many disciplines. They can be achieved by computational analyses or non-computational analyses.

1.6.1 Computational analyses

Computational analyses involve the use of statistical techniques to derive readability formulas. Common statistical approaches include stepwise regression and correlation measures. The principle behind computational analyses involves extracting textual attributes that can be quantified easily and are predictive of difficulty. Some examples are sentence length and word syllable count (Lau, 2006). Then, these textual attributes are used to develop readability formulas to predict a readability score using regression and correlation techniques.

1.6.1.1 Textual attributes

To extract textual attributes that are indicative of the passage's reading difficulty, it is necessary to analyze the construct of the language. This section contains an introduction the basic textual factors in English that are important to the reading ease of English text. These fundamental textual factors are similar across alphabetic languages. The most common features that readability formulas primarily extract are word and sentence features. Readability formulas in other languages more-or-less operate by similar principles as English readability formulas (Contreras, Garcia-Alonso, Echenique, & Daye-Contreras, 1999; Spaulding, 1956).

1.6.1.1.1 Words

The knowledge of words has always been a strong predictor of a reader's reading skills and verbal development (DuBay, 2004). J. Yang, Wang, Chen, and Rayner (2009) stated that word recognition is the first step to successful reading comprehension. In the education system, short and easy words are more likely to be taught first (Lorge, 1944) and these words are the ones used most frequently (E. L. Thorndike, 1932). Fry (1993) found that the first 100 frequent words taught make up half of all written material in the U.S. and the first 300 frequent words make up 65%. It was concluded that frequent words are more familiar and are easier to understand (Fry, 1993). Thus, intuitively, if a passage contains more frequent words, then the passage is easier to read.

Another way to capture a word's complexity involves measuring its syllable count. A syllable is a unit of organization for a sequence of speech sounds and forms the phonetic units of a word (Oxford University Press, 2017). Shorter words are generally easier and have lower syllable counts. Thus, word syllable count has been used as a proxy measure of word complexity. Consider the example, "cup" vs "spontaneous". The pronunciation of cup has only one syllable while "spontaneous" has four syllables. Cup is a simpler word than spontaneous, is shorter and has fewer syllables. Therefore, syllabic count, as an indirect measure of word length, is able to capture a word's difficulty.

1.6.1.1.2 Sentence

The sentence is the basic unit of meaningful communication. A sentence is composed of a string of words combined together following syntactic rules. Sentence complexity can be measured by its length and its structure. Studies comparing historical English literature to modern day English literature have found that over the course of history, sentences have become

shorter and easier to understand. Pre-Elizabethan times saw 50 words per sentence while today the average is about 20 words per sentence (Sherman, 1893). Shorter sentences place a lighter cognitive burden on the reader. Reading comprehension is improved when shorter sentences are used (Doak, Doak, & Root, 1996d, p.64).

Another way of measuring sentence complexity is to analyze the sentence structure. This involves a preliminary process where part-of-speech (POS; noun, verb, adjectives, etc.) tags are assigned to the words within a sentence (Toutanova, Klein, Manning, & Singer, 2003). This allows for subsequent analyses of sentence complexity such as deciding whether the sentence was written in the active or passive voice. Sentences in the active voice are easier to understand than sentences written in the passive voice (Carr, 2016). Sentences written in the passive voice often use more words and prepositional phrases, which can obscure the intended meaning (University of Wisconsin, 2016). Writing guidelines almost unanimously recommend writing in the active voice when possible (DuBay, 2004).

1.6.1.2 English language readability measures

The initial aim of readability formulas, was to address the need to match educational material to the ability of students (Dale & Chall, 1949). Children learn progressively from material that is suitable for them. Dale stated, “The book must match the reader if education has to take place” (Dale & Chall, 1949). However, there was no available method of matching textbooks to the ability of the reader. Sherman (1893), through his objective analysis of literature, identified textual features, such as sentence length, that could potentially be appropriate indicators of text difficulty (Sherman, 1893). This approach, laid the foundation for future readability research. If a high correlation existed between a textual feature and reading difficulty, then the textual feature would be an appropriate indicator.

Other pioneers in readability research include Thorndike who introduced the concept of a word's frequency as a measure of word difficulty (Thorndike, 1927). Thorndike first noticed that teachers were using word counts to match text with students' ability. He found that the more frequently a word appeared, the more familiar it was and the easier it was to understand. If a passage contained more frequent words than intuitively, the passage was easier to read.

Stemming from this, Thorndike introduced "The Teacher's Word Book", which listed the 10,000 most frequent words in American English (Thorndike, 1927). He would follow on his work with "The Teacher's Word Book of 20,000 Words" in 1932 (Thorndike, 1932) and "The Teacher's Word Book of 30,000 Words" in 1944 with his colleague Lorge (Lorge & Thorndike, 1944).

From Thorndike's work stemmed the first readability formula. Lively and Pressey (1923) often found that text books were riddled with difficult words and that more time was spent teaching vocabulary rather than the subject content (Lively, 1923). They needed a way to select textbooks that had a lower vocabulary burden. From counting 1,000 word samples, they found that counting the median index number of words in the Thorndike list of 10,000 words, was the best predictor for vocabulary burden. The higher the index number, the harder the vocabulary burden of the text book. This allowed them to effectively choose suitable textbooks for their students. Since then, others have followed suit in incorporating word frequency measures into their own readability formulas (Patty & Painter, 1931).

Vogel and Washburne (1928) developed a readability formula using Thorndike's 10,000-word list. The aim was also to select textbooks in accordance with children's reading ability. From 152 books that children had read and said they liked, Vogel and Washburne (1928) analyzed multiple factors relating to vocabulary difficulty and sentence structure. They found four factors which gave the highest correlation with children's reading score. These four factors

were: 1) number of different words per 1,000 words, 2) number of prepositions per 1,000 words, 3) number of uncommon words (words not in the Thorndike 10,000-word list) per 1,000 word, and 4) number of simple sentences per 75 sentences. By demonstrating the importance of vocabulary and sentence measures, Vogel and Washburne's formula (1928) would become the prototype of later readability models (DuBay, 2004). Later readability formulas measured word complexity in various ways, such as counting syllables per word (Flesch, 1948). All in all, readability research has reached a consensus that the best predictors of textual difficulty are the two most commonly used: word complexity and sentence complexity measures (DuBay, 2004; Lau, 2006).

1.6.2 Non-computational analyses

The benefit of readability formulas is that they can be implemented on computers, allowing for easy application. However, they do not account for more complex linguistic features (Klare, 1954; Sung et al., 2016). Thus, some have instead called for non-computational analyses to measure comprehension (Taylor, 1953). Compared to computational analyses which can be performed automatically, non-computational analyses require actual human perception of the text. An example of this is the Cloze test (Taylor, 1953), where every fifth word is deleted and participants are asked to fill in the blanks. The percentage of words that are correctly scored is an indication of the difficulty of the passage (Taylor, 1953). Participants will score lower on harder passages and higher on easier passages. Non-computational analyses are generally more accurate than computational analyses. However due to the nature of these tests, they are more time-consuming and impractical for large scale analysis (Lau, 2006).

1.7 Chinese language computational readability analyses

Many languages have successfully developed their own readability formulas based on the English readability studies. These approaches include building basic word lists or adapting readability formulas from English readability studies. Although the approach of adapting English readability formulas is feasible for analyzing some non-English alphabetic languages, they cannot be applied to the Chinese language (S. Yang, 1970). The uniqueness of written Chinese language needs to be considered in order to develop readability formulas. This section will discuss the main lexical features in the Chinese language that may contribute to the difficulty level of a text sample. It then highlights the main differences to English and demonstrates why English readability formulas cannot be applied to the Chinese language.

1.7.1 Chinese language textual attributes

The main textual attributes of the Chinese language that affect readability, are radicals, characters, words, idioms and sentences.

1.7.1.1 Radicals

Chinese is a logographic writing system where each character represents a lexical morpheme. The composition of 80% of the characters has two components (Y. P. Chen, Allport, D. A., Marshall, J. C., 1996). One component is a radical component which may lend semantic cues to the word and the other is a phonetic component which offers a clue to pronunciation (Fan, 1986; Hoosain, 1991). For example, the characters “推” (push; pronounced /tuī/), “拉” (pull; pronounced /lā/), “抬” (lift; pronounced /tái/), “打” (hit; pronounced /dǎ/), all share the radical “扌”(hand). Each word is related in meaning to actions performed by hand. However, not all radicals will lend semantic cues to the word. For example, the meaning of “增” (increase) is not related to its radical “土” (dirt).

Phonetic components lend cues to the pronunciation. For example, the characters 請 (please; pronounced /qǐng/), 清(clean; pronounced /qīng/), 情(emotion; pronounced /qíng/), 晴(a fine day; pronounced /qíng/) all share the same phonetic component “青” (green; pronounced /qīng/). A character’s pronunciation can thus be inferred by its phonetic component.

The identification of a character during reading is thereby dependent on the radical and phonetic components. As such, the difficulty of the components, or the familiarity, will influence reading difficulty. This has been demonstrated in studies where it was found that semantic radicals are processed during character identification (Feldman & Siok, 1999; Leck, Weekes, & Chen, 1995), and that students’ knowledge of radicals correlated significantly with Chinese word reading and comprehension (Ho, Ng, & Ng, 2003). Shu and Anderson (1997) also found that students in higher school levels were better than their younger peers at identifying unknown words when the radical was familiar. Shu and Anderson (1997) concluded that good readers are better at interpreting novel characters based on prior knowledge of the radicals. These studies all suggest that radicals are important in determining a word’s difficulty.

One way to categorize a radical’s difficulty level can be based on its frequency. Those that are frequently used are more familiar. Research has found that radicals which are used in more characters were recognized faster than those used in fewer characters (Feldman & Siok, 1997). For example there are 698 words with the radical “扌” (hand) that are more easily recognized than characters with the radical “羽” (feather); where there are only 68 characters having this radical component (Feldman & Siok, 1999).

1.7.1.2 Chinese characters

Chinese characters are logograms, each with their own meaning, and are monosyllabic in pronunciation. Chinese characters are composed of strokes, and they become visually more

complex as their stroke count increases (Zang et al., 2016). More complicated characters take longer to identify and increase reading difficulty. It was found that characters with a higher stroke count caused a longer eye fixation time and a longer recognition time (Li, Bicknell, Liu, Wei, & Rayner, 2014; Ma & Li, 2015; Peng, 1997; H. M. Yang, McConkie, 1999; Zang et al., 2016).

Another factor that affects the comprehension of characters is frequency. Frequent characters are more familiar and are recognized more readily. As shown in studies, they cause shorter eye fixation times (Li et al., 2014; Tamaoka & Kiyama, 2013). If a passage contains a large number of familiar characters then the passage should be more readily understood (Lau, 2006).

1.7.1.3 Words

Because Chinese characters are logographic, where each character contains its own meaning, each character can form a word by itself. Characters can also combine with other characters to form a word. According to the Lexicon of Common Words in Contemporary Chinese Research Team (2008), 6% of word types are single-character words, 72% are two-character words, 12% are three-character words, 10% are four-character words. Although in theory there is no upper limit to word length, only 0.3% of words are longer than four characters (Lexicon of Common Words in Contemporary Chinese Research Team, 2008).

There are mainly three characteristics of Chinese words that affect readability: word stroke count, word length and word frequency. Similar to the concept introduced in the section about Chinese characters where stroke count is related to visual complexity, words with higher stroke counts are also more visually complicated. In eye movement studies, words with fewer strokes were skipped more often than words with more strokes (Liversedge et al., 2014; Zang et

al., 2016). For word length, recognition and eye fixation times were longer for words with greater length than shorter words (H. C. Chen, Song, W. Y. Lau, Wong, & Tang, 2003; Su & Samuels, 2010; G. Yan, Tian, Bai, & Rayner, 2006; H. M. Yang, McConkie, 1999; Zang et al., 2016). High-frequency words were skipped more often and fixated on for shorter durations than low-frequency words (Su & Samuels, 2010). Su and Samuels (2010) found word frequency to have a more dominant effect than word length.

1.7.1.4 Idioms

The Chinese language has many idioms that are commonly-used in spoken and written Chinese (C. Sun, 2006). Chinese idioms are coined from concepts and ideas that originate from tradition, anecdotes, fables, history and ancient literature (Abraham, 2013; C. Sun, 2006). Most idioms consist of four characters, succinctly expressing complex ideas or capturing morals behind long, ancient stories (Abraham, 2013). For example the idiom “一見鍾情” means love at first sight. If this idiom was expressed in plain words then it would be along the lines of “我第一眼看到她就愛上她了” which translates to “I fell in love with her when I first met her”. Some idioms’ meaning can be inferred by their characters, however some are deeper in meaning and cannot be understood unless one knows the story behind the idiom (T.P. Lau, 2006). For example, a literal translation of the idiom “惡貫滿盈” is “strung through with evil”. The actual meaning of this idiom is “replete with vice” (教育部國語推行委員會, 2011). However, from the characters alone, it may not be obvious what the idiom means. In ancient Chinese society, people used strings as purses to carry around money. Coins had a hole in the center and a string would be threaded through the middle to carry money around. The string was full “貫滿” when no more coins could be strung-on. Therefore, “惡貫滿盈” refers to someone who was filled with evil and

that they could not possibly be any more evil, thus “replete with vice” (教育部國語推行委員會, 2011). Unfamiliar idioms may affect a passage’s readability by making it more difficult. On the other hand, if a passage contains well-known idioms then the passage would be easier to understand as fewer words are required to express complex ideas (T. P. Lau, 2006). It should be noted that the use of idioms is not confined to Chinese language only (T. P. Lau, 2006; Possel, n.d.). Nonetheless, the principle remains that unfamiliar idioms increases the reading difficulty of text.

1.7.1.5 Sentence

A sentence is a group of words formed together under grammatical rules to express a thought or idea (T. P. Lau, 2006). Sentence length, as a function of words per sentence or strokes per sentence, has been used to measure sentence difficulty (T. P. Lau, 2006; Sung et al., 2016; S. Yang, 1970). In addition to sentence length, sentence structure also has an effect on readability. Yang investigated the effects of “full” sentences in Chinese (S. Yang, 1970). A full sentence is a sentence which includes a subject and a predicate (S. Yang, 1970). Furthermore, Wen (2014) defines a full sentence as a simple sentence. Yang found that the proportion of full sentences have a significant correlation to reading difficulty (S. Yang, 1970).

1.7.1.5.1 Segmentation

One of the major differences between Chinese and alphabetic languages is there is no marked boundary between words. In English there are spaces between words to mark the beginning and end of a word. There is no such convention in written Chinese. This is a major issue when performing any kind of textual analysis on large amounts of Chinese text. As explained earlier, word complexity and sentence structure have significant influences on readability. However, in order to derive a readability score from these factors it is important to

identify the “words” within a sentence (T. H. Chang, Sung, Y. T. Lee, 2012). This process is known as segmentation.

Segmentation can be achieved accurately when performed manually, but the drawback is the process is time-consuming. Automatic segmentation by specialized programs on the other hand, is fast but suffers from inaccuracy. This is due to two major issues. The first is the different possibilities that a group of characters can be segmented into (C. R. Huang & Xue, 2012; Ren, 2015). As there is no separation between characters in a sentence, a character could form a word with the character before or after. For example, consider the Example in 1.a and 1.b, the two-character string “天” and “氣” should be regarded as one word in 1.a and parts of two separate words in Example 1.b.

Example 1.

a. 剛剛天氣很好
The weather was fine just now

b. 他今天氣色很好
His countenance looks great today

The ambiguity becomes even more complex when more than two characters are involved. For a three-character string “A-B-C”, there are four possible combinations the characters could be formed into (C. R. Huang & Xue, 2012). They could be segmented into three separate words “A-B-C” or two two-character words “AB-C” or “A-BC” or a three-character word “ABC” (C. R. Huang & Xue, 2012). The ambiguity problem is commonly encountered by segmentation tools. It is important to achieve the highest accuracy when performing segmentation, as any errors will affect subsequent analyses (C. R. Huang & Xue, 2012).

The second issue is the number of unknown words the Chinese language can create (C. R. Huang & Xue, 2012; Sung et al., 2016). Although the number of Chinese characters remains

fairly constant, new words may be created by the combination of characters, by abbreviation of longer words and from the transliteration of foreign words (C. R. Huang & Xue, 2012). This is particularly challenging for Chinese segmentation as many computational approaches rely on case-matching with dictionaries. As there are many ways for a new word to be formed, it is hard to find a dictionary that contains all the words in the Chinese language (C. R. Huang & Xue, 2012).

Successful segmentation tools depend on their ability to resolve any ambiguities and handle unknown words. Current approaches to solve these problems include: 1) case-matching with dictionaries, 2) statistical calculations, 3) character tagging and machine learning and 4) word boundary decisions. For a review of these approaches please refer to (C. R. Huang & Xue, 2012). However, as accurate as segmentation is becoming, 100% accuracy has yet to be achieved (T. P. Lau, 2006; Sung et al., 2016). This will thus reflect on subsequent analyses.

1.7.2 Traditional Chinese vs Simplified Chinese

This section will discuss the main differences between SC and TC. Traditional Chinese as the name suggests, is the written form that has been used traditionally in Chinese speaking populations. Now it is only used in Hong Kong and Taiwan. This was because of the plain language movement promoted by the Chinese Government between 1955-1964. A script reform of simplifying characters was carried out to promote literacy as TC is difficult to write (Bökset, 2006). Today, only Taiwan and Hong Kong uses TC. On the other hand, SC is used in China, Singapore and places where there are Chinese-speaking populations (Jordan, 2002b).

The biggest difference between TC and SC is the characters. TC characters are more complicated and have more strokes than SC. For a detailed review of how TC characters were simplified please refer to (Bökset, 2006) and (Jordan, 2002b). One of the by-products that

resulted from the simplification process was that some characters now shared the same form as others. For example, “in the future” in SC is “以后”, which was simplified from “以後” (in the future). The two forms of the same word share the first character “以” while differing by the second character. “後” was simplified to become “后”. However, “后” also means “queen”. Thus the character “后” in SC now has two meanings and must be considered in context when deciphering which meaning is intended.

Initially, the difference between the two forms of written Chinese was mainly in the number of strokes, however new words and concepts that have developed over the years make these two writing systems more dissimilar. For example, there were no words in the Chinese language for computers. Mainland China now calls computers “計算機” which literally means ‘calculator’, while Taiwan calls them “電腦” which literally means ‘electric brain’.

Because of these differences, there is not a one-to-one correspondence between SC and TC characters. Any computer assisted conversion, such as Google Translate, attempting to decipher from one form to the other will be inaccurate unless corrected manually (Shi, 2013). For this reason, this study will only analyze passages written in TC, as the readability formulas employed in this study were developed for TC.

1.7.3 Chinese language readability measures

In comparison to the plethora of readability studies on English texts, there are only a few readability formulas developed for Chinese texts. Measuring readability in Chinese is a different matter to English. For example, the difficulty of a word in English may be measured by the number of letters it has, or its syllable count. However, these two measurements of semantic complexity cannot be adopted for Chinese, as Chinese characters are composed of strokes rather than phonetic letters and are monosyllabic. A parallel comparison to word length or syllable

count would be to measure stroke count or proportion of frequent words. Chinese readability studies therefore must consider the unique characteristics of the language and determine the textual attributes that represent the text's difficulty level (S. Yang, 1970). In addition, these textual attributes must be easily measurable (S. Yang, 1970).

The readability formulas adopted for this study were the Jing Readability formula and the Chinese Readability Index Explorer (CRIE) 1.0 formula. This section will describe them in detail.

1.7.3.1 Jing readability formula

The Jing readability formula was the first to calculate readability as a RGL. It was developed using corpora from 1st to 12th grade Chinese textbooks used in Taiwan. From the textbooks, Jing (Jing 荆, 1995) extracted the passage length, average sentence length, characters per passage and proportion of frequent characters to develop a readability formula. To calculate the proportion of frequent characters, Jing first counted the amount of different characters and how many times each character appeared. From this, the average frequency was calculated and any character that had a frequency count greater than the average frequency was deemed a frequent character. Initially, there were 785 frequent characters identified from the 1st to 12th grade textbooks, however frequent characters derived from only 1st to 6th grade text books produced a better readability formula. Therefore, the final frequent word list was derived from 1st to 6th grade textbooks and consisted of 495 characters. After extracting the textual features, stepwise regression analysis was performed to develop a readability formula. Jing also accounted for whether passages were poetry or presented in ancient Chinese. This was because many lessons in Chinese textbooks were written in these styles. The readability formula Jing produced is:

Readability grade level (Y) = 8.76105604+0.00272438*[Passage length] +0.07866782*[Average sentence length] -8.94311010*[proportion of frequent characters] +0.42920182*[poetry] +3.23677141*[ancient Chinese].

Here, [poetry] and [ancient Chinese] are binary decisions, and the only possible values are 0 or 1. This means that if the passage is a poem then [poetry] = 1 and a value of 0.42920182 is added to the readability grade level. Similarly, if passage exists in the ancient Chinese form, then [ancient Chinese] = 1 and a value of 3.23677141 is added to the readability grade level. If passage is not a poem or is not ancient Chinese, then [poetry] or [ancient Chinese] = 0.

The Jing formula was able to account for 85% of the variance of the text difficulty. Interestingly, Jing did not incorporate any “word” features in his formula. Analysis of the complexity of words have always been a staple in English readability formulas. Perhaps there were not any segmentation tools at that time and manual segmentation was too laborious for all of the passages that had to be analyzed. Nevertheless, Jing argued that modifying the readability formula to include a “word” feature may offer little improvement as the readability formula already accounted for 85% of the variance in text difficulty. Jing has now developed this into a web-based system that can automatically calculate a RGL for any given text written in TC (Jing 荆, Zhao, S.F., Weng, L. C., 2007) and is one of the systems employed in this study.

1.7.3.2 Chinese Readability Index Explorer 1.0

The Chinese Readability Index Explorer (CRIE) is also a web-based system that can automatically analyze multi-level textual attributes, including “word” related features which the Jing readability formula does not account for. The architecture of the CRIE system involves pre-

processing textual features analysis. The pre-processing stage includes segmentation, part-of-speech (POS) tagging and grammar parsing. This establishes the ground work for subsequent textual feature analysis. The research group developed a segmentation and part-of-speech tagging program called Word Extractor for Chinese Analysis (WECAn) (T. H. Chang et al., 2012) and HanParser (T. H. Chang, C. L. Liu, B. Chen, Sung, S. Y. Su, 2013) for grammar parsing.

For segmenting a string of characters into words, WECAn employs a matching technique against a dictionary (Sung et al., 2016). They addressed the need for a large dictionary by obtaining words from four corpora: Sinica Balanced Corpus 4.0 (C. R. Huang, K. J. Chen, F. Y. Chen, Wei, L. L. Chang, 1997), Sinica Treebank 3.1 (F. Y. Chen, P. F. Tsai, K. J. Chen, C.R. Huang, 1999), Chinese Knowledge and Information Processing (CKIP) group's Chinese Electronic Dictionary (CKIP, 1993) and Gigaword (C. L. Huang, Chung., Hui, Y. C. Lin, Seih, Lam, Pennebaker, 2012). From these corpora, a dictionary of 11.68 million Chinese words was derived (Sung et al., 2016). After the initial matching, WECAn then corrects any errors produced by ambiguity. Next, WECAn extracts the unknown words that cannot be segmented as they are not contained in the dictionary using a strict phrase likelihood ratio algorithm (T. H. Chang et al., 2012). The accuracy rate of WECAn segmentation was 93% (T. H. Chang et al., 2012; Sung et al., 2016).

After segmentation, each word requires POS tagging in order to perform sentence parsing. Many Chinese words can be tagged with different POS tags and create ambiguity issues. WECAn analyses all the possible POS combinations a word can have with its neighboring word. The POS combination with the highest probability is thereby assigned to the words. The accuracy rate for POS tagging was 92% (T. H. Chang et al., 2012).

For syntactic analysis, the POS-tagged words need to undergo sentence parsing. Sentence parsing identifies the grammatical relationship words in a sentence have with one another. This is required for syntactic complexity calculations, such as determining the proportion of full sentences. The accuracy rate of HanParser was estimated to be 86% (T. H. Chang et al., 2013).

Their CRIE 1.0 Readability formula (Sung et al., 2016) was developed using stepwise regression. The formula is:

$$\text{CRIE Readability 1.0} = 4.53 + 0.01 * [\text{proportion of difficult words}] - 0.86 * [\text{simple sentence ratio}] - 1.45 * [\text{content word frequency in logarithmic}] + 0.02 * [\text{personal pronouns}].$$

In this readability formula, difficult words were words that were in Academia Sinica's database of 3,000 difficult words. A simple sentence here is defined as only having a subject and a predicate (S. Yang, 1970). A content word carries semantic content and is usually a noun, verb, adjective or adverb (Lexico Publishing Group, 1995). More time is spent reading and processing content words than function words. Function words mainly express grammatical relationships and have little semantic content (Lexico Publishing Group, 1995). Personal pronouns are "he, she, it, we, they, me, him, her, us and them". However, the accuracy rate of the CRIE Readability 1.0 formula only had an accuracy rate of 55% (Sung, J. L. Chen, Y. S. Lee, Cha, Tseng, W. C. Lin, K.E. Chang, 2013). Nonetheless, this readability formula was adopted because of the immense versatility of the CRIE system, allowing for ease of computation.

1.7.3.3 Other Chinese readability formulas

There are other existing Chinese readability formulas such as Yang (1970) and Jeng's readability formulas (Jeng, 2001). However, these were not employed in this study for the reasons described below.

1.7.3.3.1 Yang readability formula

Using stepwise regression, Yang (1970) developed a seven-factor readability formula which could explain 70% of the variance in reading comprehension. Many of the textual factors in the formula cannot be computed automatically. The decision was made not to pursue this formula as it was not suitable to carry out large scale readability analysis. Furthermore, it was validated recently against Lau's readability model and there was poor correlation between the predicted readability scores (T. P. Lau, 2006). Thus due to lack of computation ease and poor validity, this formula was not employed for the current study.

1.7.3.3.2 Jeng Readability Formula.

Jeng (2001) estimated readability levels using an Artificial Neural Network (ANN) approach. This is a complicated process and is beyond the scope of this study. Although in the same study Jeng developed a six-factor readability formula, the textual factors in this formula are unconventional and therefore cannot be computed automatically. Furthermore, the definitions of some elements are vague and cannot be interpreted with confidence. Therefore, this study did not employ Jeng's ANN approach and readability formula to predict Chinese text readability.

1.8 Research questions

In order for hearing-related health information on the Internet to be usable, it needs to be readable. To-date there are no studies that have investigated the readability of hearing-related websites in Chinese. Given the large population of Chinese speakers in the world, there is a need

for readability assessment of hearing-related websites in Chinese. Although the majority of Chinese speakers are in China, there are limited resources for analyzing the readability of texts written in SC. Thus as a first step, hearing-related websites written in TC were assessed. This was conducted to answer the following primary research question: What is the readability of Traditional Chinese online hearing health information?

Hypothesis 1: Similar to the English language research, it was hypothesized that the median RGL of the websites would exceed the recommended 6th RGL.

Hypothesis 2: The mean RGL of websites from a commercial origin would be significantly lower than the mean RGLs of websites from government and non-profit organizations.

No previous studies have compared the results of readability analyses between the CRIE and Jing formulas. Therefore, a secondary aim of this study was to compare the RGL obtained for each website using the different formulas.

Hypothesis 3: Similar to the English language research, it was hypothesized there would be a significant relationship between the RGL produced by each formula.

2 Methods

2.1 Basic hardware and software employed

The Internet searches were performed using a 13-inch MacBook Pro operating on OS X (El Capitan version 10.11.4). Safari (version 9.1) was the browser used for the search engines and Firefox (version 50.1.0) was used to assess HONcode compliance.

2.2 Search strategy

The countries that employ TC as their official writing system are Taiwan and Hong Kong. In 2016, Google was the most commonly used Internet search engine in Taiwan and Hong Kong, accounting for 83.4% and 79.5% of the market share, respectively (AJPR, 2016). In order to provide customized, relevant results, Google automatically identifies the Internet protocol (IP) address and directs the user to the respective domain. Therefore, the country specific Google domains for Taiwan and Hong Kong were used to conduct the search (google.com.tw and google.com.hk).

A panel of 39 people with no expertise in the hearing health profession, who spoke Mandarin as their primary language, were recruited to identify keywords for the Internet search. The panel was identified through the researcher's Facebook friend list as people whose native language was Mandarin Chinese. They were asked “假如你開始發覺有些時候聽不太清楚,然後你想上網找相關資料跟處理/治療的方法,你會輸入哪些關鍵字?請把你能想到的都寫下來” which translates to “Let's say you are starting to realize you have listening difficulties. You want to find out general information about your problem and its treatment so, as a first step, you search the Internet. What keyword(s) do you try? Feel free to mention as few or as many as you can think of.”

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The keywords that were identified by two or more participants were: 助聽器 (Hearing aids), 重聽 (Hard of hearing), 聽不清楚 (Can't hear properly), 聽力障礙 (Hearing impairment), 聽力治療 (Hearing intervention), 耳朵 (Ear), 聽力退化 (Hearing deterioration), 耳聾 (Deaf), 耳鳴 (Tinnitus), 聽力 (Hearing ability), 聽覺受損 (Hearing damage), 耳朵聽不清楚 (Can't hear properly), 重聽治療法 (Treatment for hard-of-hearing).

These keywords were entered into Google Trends ([google.com/trends](https://www.google.com/trends)), to identify their relative search frequency, related Google queries, and information about the geographical distribution of people conducting searches with those keywords. Keywords were ranked based on their relative search frequency in 2016, compiled across all countries of interest. They were then entered into Google search to retrieve results that were related to hearing or hearing impairment. Keywords that returned results that were not related to hearing or hearing impairment were omitted. The five keywords that retrieved the most relevant information were 耳朵 (ear), 聽力 (hearing), 助聽器 (hearing aids), 重聽 (hard of hearing), 聽不清楚 (can't hear properly) and were thereby chosen to conduct further searches associated with the study.

2.3 Inclusion and exclusion criteria.

The inclusion criteria were that the webpage must: (1) be in TC, (2) contain information relating to hearing or hearing impairment or its treatment, (3) be available to the public, (4) be able to be copied and pasted, and (5) contain information about the organization hosting the webpage. In some instances, the information about the organization hosting the website was not apparent on the website. Further Internet searches were performed to obtain this information. In cases where this information could not be obtained, the website was excluded from the study. Webpages solely containing information regarding hearing aid or assistive device use, care and maintenance were not included however, as they are not directly related to the treatment of

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hearing impairment. The exclusion criteria were that the webpage must not: (1) be a Google-identified advertisement, (2) be a video or a video hosting website, (3) be an animation, (4) be an image (4) be a directory listing, (5) contain less than 100 words in length, (6) only contain information relevant to pediatric or congenital hearing loss, (7) only contain information about tinnitus, and (8) only contain information about vision, the vestibular system, and tumors or other brain lesions.

2.4 Internet search

Research has shown consumers only tend to access the first 9 results in an Internet search (Eysenbach & Kohler, 2002). Thus, for this study I decided to include the first 10 results yielded from each keyword. Each result was then assessed against the inclusion and exclusion criteria.

Information about the website origin was noted and used for analysis. For each search, I collected the following information: (1) the Uniform Resource Locator (URL) of the webpage, (2) the organization hosting the webpage: country of origin, type of organization, and (3) whether the webpage had HONcode certification (Boyer, Selby, Scherrer, Appel, 1998). To assess whether websites were HONcode certified, the HONcode toolbar was installed. The HONcode toolbar is a web browser add-on for Firefox or Chrome Internet browsers, that indicates whether a website is HONcode certified (Boyer, Selby, Scherrer, Appel, 1998). Safari (version 9.1) was used for the Internet search and Firefox (version 50.1.0) was used to assess HONcode certification. This was because it was learned at a later date that the HONcode toolbar was available and by then, the Internet search had already been completed using Safari (version 9.1). The period between these two procedures was approximately one month.

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2.5 Readability assessment

From each search result, each webpage within the website was searched and included if it passed the inclusion and exclusion criteria. For example, if the webpage with the URL “http://www.ear.com.tw/online_ans.php” provided a search result, then all of the webpages contained within the website “<http://www.ear.com.tw>” were matched against the inclusion and exclusion criteria. When webpages within a website had near-identical content, they were regarded as duplicates and removed from the data pool. For example, the catalogue of hearing aid manufacturer websites often has the same webpage content for different hearing aid styles that are models from the same line, albeit with a different heading. The near-identical webpages were regarded as duplicates and only one webpage that was representative of the duplicates was included for analysis.

The content from each webpage was then copied and pasted into Microsoft OneNote (Microsoft Corporation, 2016c). When it was not clear whether the content was relevant, the researcher discussed the content with supervisory colleagues and reached a consensus about whether or not to include the content in the analysis. Texts that were captions of images, graphs or tables were excluded from the analysis. Large bodies of numbers were also excluded from the analysis. This was achieved by manually removing the captions and large body of numbers via Microsoft OneNote (Microsoft Corporation, 2016c). The resultant text was then copied and pasted into Microsoft Word (Microsoft Corporation, 2016b) and saved as a plain text file (.txt). This removed all formatting, per the requirements of the CRIE and R.A.S.

2.5.1 Chinese Readability Index Explorer (CRIE)

The CRIE system (Sung et al., 2016) was accessed using the URL: <http://www.chinesereadability.net/CRIE/index.aspx?LANG=ENG>. The automatic readability

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assessment was not available and only textual analysis of linguistic features could be performed. The 70 textual features it can measure were identified as relevant features based on its training corpus using Taiwanese primary and secondary Chinese-language textbooks. The features: “Difficult words”, “Average strokes”, “Average frequency of content word in domain in logarithmic” and “Personal pronouns” were selected. Then the .txt files of the webpages were compressed into .zip files for “Batch process” analysis. Batch processing allows the simultaneous analysis of multiple files. The compression was performed using YemuZip (YellowMug Software, 2016). Once the computation was completed, results were downloaded as an .xls file. Microsoft Excel (Microsoft Corporation, 2016a) was used to open the .xls files and apply the CRIE 1.0 readability formula ($4.53 + 0.01 * [\text{Difficult words}] - 0.86 * [\text{Simple sentence ratio}] - 1.45 * [\text{Content word frequency in logarithmic}] + 0.02 * [\text{Personal pronouns}]$) (Sung et al., 2016).

2.5.2 Readability Analyzer System

The Readability Analyzer System (R.A.S) was accessed using the URL: <http://140.127.45.25/Readability/Analyze/index.aspx>. There were three options to choose from to perform the readability analysis: The first consisted of entering the URL of the webpage, the second was uploading the .txt file and the third supported a copy and paste method. The first method of entering the webpage would include hypertext markup language (HTML)—the framework for marking text files to enable various effects (e.g., font or color changes) or signify hyperlinks. This means that HTML source codes, headers and links would be included for analysis. This was unnecessary and is contrary to how the Jing Formula should be applied (Jing 荊, 1995). Using this option would result in a higher RGL due to the paragraph length being increased. The second option of uploading the .txt file could not be employed as it was not

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compatible with our equipment and would not function reliably. Thus, the third option consisting of copying and pasting was employed. Plain text was copied entirely from each .txt file and pasted in the box under the heading “Analyze by pasted content for analysis”. The “poetry” or “ancient Chinese” boxes were left unchecked. The system then produced the number of characters, average characters per sentence, ratio of common characters and a RGL. The information produced was stored using a Microsoft Excel spread sheet (Microsoft Corporation, 2016a).

2.6 Statistical Analyses

SPSS Statistics (IBM Corp, 2016) was used to perform statistical analysis. Descriptive statistics (mean RGL and standard deviation) were used to address the first study hypothesis. A between-group analysis of variance (ANOVA) was used to address the second study hypothesis. A Pearson product-moment correlation was used to address the third study hypothesis.

3 Results

The Internet search returned 100 results (first 10 results X 5 search terms X 2 Google domains). Results that did not match the inclusion and exclusion criteria were removed. The remaining results were then assessed for duplicates as there was some overlap in the different search results. After removing duplicates, there were 32 websites remaining. Of the 32 websites, 9 websites had their host organization located in Hong Kong, 21 websites had host organizations located in Taiwan and 2 websites were targeted at a global audience (world). When the websites were sorted according to organization type, 24 websites were commercial websites, 2 were government-associated websites and 6 were non-profit websites. None of the websites had HON certification. The URLs of the websites are shown in Table 3.1.

The website www.hkhearingspeech.com passed the inclusion and exclusion criteria but it had a secondary link to www.hkhearingspeech.com/blog that could not be assessed for readability analysis. The content of all webpages within the link [hkhearingspeech.com/blog](http://www.hkhearingspeech.com/blog) could not be copied and pasted. The webpages that could not be copied included webpages related to “聽力治療” (Intervention for HI), “言語治療” (Speech and language therapy), “助聽器” (Hearing aids), and “耳鼻喉專科” (Ear, nose and throat). All the other webpages within www.hkhearingspeech.com that could be copied and pasted, and matched the inclusion and exclusion criteria were included for analysis.

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Table 3-1. *Retrieved Websites After Matching Against Inclusion Criteria and Removing Duplicates.*

Website	Country of origin	Type of organization	HON certification
http://www.otichearing.com/adult-hearing-test/	Hong Kong	Commercial	No
http://www.hearing.com.hk	Hong Kong	Commercial	No
http://www.hearingaids.com.hk	Hong Kong	Commercial	No
http://www.optical88.com.hk/whatsnew/newin.php?id=49	Hong Kong	Commercial	No
http://orientaldaily.on.cc/cnt/news/20120819/00176_090.html	Hong Kong	Commercial	No
http://hkhearingspeech.com	Hong Kong	Commercial	No
http://www.phonak.com.hk/ch/products/category/hearing-aids/	Hong Kong	Commercial	No
http://www.elderlysd.com/elderinfo/hearing.html	Hong Kong	Commercial	No
http://www.kenkon.com.tw/health_self_survey.php?act=view&id=30	Taiwan	Commercial	No
https://www.bestsound-technology.com.tw/products/	Taiwan	Commercial	No
http://beltone.com.tw	Taiwan	Commercial	No
http://www.goldenday.com.tw/hearing.php	Taiwan	Commercial	No
http://news.ltn.com.tw/news/life/paper/772125	Taiwan	Commercial	No
http://www.uho.com.tw/hotnews.asp?aid=23191	Taiwan	Commercial	No
http://health.udn.com (health/story/6631/749604, /health/story/5969/1658226)	Taiwan	Commercial	No
http://focus.uho.com.tw/hearinghealth/	Taiwan	Commercial	No
http://www.drhearing.com.tw/content/product/index	Taiwan	Commercial	No
http://www.ear.com.tw/CGMH-WEB/earinfo.html	Taiwan	Commercial	No
http://erdo.cc	Taiwan	Commercial	No
http://www.pubu.com.tw/news/老年重聽預防更勝治療-聽力傷害你我需知-2190	Taiwan	Commercial	No
http://www.dharmazen.org/X1Chinese/D32Health/H806.htm	Taiwan	Commercial	No
https://www.facebook.com/permalink.php?story_fbid=409161662500036&id=204116693004535	Taiwan	Commercial	No
http://long2.go168.tw/service03.html	Taiwan	Commercial	No
https://tw.answers.yahoo.com/question/index?qid=20050826000013KK00990	Taiwan	Commercial	No
http://odcb.org.hk/b5_content.php?sid=4&cid=11&sub=1	Hong Kong	Government	No
http://epaper.ntuh.gov.tw/health/201503/project_1.html	Taiwan	Government	No
http://www.hearingtw.org/hearingloss_view.php?no=10	Taiwan	Non-profit	No
http://learchen.myweb.hinet.net/Pathology/content_degree.htm	Taiwan	Non-profit	No
http://web2.ctsh.hcc.edu.tw/stu98/s9811330/public_html/w4.html	Taiwan	Non-profit	No
http://www.twhealth.org.tw/index.php?option=com_zoo&task=item&item_id=920&Itemid=21	Taiwan	Non-profit	No
https://zh.wikipedia.org/wiki/助聽器	World	Non-profit	No
https://zh.wikipedia.org/wiki/耳	World	Non-profit	No

Readability of online hearing health information

Both the CRIE 1.0 and Jing formulas produced readability results as a RGL and are displayed in Figures 3.1 and 3.2. A mean RGL was calculated for each website. The box plot in Figure 3.1 shows the spread of website's RGL. The website with the lowest CRIE 1.0 RGL was www.kenko.com.tw with a RGL of 2.76 while the highest was long2.go168.tw with a RGL of 10.23. Similarly, the website with the lowest RGL as calculated by the R.A.S. system was also www.kenko.com.tw with a RGL of 3.57 and the highest was long2.go168.tw with a RGL of 12.25.

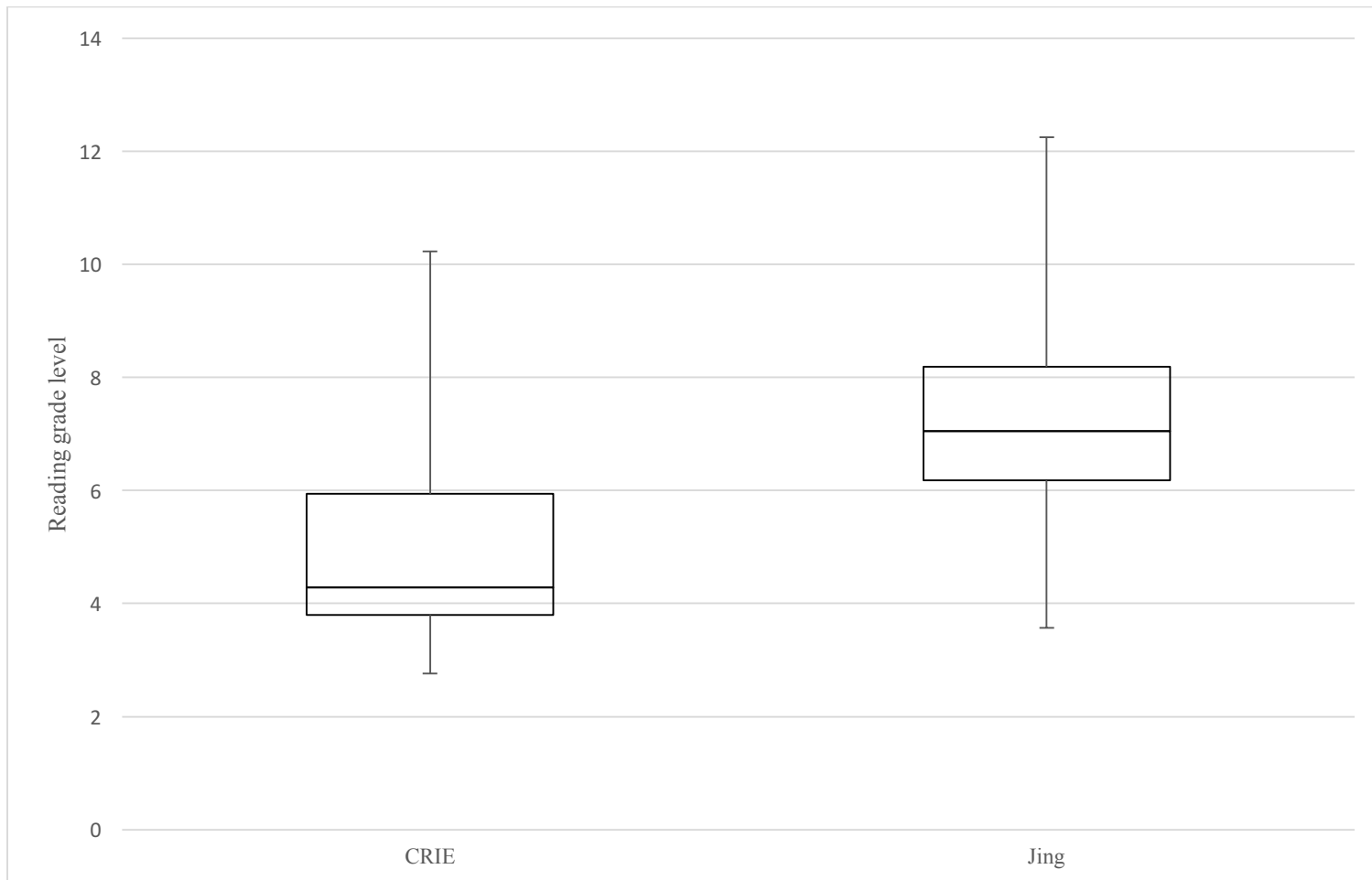


Figure 3-1. *Box Plot of Reading Grade Level of Chinese Websites*. CRIE = Chinese Readability Index Explorer. The boxes represent the middle 50% of websites, the horizontal line within the boxes represent the median, the vertical line on top of the boxes represent the upper 25% of websites, the bottom vertical line represent the lower 25% of websites.

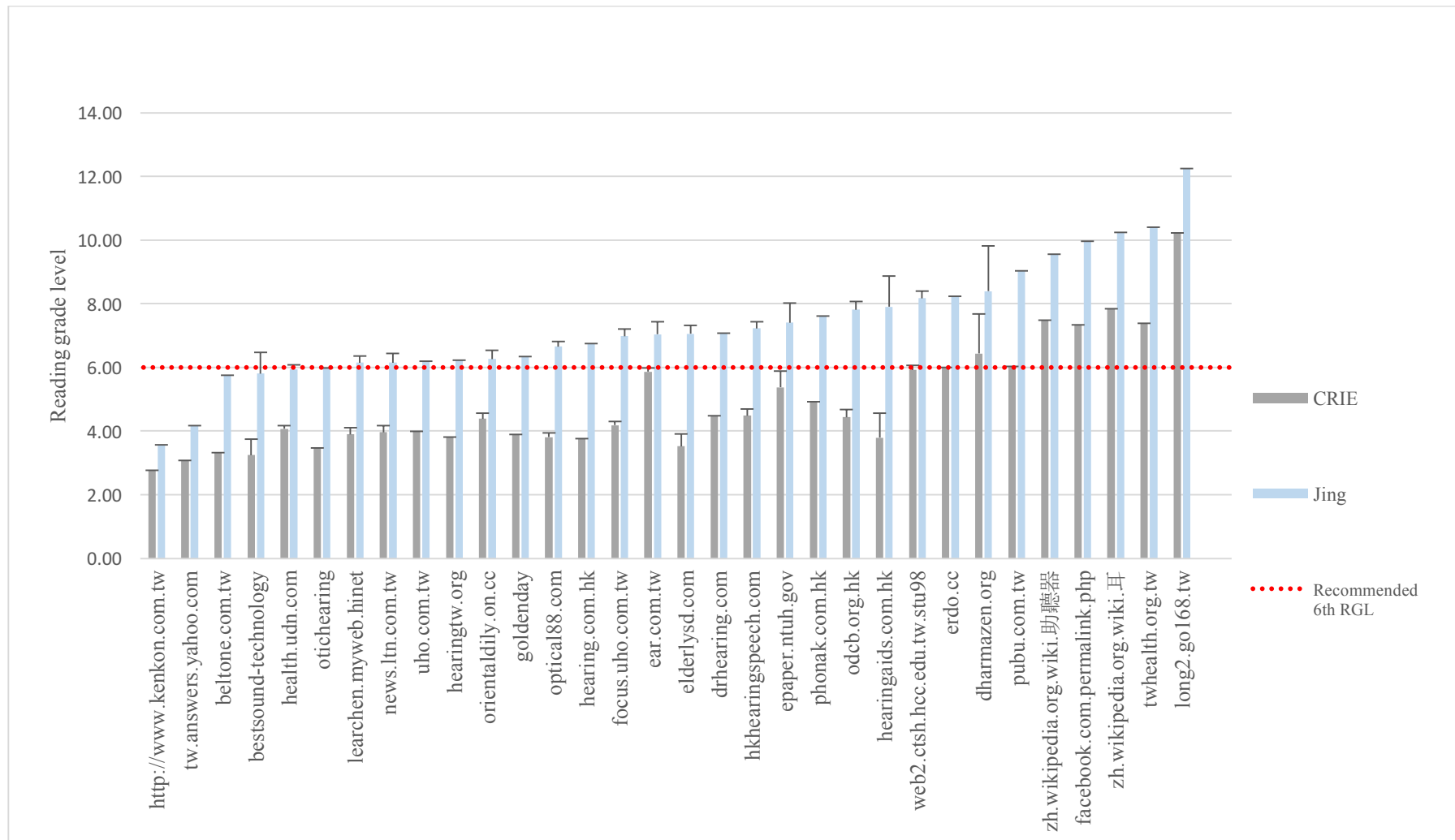


Figure 3-2. *Reading Grade Level of Hearing Related Websites in Chinese.* Results are expressed as mean and error bars are standard error of the mean. CRIE = Chinese Readability Index Explorer. RGL= Reading grade level.

3.1 Websites within the recommended RGL for health information

It was hypothesized that the median RGL of websites would exceed the recommended 6th RGL for health information (Safeer & Keenan, 2005). This hypothesis was not supported for the CRIE1.0 formula, but it was supported for the Jing formula. From Figure 3.2 it can be seen that for the CRIE 1.0 formula, 25% of the websites had a RGL higher than 6. However, according to the Jing Formula, 81% of the websites had a RGL that were higher than 6.

A Pearson product-moment correlation was used to test hypothesis 3, which theorized that the RGL from the two formulas would be significantly-related. This hypothesis was supported by the graph shown in Figure 3.3. The Pearson correlation showed a significant positive relationship: $r=0.93$, $n = 32$, $p < 0.0005$.

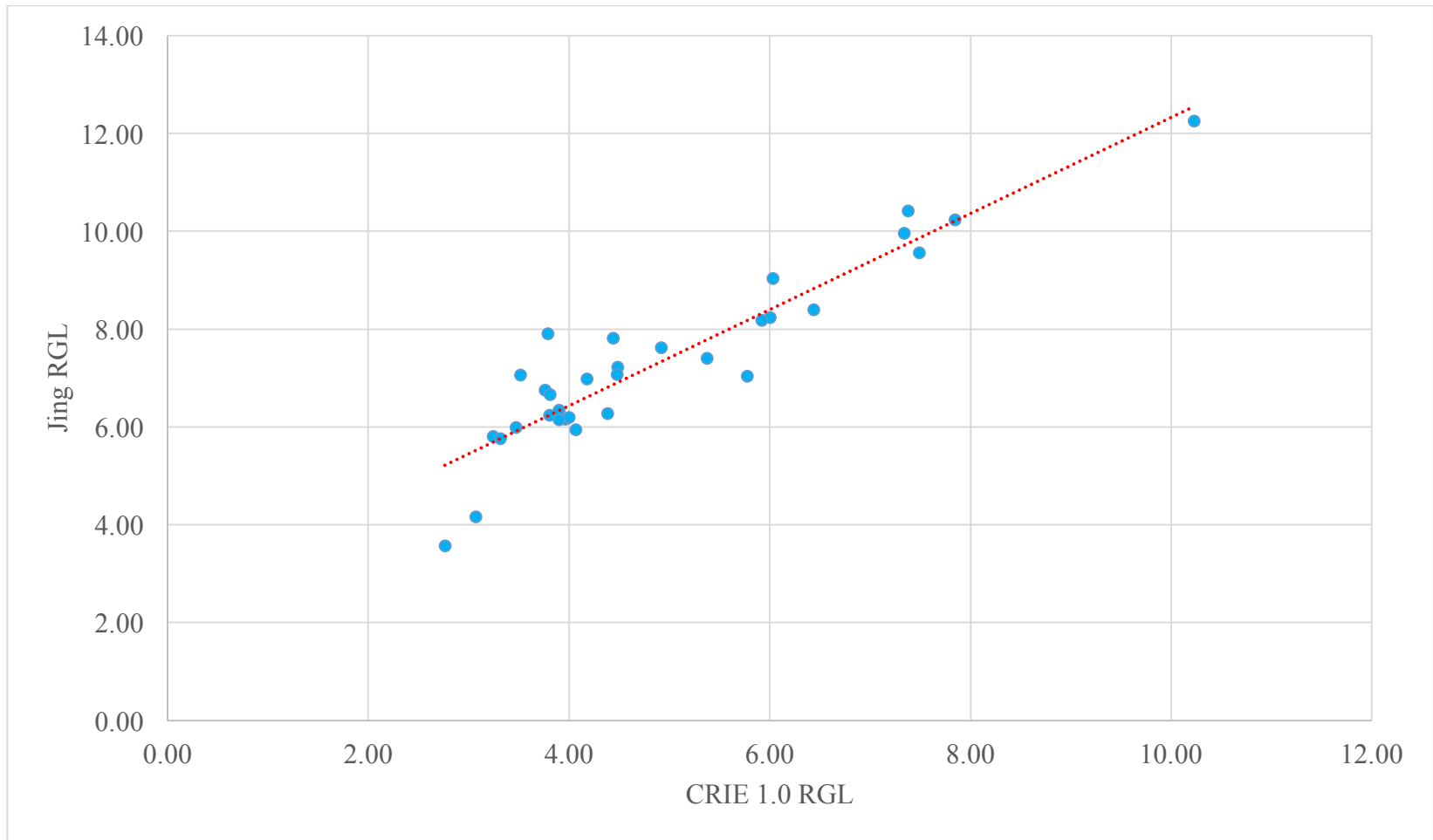


Figure 3-3. *Relationship between CRIE 1.0 and Jing Formulas*. Individual blue dots are each website’s reading grade level and red dotted line is the linear regression line. CRIE = Chinese Readability Index Explorer. RGL = Reading grade level.

3.2 Readability by organization type

It was hypothesized that commercial websites would have better readability due to better resources and more informed marketing teams. These data are shown in Figure 3.4. A one-way ANOVA was performed for each readability formula to test this hypothesis. The data indicate the hypothesis was not supported using either formula: CRIE 1.0: $F(2,29) = 1.77, p = 0.187, \eta^2_p = 0.11$, Jing: $F(2,29) = 1.63, p = 0.214, \eta^2_p = 0.10$. Although these results did not reach statistical significance, a trend can be seen in Figure 3.4. For both the CRIE 1.0 and Jing formula, non-profit organizations had the highest mean RGL. Government-affiliated websites had the next highest mean RGL. Finally, commercial websites had the lowest mean RGL.

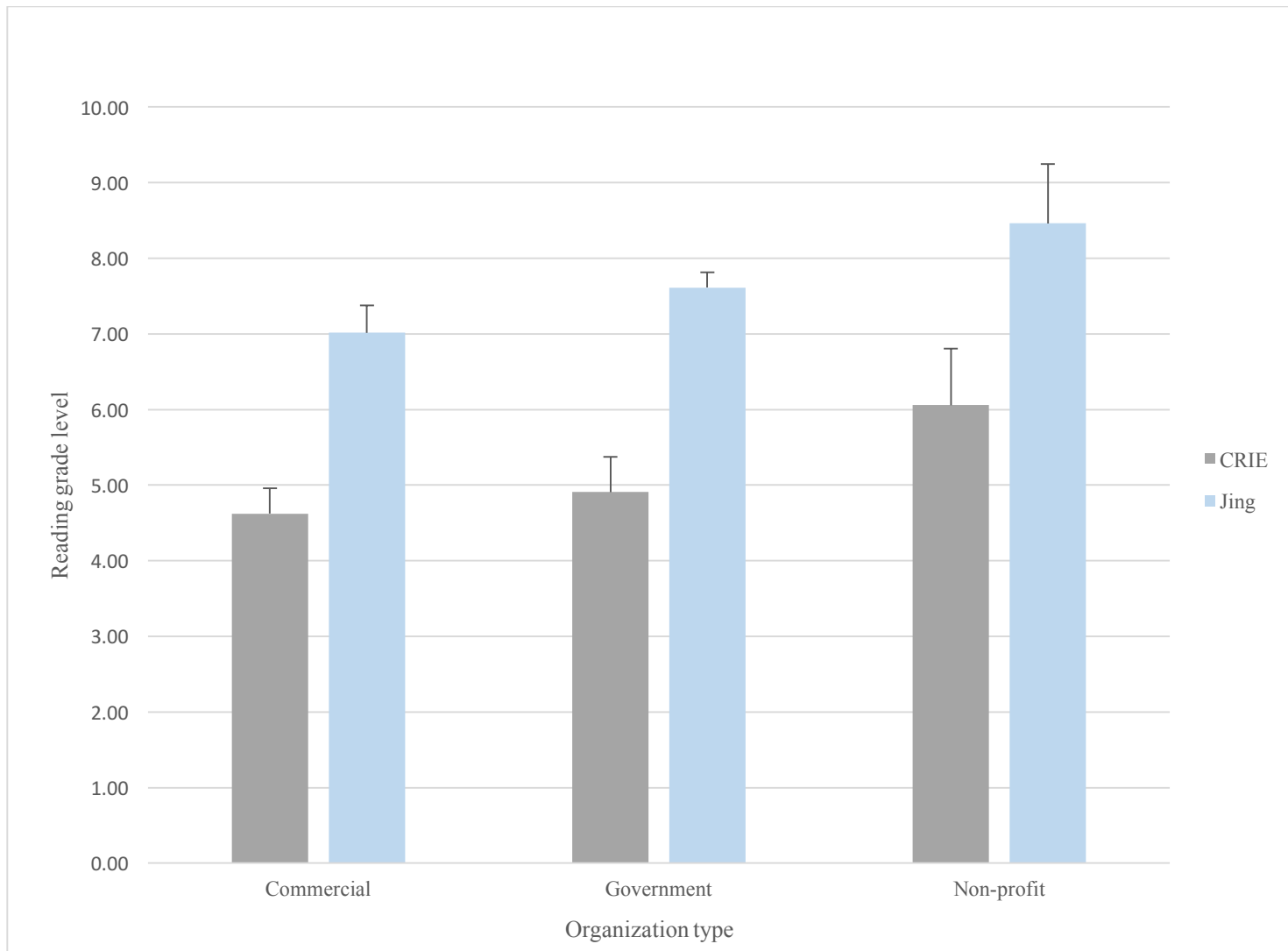


Figure 3-4. *Reading Grade Level According to Organization Type*. CRIE = Chinese Readability Index Explorer. Results are expressed as mean and error bars are standard error of mean.

4 Discussion

4.1 Readability of Traditional Chinese online hearing health information

The primary research question for this study was: What is the readability of TC online hearing health information? Three hypotheses were subsequently generated. The first hypothesis was that the median RGL of the websites would exceed the recommended 6th RGL (Doak, Doak, & Root, 1996a; Safeer & Keenan, 2005). This was supported according to the Jing formula but not for the CRIE 1.0 formula. Reasons for the differences can be attributed to how the CRIE and R.A.S system produce RGLs. To obtain CRIE 1.0 RGLs, the text first undergoes segmentation, POS tagging and grammar parsing to obtain the quantitative value of textual features. Each of these steps is performed by computational analyses, thus there are inaccuracies associated with every step which can be passed along to the next processing step. The final quantitative value of textual feature then, reflects all the inaccuracies associated with every processing step. As a result, the CRIE 1.0 formula only accounts for 55 % (.743²) of the variance of text difficulty (Sung, J. L. Chen, Y. S. Lee, Cha, Tseng, W. C. Lin, 2013).

Conversely, the R.A.S system does not need to perform the same processing steps—as the Jing formula does not involve analysis of word or sentence features (Jing 荊, 1995). The textual features that are analyzed, are [Passage length], [Average sentence length] and [Proportion of frequent characters]. The quantitative value for these textual features can be obtained easily with minimal error. Also, the common character list that Jing uses for his readability formula is from the same corpus used to develop the readability formula (Jing 荊, 1995). This approach lacks external validity and is contrary to the method that the CRIE system and others in the field have adopted (Flesch, 1948; Sung et al., 2016; Edward L Thorndike, 1927). This approach will result in higher correlations with text difficulty, as the common character list consists of characters that

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will appear in the texts used to validate the formula. This, along with the initial processing steps, may explain the Jing formula's high correlation (85%) with text difficulty. However, the Jing formula was validated later by Jeng (2001) and it was found the Jing formula was able to predict textbooks with an accuracy of <2 semester-based RGLs (within a 1-year education level), 74% of the time.

There is not a recommended readability level for Chinese health information. The recommended 5th -6th RGL for English health information, was applied to the current study because there is some evidence that the health literacy levels between the U.S. and Taiwan are comparable. In a recent study of health literacy levels of U.S. adults, 46% of adults were found to have restricted health literacy levels (Rudd, 2007). In Taiwan, 30% of adults have inadequate or marginal health literacy (S. Y. Lee, 2010). Another study found that the mean health literacy levels of Taiwanese people was only borderline sufficient (Duong et al., 2015). Therefore, the same recommended 5th to 6th RGL was applied to Chinese health information as well.

To-date, there are no published studies examining the readability of online Chinese hearing health information, nor are there any published readability studies characterizing online Chinese health information. In comparison to studies of online hearing health information in English, the large proportion of Chinese websites exceeding the recommended readability level is similar to their English counterparts. A systematic review of studies of online hearing health information (Laplante-Levésque & Thorén, 2015), revealed that the websites assessed had mean RGLs of 9 to 14. In particular, the studies included in the review showed large variations of RGLs in their findings. For example, in the study of consumer documents on ASHA's website (Atcherson et al., 2014), the Flesch-Kincaid RGL for consumer documents after 2011 was 9.0, with a range of 4.5 - 15.1. The mean RGL of Chinese websites from this study was 7.32, with a

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comparable range of 4.16 – 12.25. Poor readability of online hearing health information was not only found in the studies reviewed by Laplante-Levésque and Thorén (2015), but in other recent studies as well. Using multiple readability formulas, Svider (2013) found online patient education material from otolaryngology departments of academic institutes, to have poor readability. According to the Flesch-Kincaid grade level results, no institution had a RGL lower than 8.5 for their patient education material (Svider, 2013). In another study of online information for glue ear (Ritchie, Tornari, Patel, & Lakhani, 2016), it was found that the mean Flesch Reading Ease score was 49.7 with a range of 25.8-65.7. This indicates a reading level suitable for 11-15 year olds. However, 33% of the websites had readability scores only suitable for college-level reading skills. For an analysis of hearing aid information (Joseph, 2016), the average RGL according to multiple readability measures was at least 10, and the Flesch Reading Ease score revealed hearing aid information to be “fairly difficult” to read (Joseph, 2016).

Health literacy has yet to gain wide recognition in Taiwan and Hong Kong and this is evident by the lack of published information on this topic. As more and more people search the Internet for health information, health-related websites need to provide easy-to-read material(s). The websites included in this study that had high RGLs, were generally longer in passage length. Long passages may cause the online health seeker to lose interest before they reach the critical part of health information, or include irrelevant information that may cause confusion. Other ways to improve readability include reducing sentence length and simplifying vocabulary (Dubay, 2004; Jing 荊, 1995; Sung et al., 2016). Breaking down long sentences into several shorter sentences may make a text easier to read and understand (Dubay, 2004; Jing 荊, 1995; Sung et al., 2016). Also, simplifying vocabulary so that more common words or common characters are used, will reduce reading difficulty as well (Dubay, 2004; Jing 荊, 1995; Sung et

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al., 2016). Other ways to present information using tables, charts and figures can also reduce reading difficulty and increase comprehension (Doak et al., 1996a; DuBay, 2004). However, these are not included in readability formulas. In fact, the Jing and CRIE 1.0 formula requires that all tables and pictures are removed before analyzing for readability.

The website, www.hkhearingspeech.com had a subsection www.hkhearingspeech.com/blog that could not be assessed for readability. This was because the webpages in that subsection could not be copied and pasted into Microsoft Word for pre-processing. The anomaly was because of the format of the webpages and not the equipment or browser that this study employed. The websites could not be analysed by the “copy URL” option available via the R.A.S. There were many webpages within the subsection and to say how these would have affected the final results would be speculation. Some of the webpages were related to tinnitus and paediatric hearing, and did not pass the inclusion and exclusion criteria. The webpages that passed the criteria were in general, approximately 500-1,000 characters in length. However, the proportion of common words and common characters could not be estimated. Thus, it cannot be known what the readability of these webpages were and how the mean RGL of www.hkhearingspeech.com would be affected.

Interestingly, keywords did not always return relevant results. For the search term “耳朵” (ear), two of the returned websites were related to fortune-telling, one was related to reflexology. In Chinese culture, it is common practice to fortune-tell by assessing the features of the face and the ear is believed to be a significant predictor. Another search term that returned unexpected results was “聽力” (hearing ability) where four of the returned websites were related to English listening comprehension. “聽力” is also interpreted as listening skills in Chinese and is commonly used in reference to English listening comprehension skills. This was because, like

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other languages (About.com, 2015), many words in Chinese are poly-semantic or have a wide variety of use. The irrelevant websites should not be a barrier to hearing health seeking as health information seekers would be able to identify the irrelevant websites.

4.2 Relationship between CRIE 1.0 and Jing readability formulas

A secondary aim of this study was to compare the results of readability analyses between CRIE 1.0 and Jing formulas. Hypothesis 3 theorized that there would be a significant relationship between the RGL results produced by each formula. This hypothesis was supported as it was found that the RGL results produced by the two formulas were strongly and significantly correlated. A strong correlation indicates that there was a near-linear relationship between the results of the CRIE 1.0 and Jing readability formulas. An interesting observation was that the gradient of the regression line was close to 1 and the RGLs for each website differed by approximately 2. This indicates that the results produced by the Jing formula were 2 RGLs higher than CRIE 1.0 results for each website, on average. However, differences in RGL for the same text is not uncommon (Atcherson et al., 2014; Svider, 2013) and can be attributed to how each readability formula produces RGLs.

4.3 Readability of hearing health websites according to organization type

Readability of websites was examined to see if there was a difference according to organization type. The initial thought in analyzing differences according to organization type, was that commercial organizations may have a stronger marketing strategy and that readability would be an area of focus. A general trend was observed, and commercial websites had lower RGLs followed by government and non-profit organizations, respectively. However, the differences were not statistically-significant. Another recent study also did not find any significant differences according to organization type (Ritchie et al., 2016). One reason for a lack

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of statistical significance could be that there were not enough websites within the government (n=2) and non-profit categories (n=6). Although the null hypothesis, which theorized there would not differences could not be rejected, it was obvious that there are many more commercial websites providing hearing health information, than non-profit and government agencies. The commercial websites that were analyzed included hearing aid manufacturers and hearing health service providers. The information these websites provide, is more likely to be biased in promoting their own products and services. In turn, the hearing health seeker may be deprived of other intervention options if they solely rely on one commercial website. Regardless of the motive in providing hearing health information, websites should all aim to direct the hearing health seeker to service providers. Given the low accuracy rate of people who self-diagnose their health condition after accessing online health information (M. Duggan, Fox, S., 2013), it is important to have an audiologist /audiometrist or an ear, nose and throat doctor to assess the patient directly. In addition, hearing health websites should address any potential, patient concern regarding assessment by hearing health practitioners. Hearing health seekers should feel confident and safe to seek help from a physician or service provider.

4.4 Limitations

4.4.1 Asked people that were known to the researcher through Facebook

One of the limitations associated with this study was that the search terms were identified by people known to the researcher. In particular, they were recruited through the researcher's Facebook contact list. People who the researcher associates with are unlikely to represent the demographic makeup of Taiwan or Hong Kong. Furthermore, not all Internet users engage with Facebook. In 2014, of the people who were over 65 years of age in the U.S. that used the Internet, only 56% had Facebook accounts (Duggan, Ellison, Lampe, Lenhart, Madden, 2015).

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For people aged 50-64 years, only 63% of the Internet users interacted with Facebook (Duggan, Ellison, Lampe, Lenhart, Madden, 2015). Thus the method of recruiting people through Facebook, is not representative of the people who use the Internet to search for health information. As a result of recruiting the researcher's associates through Facebook, the search terms may be a biased representation of what people will use/type when searching for hearing health information. Also more Taiwanese people were surveyed than Hong Kong and Chinese people. Although people from these three places share the same language, the vocabulary used is different. Suggestions for future studies include sampling Internet users of age groups: 18-29 years old, 30-49 years old, 50-64 years old and 65 years old and above, from each Chinese-speaking country. The search terms identified from the people associated with each specific country, could then be used for that country's Google domain.

4.4.2 Readability formulas

4.4.2.1 Word lists

Many researchers have alluded to the dangers of placing too much trust on readability formulas (Bailin & Grafstein, 2001; Redish, 2000). Reasons for such caution are mainly due to the textual features that are measured. While the following arguments have been made against English readability formulas, they may be similarly applicable to the Chinese language. Bailin and Grafstein (2001) criticized the use of common word lists to measure word difficulty. Word lists that are commonly used today, to judge word complexity, were built almost half a century ago. Given the rapid pace at which language is changing, many words that were common, have become obscure and irrelevant (Bailin & Grafstein, 2001). Bailin and Grafstein (2001) gave examples of words that are from Dale's 3000-word list but are now unfamiliar to young readers. Past common words, thus cannot be regarded as common words in today's society. While words

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become outdated, new words become familiar. Words and phrases such as “mobile phones”, and “tablets” are now familiar words to most people, but were not commonplace until recently. Furthermore, groups of people from different cultural backgrounds, socioeconomic status, and generations have vastly different core vocabulary that they use in their daily lives (Bailin & Grafstein, 2001; Redish, 2000). Additionally, words have multiple meanings and depending on the context, easy words may be considered as hard words. For example, the word *string* has a common meaning but when used in the context of theoretical physics—string theory—its meaning is altogether different. A common word list that works as a yardstick cannot accommodate for these issues.

4.4.2.2 *Sentence length*

Another issue of readability formulas that has been criticized is the use of sentence length. Sentence length has been ubiquitously equated with sentence difficulty. However, this does not always hold true. Longer sentences that are written with logical connectives are easier to comprehend than short sentences without any communicative unity (Bailin & Grafstein, 2001).

4.4.2.3 *Other linguistic features*

Additionally, other linguistic features that are important to reading difficulty have not been included in readability formulas. These include features on the semantics level, syntax level and cohesion level (Meyer, 2003; Sung et al., 2016; Sung et al., 2015). These have been discussed elsewhere and to review them one by one is not the purpose of this thesis. Please refer to Sung et al. (2016) for an overview of these features. Traditional readability research has not accounted for these linguistic features. Now with the advance of mathematical models and machine learning, these linguistic features can conceivably be incorporated into analysis. In

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particular, the CRIE group (Sung et al., 2016) and Lau (2006) have separately published readability prediction models using Support Vector Machine, which automatically analyzes readability using 15-24 linguistic features. CRIE's readability model, CRIE 2.0, was reported to have an accuracy rate of 73% (Sung et al., 2013; Sung et al., 2015). Lau's readability model was able to predict readability to within 1 RGL, 90% of the time (T. P. Lau, 2006). Importantly, these two readability models address word complexity analysis, a feature that the Jing formula does not account for. Currently, both readability models are not publicly available. They will likely be extremely useful for future studies should they become available.

4.4.3 Suitability

This study solely focused on readability analysis of online hearing health information. However, readability formulas cannot provide a measurement of the suitability of health information. There are many other factors that influence the suitability other than mathematical analysis of textual features. Recognizing this shortcoming of readability formulas, the Suitability Assessment of Materials (SAM) instrument was developed to assess the factors that influence suitability (Doak et al., 1996b). The SAM is a 22 item instrument that examines factors relating to 1) content, 2) literacy demand, 3) graphics, 4) layout and typography, 5) learning stimulation and motivation, and 6) cultural appropriateness (Doak et al., 1996b). Atcherson et al. (2014) found in their readability analysis of articles on the ASHA website, one article that had a high RGL (difficult to read) received a SAM score of "adequate suitability". In the present study, the specific webpage

http://www.twhealth.org.tw/index.php?option=com_zoo&task=item&item_id=48&category_id=11&Itemid=12 had a RGL of 12.76 according to the Jing formula. This indicates that the webpage is suitable for people with at least 12 years of education. However, when I applied the

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SAM instrument to assess its suitability, I obtained a score of 50% (21/42) for this webpage, indicating “adequate readability”. This specific example demonstrates the limitations of readability formulas and the need for other factors to be considered when examining Internet health information.

4.4.4 Readership characteristics

Another factor that readability formulas do not account for is the characteristics of the individual reader. Studies have found prior knowledge and motivation to be important reader characteristics which influence reading comprehension. Readers with prior knowledge of the topic are able to acquire and retain information better (Lipson, 1982; Recht, 1988). Readers who are motivated are less influenced by text difficulty (Fass, 1978). It is plausible that online health information seekers will be motivated, and potentially anxious to find out about their health condition(s).

4.5 Future directions

4.5.1 Simplified Chinese

This study was a first step in analyzing readability of Chinese hearing health websites. Because the majority of Chinese readability formulas were developed mainly for TC, this study could not feasibly assess SC hearing health websites. The majority of Chinese speakers are in China and use SC. As of 2017, the population of China is at 1.3 billion people (Worldometers, 2017). Comparatively, the population of Taiwan and Hong Kong together, is only 30 million people (Worldometers, 2017). Thus, there is a pressing need to analyze readability of SC hearing health websites. The CRIE system is able to perform textual feature analysis for SC, however the CRIE 1.0 readability formula’s correlation with text difficulty is poor (55%) (Sung et al., 2013). The CRIE research team has published the CRIE 2.0 readability model that can analyze SC text,

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which reportedly has a higher correlation with text difficulty than the CRIE 1.0 (Sung et al., 2016). However, at the time of writing, the CRIE 2.0 readability model was not available on the CRIE website (www.chinesereadability.net). Lau has also indicated that their readability model will be developed for SC (T.P. Lau, 2006). Thus, hearing health websites in SC should be analyzed for readability once these models become available.

4.5.2 Health On the Net code

None of the websites identified in this study had HONcode certification. To be certified for HONcode, the websites need to apply for certification, provided that the website meets the principles of HONcode. Although it is free to become certified, there are only a few Chinese hearing health websites that are certified. A simple search using the HONsearch on the HON website demonstrated this (HON, 2014). Entering the 5 keywords from this study into the HONsearch returned only 15 webpages that were HONcode certified. Some of the websites were even machine translated from English. The lack of HONcode certification, could therefore be due to an awareness issue rather than a quality issue. Studies have found that HONcode certified health websites were of a better quality than websites which were not (Breckons, 2008; Nason et al., 2012). The HON foundation has been developing an automated HONcode analysis system. The automated system detects whether websites meet each of the HONcode principles separately. As of 2014, they were working towards achieving an over 85% accuracy rate for all HONcode principles (Boyer, Dolamic, 2014). However, given the higher adoption rate of the HONcode in European countries, development of the automated tool for the Chinese language may have a lower priority.

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4.5.3 DISCERN

DISCERN is a short instrument with 16 items, designed for consumers to self-assess the quality of health information (Charnock, 1999). It has good reliability (C. E. Rees, Ford, & Sheard, 2002) and is often used in conjunction with readability formulas to evaluate health information (Laplante-Levésque et al., 2012; Ritchie et al., 2016). With the vast amount of health information available via the Internet, it is important not just for consumers, but also for information providers, to be able to judge the quality of health information. However, the DISCERN tool was not designed for non-English languages (Charnock, 1999), thus to apply the DISCERN tool for the websites in this study, a first step in this process would involve assessing whether it is suitable for TC or SC.

4.5.4 Website accuracy

Although the quality of online health information may be assessed by tools such as the HONcode and DISCERN, there is currently no standardized tool to analyze the accuracy of health information. Due to the importance of health information, assessing the accuracy of information on health-related websites should be of top priority. Nonetheless, developing a tool to analyze the accuracy of health information can be extremely difficult. The vast amount of medical conditions and ever-expanding knowledge through progresses in research, suggest that a universal tool to assess accuracy of health information is not feasible. Instead, efforts to address this issue should be taken up by each health-disciplines' service providers. In hearing health, audiologists or professional audiological associations can assess the accuracy of hearing health related websites and provide an accuracy 'badge' to websites, much like the HONcode certification.

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1.1.1 Readability of crucial parts

Wang, Miller, Schmitt, and Wen (2013) identified that within a document of health information, there was large variation in text readability. Health information may contain introductory material that is easy to read but the critical part about health information may be more difficult. These key areas are most important for health information seekers and it is crucial that all components are understood by the reader, without any ambiguity and/or misunderstanding. Including easy to read areas in a readability assessment, may potentially mask the greater literacy skill required to read more essential passages. Wang et al. (2013) suggested that in the context of health care, key areas of health information such as symptoms, disease management, must be evaluated for readability. However, this could not be performed for this study as identifying crucial parts requires agreement between different researchers. At the time of this study, there were no other researchers in the author's contact that had knowledge of both TC and hearing health.

5 Conclusion

Hearing impairment is a prevalent issue that affects many people. It causes spoken communication to breakdown, which may in turn, lead to many adverse consequences. As more and more people turn to the Internet for health information, there is a need for a readability analysis of online hearing health information. Most of the focus has been centered on English online hearing health information and has found it to be written at levels too difficult for the general public. However, there are no studies investigating Chinese online hearing health information and yet the Chinese language is spoken by the largest number of native speakers in the world. Due to the limited Chinese readability formulas available, this study focused on TC online hearing health information. This study found that the readability of TC online hearing health information was too difficult according to the Jing formula but not for the CRIE 1.0 formula. Reasons for the difference were most likely due to how the two readability formulas derive their scores. However, the Jing formula can explain more of the variance in text difficulty when compared with the CRIE 1.0 formula. Thus according to the Jing formula, most TC online hearing health information is too difficult for the general population to understand. Comprehension of health information is vital to patient empowerment (Bader, 1998), better management of health conditions and improvement in health outcomes (Connell et al., 1985; Farquhar et al., 1977; Reichard, 1996). It was also found that readability of online TC hearing health information did not differ significantly according to organization type. Although readability formulas are not measures of comprehension, they remain important indices of the difficulty that can be associated with accessing health information. Improving the readability of such information is an important step in improving consumers' understanding and usability of online hearing health information. And, per the Jing and CRIE 1.0 analyses, this can be achieved

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by primarily using shorter sentences and more common words. Future directions include performing readability analysis for online hearing health information written in SC as the majority of Chinese speakers use SC. This is currently not feasible as there are no reliable readability formulas for SC. In addition, to supplement the findings from this study, the websites should be assessed for their suitability and quality.

6 References

- About.com. (2015, 22 Dec, 2015). Polysemy (words and meanings). *Glossary of Grammatical & Rhetorical Terms*. Retrieved from <http://grammar.about.com/od/pq/g/polysemyterm.htm>
- Abraham, W. (2013). Part I: Getting Started. In W. Abraham (Ed.), *Chinese For Dummies* (pp. 17-19). Somerset, UNITED STATES: Wiley.
- AJPR. (2016). Search engine market share in Asia - January 2016. Retrieved from <https://www.ajpr.com/search-engine-market-share-in-asia-january-2016/>
- Alberti, P. (2001a). The anatomy and physiology of the ear and hearing. In B. Goelzer, Hansen, C., Sehrndt, G. (Ed.), *Occupational Exposure to Noise: Evaluation, Prevention and Control* (pp. 53-62). Dortmund, Germany: World Health Organization.
- Alberti, P. (2001b). The pathophysiology of the ear. In B. Goelzer, Hansen, C., Sehrndt, G. (Ed.), *Occupational Exposure to Noise: Evaluation, Prevention and Control* (pp. 63-78). Dortmund, Germany: World Health Organization.
- Arlinger, S. (2003). Negative consequences of uncorrected hearing loss - A review. *International Journal of Audiology*, 42 Suppl 2, S17-20.
- ASHA, American Speech-Language-Hearing Association. (2016). Effects of hearing loss on development. Retrieved from <http://www.asha.org/public/hearing/Effects-of-Hearing-Loss-on-Development/>
- Atcherson, S. R., DeLaune, A. E., Hadden, K., Zraick, R. I., Kelly-Campbell, R. J., & Minaya, C. P. (2014). A computer-based readability analysis of consumer materials on the American Speech-Language-Hearing Association website. *Contemporary Issues in Communication Science and Disorders*, 41(Apr), 12-23.
- Auchter, M., Le Prell, C. G. (2014). Hearing loss prevention education using Adopt-a-Band: Changes in self-reported earplug use in two high school marching bands. *American Journal of Audiology*, 23(2), 211-226.
- Bader, S. A., Braude, R. M. (1998). "Patient informatics": Creating new partnerships in medical decision making. *Academic Medicine*, 73(4), 408-411.
- Bailin, A., & Grafstein, A. (2001). The linguistic assumptions underlying readability formulae: A critique. *Language & Communication*, 21(3), 285-301. doi:[http://dx.doi.org/10.1016/S0271-5309\(01\)00005-2](http://dx.doi.org/10.1016/S0271-5309(01)00005-2)
- Becker, M. H. (1974). The health belief model and personal health behavior. *Health Education Monographs*, 2, 324-473.
- Bessell, T. L., Silagy, C. A., Anderson, J. N., Hiller, J. E., & Sansom, L. N. (2002). Measuring Prevalence: Prevalence of South Australia's online health seekers. *Australian and New Zealand Journal of Public Health*, 26(2), 170-173. doi:10.1111/j.1467-842X.2002.tb00912.x
- Bökset, R. (2006). *Long story of short forms: The evolution of simplified Chinese characters*. (Dissertation/Thesis), Stockholm University Stockholm.
- Boyer, C., Baujard, V., Geissbuhler, A. (2011). Evolution of health web certification through the HONcode experience. *Studies in Health Technology and Informatics*, 169, 53-57.
- Boyer, C., Dolamic, L. (2014). Feasibility of automated detection of HONcode conformity for health-related websites. *International Journal of Advanced Computer Science and Applications*, 5(5), 69-74.
- Boyer, C., Selby, M., Scherrer, J. R., Appel, R. D. (1998). The Health On the Net code of conduct for medical and health websites. *Computers in Biology and Medicine*, 28, 603-610.

- Breckons, M., Jones, R., Morris, J., Richardson, J. (2008). What do evaluation instruments tell us about the quality of complementary medicine information on the Internet? *Journal of Medical Internet Research*, 10(1), e3.
- Briggs, R., & Luxford, W. M. (1994). Correction of conductive hearing loss in children. *Otolaryngologic Clinics of North America*, 27(3), 607-620.
- Cao, W., Zhang, X., Xu, K., & Wang, Y. (2016). Modeling online health information-seeking behavior in China: The roles of source characteristics, reward assessment, and Internet self-efficacy. *Health Communication*, 31(9), 1105-1114.
doi:10.1080/10410236.2015.1045236
- Carr, S. (2016). Learning from linguistics: Structuring our sentences sensitively. *Bereavement Care*, 35(1), 31-35. doi:10.1080/02682621.2016.1160619
- Center for Health Protection. (2011). Be aware of hearing loss. *Non-Communicable Diseases Watch*, 4(3), 1-8.
- Chang, H. P., & Chou, P. (2007). Presbycusis among older Chinese people in Taipei, Taiwan: A community-based study. *International Journal of Audiology*, 46(12), 738-745.
doi:10.1080/14992020701558529
- Chang, J. (1987). Chinese speakers. In M. Swan, Smith, B. (Ed.), *Learner English* (2 ed., pp. 310-324). Cambridge, United Kingdom: Cambridge University Press.
- Chang T. H., Liu., C. L., Chen, B., Sung, Y. T., Su, S.Y. (2013). *A grammar parser for automated essay scoring of Chinese as a second language: Development and implementation*. Paper presented at the 21st annual meeting of the International Association of Chinese Linguistics, Taipei, Taiwan.
- Chang, T. H., Sung, Y. T., Lee, Y. T. (2012). *A Chinese word segmentation and POS tagging system for readability research*. Paper presented at the 42nd annual meeting of the Society for Computers in Psychology, Minneapolis, MN.
- Charnock, D., Shepperd, S., Needham, G., Gann, R. (1999). DISCERN: An instrument for judging the quality of written consumer health information on treatment choices. . *Journal of Epidemiology and Community Health*, 53, 105-111.
- Chen, F. Y., Tsai, P. F., Chen, K. J., Huang, C. R. (1999). Sinica Treebank. *Computational Linguistics and Chinese Language Processing*, 4(2), 87-104.
- Chen, H. C., Song, H., Lau, W. Y, Wong, K. F. E., & Tang, S. L. (2003). Developmental characteristics of eye movements in reading Chinese. In C. McBride-Chang & H.-C. Chen (Eds.), *Reading Development in Chinese Children* (pp. 157-169). Westport, CT: Praeger.
- Chen, Y. P., Allport, D. A., Marshall, J. C. (1996). What are the functional orthographic units in Chinese word recognition: The stroke or stroke pattern? *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, 49(4), 1024-1043.
- CKIP, Chinese Knowledge and Information Processing (Ed.) (1993) Chinese Electronic Dictionary. Taiwan: Academia Sinica.
- Cline, R. J. W., & Haynes, K. M. (2001). Consumer health information seeking on the Internet: The state of the art. *Health Education Research*, 16(6), 671-692.
doi:10.1093/her/16.6.671
- Connell, D. B., Turner, R. R., & Mason, E. F. (1985). Summary of findings of the School Health Education Evaluation: Health promotion effectiveness, implementation, and costs. *Journal of School Health*, 55(8), 316-321.

- Contreras, A., Garcia-Alonso, R., Echenique, M., & Daye-Contreras, F. (1999). The SOL formulas for converting SMOG readability scores between health education materials written in Spanish, English, and French. *Journal of Health Communication, 4*(1), 21-29. doi:10.1080/108107399127066
- Coplan, J. (1987). Deafness: Ever heard of it? Delayed recognition of permanent hearing loss. *Pediatrics, 79*(2), 206-213.
- Dale, E., & Chall, J. S. (1949). The concept of readability. *Elementary English, 26*(1), 19-26.
- Diaz, J. A., Griffith, R. A., Ng, J. J., Reinert, S. E., Friedmann, P. D., & Moulton, A. W. (2002). Patients' use of the Internet for medical information. *Journal of General Internal Medicine, 17*(3), 180-185. doi:10.1046/j.1525-1497.2002.10603.x
- Doak, C. C., Doak, L. G., & Root, J. H. (1996a). Applying theory in practice *Teaching Patients with Low Literacy Skills* (2 ed., pp. 11-26). Philadelphia, PA: J. B. Lippincott Company.
- Doak, C. C., Doak, L. G., & Root, J. H. (1996b). Assessing Suitability of Materials *Teaching Patients with Low Literacy Skills* (2 ed., pp. 41-60). Philadelphia, PA: J. B. Lippincott Company.
- Doak, C. C., Doak, L. G., & Root, J. H. (1996c). The literacy problem *Teaching Patients with Low Literacy Skills* (2 ed., pp. 1-9). Philadelphia, PA: J. B. Lippincott Company.
- Doak, C. C., Doak, L. G., & Root, J. H. (1996d). Teaching patients with low literacy skills. *The American Journal of Nursing, 96*(12), 16.
- DuBay, W. H. (2004). *The principles of readability*. Costa Mesa, CA: Impact Information.
- Duggan, Ellison, N.B., Lampe, C., Lenhart, A., Madden, M. (2015). Demographics of key social networking platforms. *Social Media Update 2014*. Retrieved from <http://www.pewInternet.org/2015/01/09/demographics-of-key-social-networking-platforms-2/>
- Duggan, M., Fox, S. (2013). Health online 2013. *The Pew Internet & American Life Project*. Retrieved from <http://www.pewInternet.org/fact-sheets/health-fact-sheet/>
- Duong, V. T., Lin, I. F., Sorensen, K., Pelikan, J. M., Van Den Broucke, S., Lin, Y. C., & Chang, P. W. (2015). Health literacy in Taiwan: A population-based study. *Asia Pacific Journal of Public Health, 27*(8), 871-880. doi:10.1177/1010539515607962
- El Dib, R. P., & Mathew, J. L. (2012). Interventions to promote the wearing of hearing protection. *Cochrane Database of Systematic Reviews* (4), Cd005234. doi:10.1002/14651858.CD005234.pub3
- Eng, T. R., Maxfield, A., Patrick, K., Deering, M. J., Ratzan, S. C., & Gustafson, D. H. (1998). Access to health information and support: A public highway or a private road? *The Journal of the American Medical Association, 280*(15), 1371-1375.
- Eysenbach, G., & Kohler, C. (2002). How do consumers search for and appraise health information on the world wide web? Qualitative study using focus groups, usability tests, and in-depth interviews. *The British Medical Journal, 324*(7337), 573-577.
- Fan, K. Y. (1986). *Graphic symbol of the Chinese character*. Paper presented at the Symposium of Chinese Character Modernization, Beijing, China.
- Farquhar, J. W., Maccoby, N., Wood, P. D., Alexander, J. K., Breitrose, H., Brown, B. W. Jr., . . . Stern, M. P. (1977). Community education for cardiovascular health. *The Lancet, 1*(8023), 1192-1195.
- Fass, W., Schumacher, G. M. (1978). Effects of motivation, subject activity, and readability on the retention of prose materials. *Journal of Educational Psychology, 70*(5), 803-807.

- Feinstein, L., Sabates, R., Anderson, T. M., Sorhaindo, A., Hammond, H. (2006). *What are the effects of education on health?* Paper presented at the Measuring the Effects of Education on Health and Civic Engagement: Proceedings of the Copenhagen Symposium, Copenhagen, Denmark.
- Feldman, L. B., & Siok, W. W. T. (1999). Semantic radicals contribute to the visual identification of Chinese characters. *Journal of Memory and Language*, 40(4), 559-576.
doi:<http://dx.doi.org/10.1006/jmla.1998.2629>
- Feldman, L. B., Siok, W. W. T., (1997). The role of component function in visual recognition of Chinese characters. *Journal of Experimental Psychology: Learning Memory and Cognition*, 23(3), 776-781.
- Flesch, R. (1948). A new readability yardstick. *Journal of Applied Psychology*, 32(3), 221-233.
doi:10.1037/h0057532
- Fox, S. (2006). Online health search 2006. *Pew Internet & American Life Project*. Retrieved from <http://www.pewInternet.org/>
- Fox, S., Duggan, M. (2013). Health online 2013. Retrieved from <http://www.pewInternet.org/fact-sheets/health-fact-sheet/>
- Freda, M. C. (2005). The readability of American Academy of Pediatrics patient education brochures. *Journal of Pediatric Health Care*, 19(3), 151-156.
doi:<http://dx.doi.org/10.1016/j.pedhc.2005.01.013>
- Friedman, D. B., & Hoffman-Goetz, L. (2006). A systematic review of readability and comprehension instruments used for print and web-based cancer information. *Health Education & Behavior*, 33(3), 352-373. doi:10.1177/1090198105277329
- Fry, E. B., Kress, J. E., Fountoukidis, D. L. (1993). *The reading teacher's book of lists* (3 ed.). West Nyack, NY: The Center for Applied Research in Education.
- Grandinetti, D. A. (2000). Doctors and the Web. Help your patients surf the Net safely. *Medical Economics*, 77(5), 186-188, 194-186, 201.
- Ho, C. S. H., Ng, T. T., & Ng, W. K. (2003). A “radical” approach to reading development in Chinese: The role of semantic radicals and phonetic radicals. *Journal of Literacy Research*, 35(3), 849-878. doi:10.1207/s15548430jlr3503_3
- Hol, M. K., Snik, A. F., Mylanus, E. A., & Cremers, C. W. (2005). Long-term results of bone-anchored hearing aid recipients who had previously used air-conduction hearing aids. *Archives of Otolaryngology–Head & Neck Surgery*, 131(4), 321-325.
- HON, Health On the Net Foundation. (2010). Operational definition of the HONcode principles. *Health On the Net Code of Conduct*. Retrieved from <http://www.hon.ch/HONcode/Guidelines/guidelines.html>
- HON, Health On the Net Foundation. (2014). HONsearch section for patient and individual. *HONsearch*. Retrieved from <http://www.hon.ch/HONsearch/Patients/index.html>
- Hoosain, R. (1991). *Psycholinguistic implications for linguistic relativity: A case study of Chinese*: Psychology Press.
- Hsu, W. T., Hsu, C. C., Wen, M. H., Lin, H. C., Tsai, H. T., Su, P., . . . Hsu, Y. C. (2016). Increased risk of depression in patients with acquired sensory hearing loss: A 12-year follow-up study. *Medicine (Baltimore)*, 95(44), e5312.
doi:10.1097/md.0000000000005312
- Huang, C. L., Chung, C. K., Hui, N., Lin, Y. C., Seih, Y. T., Lam, B. C. P., Pennebaker, J. W. (2012). The development of the Chinese linguistic inquiry and word count dictionary. *Chinese Journal of Psychology*, 54(2), 185-201.

- Huang, C. R., Chen, K. J., Chen, F. Y., Wei, W. J., Chang, L. L. (1997). Design criteria and content of segmentation standard for Chinese information processing. *Applied Linguistics*, 1, 92-100.
- Huang, C. R., & Xue, N. (2012). Words without Boundaries: Computational Approaches to Chinese Word Segmentation. *Language and Linguistics Compass*, 6(8), 494-505. doi:10.1002/lnc3.357
- IBM Corp. (2016). SPSS Statistics for Macintosh (Version 24.0). Armonk, NY: IBM Corp.
- Internet World Stats. (2016a). Asia marketing research, Internet usage, population statistics and facebook information. Retrieved from <http://www.Internetworldstats.com/asia.htm>
- Internet World Stats. (2016b). World Internet users and 2016 population stats. Retrieved from <http://www.Internetworldstats.com/>
- Iverson, S. A., Howard, K. B., & Penney, B. K. (2008). Impact of Internet use on health-related behaviors and the patient-physician relationship: A survey-based study and review. *The Journal of the American Osteopathic Association*, 108(12), 699-711.
- Jeng, C.-C. (2001). *Chinese readability analysis using artificial neural networks*. Northern Illinois University, Dekalb, Illinois.
- Jordan, D. K. (2002a, 21 June 2015). The Chinese Language(s): An overview for beginners. Retrieved from <http://pages.ucsd.edu/~dkjordan/chin/SimplifiedCharacters.html>
- Jordan, D. K. (2002b, 21 June 2015). More than you want to know about simplified characters. Retrieved from <http://pages.ucsd.edu/~dkjordan/chin/SimplifiedCharacters.html>
- Joseph, J., Svider, P. F., Shaigany, K., Eloy, J. A., McDonald, P. G., Folbe, A. J., Hong, R. S. (2016). Hearing aid patient education materials: Is there room for improvement? *Journal of American Academy of Audiology*, 27, 354-359.
- Kamil, R. J., & Lin, F. R. (2015). The effects of hearing impairment in older adults on communication partners: a systematic review. *Journal of American Academy of Audiology*, 26(2), 155-182. doi:10.3766/jaaa.26.2.6
- Kaplan, W., Wirtz, V. J., Mantel-Teeuwisse, A., Stolk, P., Duthey, B., Laing, R. (2013). *Priority diseases and reasons for inclusion: Hearing loss*. Retrieved from Geneva, Switzerland:
- Kennedy, C. R., McCann, D. C., Campbell, M. J., Law, C. M., Mullee, M., Petrou, S., . . . Stevenson, J. (2006). Language ability after early detection of permanent childhood hearing impairment. *New England Journal of Medicine*, 354(20), 2131-2141.
- Klare, G. R., Buck, B. (1954). *Know Your Reader* (1 ed., pp. 136-144). NY: Hermitage House.
- Kutner, M., Greenberg, E., Yin, J., Paulsen, C., & White, S. (2006). *The health literacy of America's adults: Results from the 2003 national assessment of adult literacy*. Washington, DC: National Center for Education Statistics.
- Laplante-Levésque, A., Brannstrom, K. J., Andersson, G., & Lunner, T. (2012). Quality and readability of English-language Internet information for adults with hearing impairment and their significant others. *International Journal of Audiology*, 51(8), 618-626. doi:10.3109/14992027.2012.684406
- Laplante-Levésque, A., & Thorén, E. S. (2015). Readability of Internet information on hearing: Systematic literature review. *American Journal of Audiology*, 24(3), 284-288. doi:10.1044/2015_AJA-14-0091
- Lau, T. P. (2006). *Chinese readability analysis and its applications on the Internet*. (Master of Philosophy), The Chinese University of Hong Kong, Hong Kong.
- Leck, K. J., Weekes, B. S., & Chen, M. J. (1995). Visual and phonological pathways to the lexicon: Evidence from Chinese readers. *Memory & Cognition*, 23(4), 468.

- Lee, S. Y., Tsai, T. I., Tsai, Y. W., Kuo, K. N. (2010). Health literacy, health status, and healthcare utilization of Taiwanese adults: results from a national survey. *BioMed Central Public Health, 10*, 614-621.
- Lexico Publishing Group. (Ed.) (1995) Dictionary.com. Long Beach, CA: Lexico Publishing Group.
- Lexicon of Common Words in Contemporary Chinese Research Team. (2008). *Lexicon of common words in contemporary Chinese*. Beijing, China: The Commercial Press.
- Li, X., Bicknell, K., Liu, P., Wei, W., & Rayner, K. (2014). Reading is fundamentally similar across disparate writing systems: A systematic characterization of how words and characters influence eye movements in Chinese reading. *Journal of Experimental Psychology: General, 143*(2), 895.
- Lin, C. Y., Yang, Y. C., Guo, Y. I., Wu, C. H., Chang, C. J., & Wu, J. L. (2007). Prevalence of hearing impairment in an adult population in southern Taiwan. *International Journal of Audiology, 46*(12), 732-737. doi:10.1080/14992020701448986
- Lin, F. R., Ferrucci, L., Metter, E. J., An, Y., Zonderman, A. B., & Resnick, S. M. (2011). Hearing loss and cognition in the Baltimore Longitudinal Study of Aging. *Neuropsychology, 25*(6), 763-770. doi:10.1037/a0024238
- Lipson, M. Y. (1982). Learning new information from text: The role of prior knowledge and reading ability. *Journal of Reading Behavior, 14*(3), 243-261.
- Liszka, H. A., Steyer, T. E., & Hueston, W. J. (2006). Virtual medical care: How are our patients using online health information? *Journal of Community Health, 31*(5), 368-378.
- Lively, B. A., Pressey, S.L. (1923). A method for measuring the 'vocabulary burden' of textbooks. *Educational Administration and Supervision, 9*, 389-398.
- Liversedge, S. P., Zang, C., Zhang, M., Bai, X., Yan, G., & Drieghe, D. (2014). The effect of visual complexity and word frequency on eye movements during Chinese reading. *Visual Cognition, 22*(3-4), 441-457.
- Lorge, I., Thorndike, E.L. (1944). The teacher's word book of 30,000 words. *New York: Teachers College, Columbia University*.
- Ma, G., & Li, X. (2015). How character complexity modulates eye movement control in Chinese reading. *Reading and Writing, 28*(6), 747-761. doi:10.1007/s11145-015-9548-1
- Mathers, C., Smith, A., Concha, M. (2003). *Global burden of hearing loss in the year 2000*. Geneva: World Health Organization.
- Meinzen-Derr, J., Lim, L. H., Choo, D. I., Buyniski, S., & Wiley, S. (2008). Pediatric hearing impairment caregiver experience: Impact of duration of hearing loss on parental stress. *International Journal of Pediatric Otorhinolaryngology, 72*(11), 1693-1703. doi:10.1016/j.ijporl.2008.08.005
- Meyer, B. J. F. (2003). Text Coherence and Readability. *Topics in Language Disorders, 23*(3), 204-224. doi:10.1097/00011363-200307000-00007
- Microsoft Corporation. (2016a). Microsoft Excel.
- Microsoft Corporation. (2016b). Microsoft Office.
- Microsoft Corporation. (2016c). Microsoft OneNote.
- Mirowsky, J., & Ross, C. E. (1998). Education, personal control, lifestyle and health: A human capital hypothesis. *Research on Aging, 20*(4), 415-449.
- Moller, A. R. (2006). *Hearing: Anatomy, Physiology, and Disorders of the Auditory System* (2nd ed.). Oxford, UK: Academic Press.

- Moore, B. (2013). *An Introduction to the Psychology of Hearing* (6th ed.). Leiden, Netherlands: Koninklijke Brill NV.
- Moreland, J., French, T. L., & Cumming, G. P. (2015). The prevalence of online health information seeking among patients in Scotland: A cross-sectional exploratory study. *JMIR Research Protocols*, 4(3), e85. doi:10.2196/resprot.4010
- Murray, C. J. L., Vos, T., Lozano, R., Naghavi, M., Flaxman, A. D., Michaud, C., . . . Lopez, A. D. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: A systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*, 380(9859), 2197-2223. doi:10.1016/S0140-6736(12)61689-4
- Nason, G. J., Baker, J. F., Byrne, D. P., Noel, J., Moore, D., & Kiely, P. J. (2012). Scoliosis-specific information on the Internet: Has the "information highway" led to better information provision? *Spine (Phila Pa 1976)*, 37(21), 1364-1369. doi:10.1097/BRS.0b013e31826619b5
- Oxford University Press. (2017). Dictionary. *Oxford Dictionary*. Retrieved from <https://en.oxforddictionaries.com/definition/syllable>
- Paul, M. L., Simons, G. F., Fennig, C. D. (2016). Ethnologue - Languages of the world. Retrieved from <http://www.ethnologue.com/>
- Peng, D., Wang, Chunmao. (1997). Basic processing unit of Chinese character recognition: Evidence from stroke number effect and radical number effect. *Acta Psychologica Sinica*, 29(01), 9-17.
- Pinheiro, P., Martin, W.H. (2015). *Economic impact and cost of hearing loss in singapore*. (Master of Science (Audiology)), National University of Singapore, Singapore.
- Possel, H. (n.d.) Famous idioms. *English Language - Smart Words*. Retrieved from <http://www.smart-words.org/quotes-sayings/idioms-meaning.html>
- Recht, D. R., Leslie, L. (1988). Effect of prior knowledge on good and poor readers' memory of text. *Journal of Educational Psychology*, 80(1), 16-20.
- Redish, J. (2000). Readability formulas have even more limitations than Klare discusses. *ACM Journal of Computer Documentation*, 24(3), 132-137.
- Rees, C. E., Ford, J. E., & Sheard, C. E. (2002). Evaluating the reliability of DISCERN: a tool for assessing the quality of written patient information on treatment choices. *Patient Education and Counseling*, 47(3), 273-275. doi:10.1016/S0738-3991(01)00225-7
- Rees, S., & Williams, A. (2009). Promoting and supporting self-management for adults living in the community with physical chronic illness: A systematic review of the effectiveness and meaningfulness of the patient-practitioner encounter. *JBIC Library of Systematic Reviews*, 7(13), 492-582.
- Reichard, P. (1996). To be a teacher, a tutor and a friend: The physician's role according to the Stockholm Diabetes Intervention Study (SDIS). *Patient Education and Counseling*, 29(3), 231-235.
- Ren, X. Y., Fu, Y. X. (2015). The review of automatic Chinese word segmentation. *Applied Mechanics and Materials*, 701, 386-389.
- Ritchie, L., Tornari, C., Patel, P. M., & Lakhani, R. (2016). Glue ear: How good is the information on the World Wide Web? *The Journal of Laryngology & Otology*, 130(2), 157-161. doi:10.1017/s0022215115003230
- Rogers, A., Vaughan, P., Prentice, T., Edejer, T. T-T. Evans, D., Lowe, J. (2002). *The world health report: Reducing risks, promoting healthy life*. Geneva, Switzerland: World Health Organization

- Rudd, R. E. (2007). Health literacy skills of U.S. adults. *American Journal of Health Behavior*, 31(suppl 1), s8-s18.
- Safeer, R. S., & Keenan, J. (2005). Health literacy: The gap between physicians and patients. *American Family Physician*, 72(3), 463-468.
- Sand-Jecklin, K. (2007). The impact of medical terminology on readability of patient education materials. *Journal of Community Health Nursing*, 24(2), 119-129.
- Sherman, L. A. (1893). *Analytics of literature: A manual for the objective study of English prose and poetry*: Ginn & Company
- Shi, X., Chen, Y., Huang, X. (2013, September). *Key problems in conversion from simplified to traditional Chinese characters*. Paper presented at the Proceedings of the XIV Machine Translation Summit, Nice, Italy.
- Shieh, C., & Hosei, B. (2008). Printed health information materials: Evaluation of readability and suitability. *Journal of Community Health Nursing*, 25(2), 73-90.
doi:10.1080/07370010802017083
- Shu, H., & Anderson, R. C. (1997). Role of radical awareness in the character and word acquisition of Chinese children. *Reading Research Quarterly*, 32(1), 78-89.
- Siow, T. R., Soh, I. P., Sreedharan, S., Das De, S., Tan, P. P., Seow, A., & Lun, K. C. (2003). The Internet as a source of health information among Singaporeans: Prevalence, patterns of health surfing and impact on health behaviour. *Annals of the Academy of Medicine, Singapore*, 32(6), 807-813.
- Smith, A. W. (1998). The World Health Organisation and the prevention of deafness and hearing impairment caused by noise. *Noise Health*, 1(1), 6-12.
- Solheim, J., Kvaerner, K. J., & Falkenberg, E. S. (2011). Daily life consequences of hearing loss in the elderly. *Disability and Rehabilitation*, 33(23-24), 2179-2185.
doi:10.3109/09638288.2011.563815
- Spaulding, S. (1956). A Spanish readability formula. *The Modern Language Journal*, 40(8), 433-441. doi:10.1111/j.1540-4781.1956.tb02145.x
- Steiger, J. (2015). Bone conduction evaluation. In J. Katz, Chasin, M., English, K., Hood, L. J., Tillery, K. (Ed.), *Handbook of Clinical Audiology* (7 ed., pp. 49-59). Philadelphia, USA: Wolters Kluwer Health.
- Stevens, G., Flaxman, S., Brunskill, E., Mascarenhas, M., Mathers, C. D., & Finucane, M. (2013). Global and regional hearing impairment prevalence: An analysis of 42 studies in 29 countries. *European Journal of Public Health*, 23(1), 146-152.
doi:10.1093/eurpub/ckr176
- Su, Y.-F., & Samuels, S. J. (2010). Developmental changes in character-complexity and word-length effects when reading Chinese script. *Reading and Writing*, 23(9), 1085-1108.
doi:10.1007/s11145-009-9197-3
- Sun, C. (2006). Chinese language and culture. In C. Sun (Ed.), *Chinese: a Linguistic Introduction* (pp. 115-146). Cambridge, United Kingdom: Cambridge University Press.
- Sun, X. B., Wei, Z. Y., Yu, L. M., Wang, Q., & Liang, W. (2008). Prevalence and etiology of people with hearing impairment in China. *Zhonghua Liu Xing Bing Xue Za Zhi*, 29(7), 643-646.
- Sung, Y. T., Chang, T. H., Lin, W. C., Hsieh, K. S., & Chang, K. E. (2016). CRIE: An automated analyzer for Chinese texts. *Behavior Research Methods*, 48(4), 1238-1251.
doi:10.3758/s13428-015-0649-1

- Sung, Y. T., Chen, J.-L., Lee, Y. S., Cha, J.-H., Tseng, H.-C., Lin, W. C., & Chang, K. E. (2013). Investigating chinese text readability: Linguistic features, modeling, validation. *Chinese Journal of Psychology, 55*(1), 75-106.
- Sung, Y. T., Chen, J. L., Cha, J. H., Tseng, H. C., Chang, T. H., & Chang, K. E. (2015). Constructing and validating readability models: The method of integrating multilevel linguistic features with machine learning. *Behavior Research Methods, 47*(2), 340-354. doi:10.3758/s13428-014-0459-x
- Svider, P. F., Agarwal, N., Choudhry, O. J., Hajart, A. F., Baredes, S., Liu, J. K., Eloy, J. A. (2013). Readability assessment of online patient education materials from academic otolaryngology-head and neck surgery departments. *American Journal of Otolaryngology - Head and Neck Medicine and Surgery, 34*, 31-35.
- Tamaoka, K., & Kiyama, S. (2013). The effects of visual complexity for Japanese kanji processing with high and low frequencies. *Reading and Writing, 26*(2), 205-223. doi:10.1007/s11145-012-9363-x
- Taylor, W. L. (1953). "Cloze procedure": A new tool for measuring readability. *Journalism Bulletin, 30*(4), 415-433. doi:doi:10.1177/107769905303000401
- Thorndike, E. L. (1927). *The teacher's word book*: Teachers College, Columbia University.
- Thorndike, E. L. (1932). *A teacher's word Book of the twenty thousand words found most frequently and widely in general reading for children and young people*: Teachers College, Columbia university.
- Tjellström, A., Lindström, J., Hallén, O., Albrektsson, T., & Brånemark, P. (1981). Osseointegrated titanium implants in the temporal bone: A clinical study on bone-anchored hearing aids. *Otology & Neurotology, 2*(4), 304-310.
- Tonsaker, T., Bartlett, G., & Trpkov, C. (2014). Health information on the Internet: Gold mine or minefield? *Canadian Family Physician, 60*(5), 407-408.
- Toutanova, K., Klein, D., Manning, C. D., & Singer, Y. (2003). *Feature-rich part-of-speech tagging with a cyclic dependency network*. Paper presented at the Proceedings of the 2003 Conference of the North American Chapter of the Association for Computational Linguistics on Human Language Technology-Volume 1.
- Tsukada, T., & Sakakibara, H. (2008). A trail of individual education for hearing protection with an instrument that measures the noise attenuation effect of wearing earplugs. *Industrial Health, 46*(4), 393-396.
- Tyler, R. S., Tye-Murray, N., & Gantz, B. J. (1991). Aural rehabilitation. *Otolaryngologic clinics of North America, 24*(2), 429-445.
- University of Wisconsin. (2016). Writing clear, concise sentences. *Writer's Handbook*. Retrieved from <http://writing.wisc.edu/Handbook/ClearConciseSentences.html>
- Vogel, M., & Washburne, C. (1928). An objective method of determining grade placement of children's reading material. *The Elementary School Journal, 28*(5), 373-381. doi:10.1086/456072
- Wang, L. W., Miller, M. J., Schmitt, M. R., & Wen, F. K. (2013). Assessing readability formula differences with written health information materials: Application, results, and recommendations. *Research in Social and Administrative Pharmacy, 9*(5), 503-516. doi:10.1016/j.sapharm.2012.05.009
- Wen, S. (2014). Chinese sentences - classified by sentence structure. In R. Wan (Ed.), *Essentials of Modern Chinese, with Traditional Chinese Example Sentences* (pp. 175): Everflow Publications.

- Wessex Universal Neonatal Hearing Screening Trial Group. (1998). Controlled trial of universal neonatal screening for early identification of permanent childhood hearing impairment. *The Lancet*, 352(9145), 1957-1964.
- WHO, World Health Organization. (2001). *Occupational Exposure to Noise Evaluation, Prevention and Control*. Geneva, Switzerland: World Health Organisation.
- WHO, World Health Organization. (2012, March 2015). Deafness and hearing loss. *Fact Sheets*. Retrieved from <http://www.who.int/mediacentre/factsheets/fs300/en/>
- Williams, W. (2004). Instruction and the improvement of hearing protector performance. *Noise and Health*, 7(25), 41-47.
- Worldometers. (2017). Countries in the world by population (2017). *Population by Country*. Retrieved from <http://www.worldometers.info/world-population/population-by-country/>
- Yan, G., Tian, H., Bai, X., & Rayner, K. (2006). The effect of word and character frequency on the eye movements of Chinese readers. *British Journal of Psychology*, 97(Pt 2), 259-268. doi:10.1348/000712605x70066
- Yan, Y. Y. (2010). Online health information seeking behavior in Hong Kong: An exploratory study. *Journal of Medical Systems*, 34(2), 147-153.
- Yang, H. M., McConkie, G.W., (1999). Reading Chinese: Some basic eye movement characteristics. In H. C. Chen (Ed.), *Reading Chinese Script: A Cognitive Analysis* (pp. 207-222). Mahwah, NJ: Taylor & Francis.
- Yang, J., Wang, S., Chen, H.-C., & Rayner, K. (2009). The time course of semantic and syntactic processing in Chinese sentence comprehension: Evidence from eye movements. *Memory & cognition*, 37(8), 1164-1176. doi:10.3758/mc.37.8.1164
- Yang, S. (1970). *A Readability Formula for Chinese Language*. University of Wisconsin--Madison. Retrieved from <https://books.google.co.nz/books?id=YYrXAAAAMAAJ>
- YellowMug Software. (2016). YemuZip (Version 2.5).
- Zang, C., Zhang, M., Bai, X., Yan, G., Paterson, K. B., & Liversedge, S. P. (2016). Effects of word frequency and visual complexity on eye movements of young and older Chinese readers. *The Quarterly Journal of Experimental Psychology*, 69(7), 1409-1425. doi:10.1080/17470218.2015.1083594
- Zargi, M., & Boltezar, I. H. (1992). Effects of recurrent otitis media in infancy on auditory perception and speech. *American Journal of Otolaryngology*, 13(6), 366-372.
- Zhang, X., Cao, J. (2010). The analysis of influence factors of health information network users' requirement. *Medicine and Society*, 23(9), 25-27.
- Zickuhr, K. (2010). *Generations 2010*. Retrieved from http://www.pewInternet.org/files/old-media/Files/Reports/2010/PIP_Generations_and_Tech10.pdf
- 教育部國語推行委員會. (2011). Dictionary of Chinese idioms. Retrieved from <http://dict.idioms.moe.edu.tw/cydic/index.html>
- 荊, 溪. (1995). 中文國文教材的適讀性研究: 適讀年級的推估. . *教育研究資訊*, 3(3), 113-127.
- 荊, 溪., Zhao, S.F., Weng, L. C. (2007). The development of readability-analyzing system for Chinese articles. *科技教育課程改革與發展學術研討會論文集*, 2006, 47-57.