

SPEECH AND ARTICULATION RATES OF
OLDER NEW ZEALAND ADULTS

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ABSTRACT

This study gathered normative speech and articulation rate data from a group of 112 New Zealand English speakers aged 64 to 91 years. It examined whether speech and articulation rates differ across context (conversation and reading), and whether they are influenced by speaker sex, age, years of education and lexical frequency. Results indicated that articulation rates in read speech were slower than in conversational speech. With regard to age and sex, results indicated that speech rate in oral reading declined with age, and there was a trend for females to speak faster than males in some situations. Neither years of education nor lexical frequency were significant predictors of speaking rates. To date there has been little information regarding normative speech and articulation rate data of older New Zealand English adults, and this study offers a guide for clinicians when diagnosing and planning treatment for clients in this age group.

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1) LITERATURE REVIEW

1.1) Speech rate and Articulation rate

The production of intelligible speech requires precise and coordinated function of the speech systems (laryngeal, supralaryngeal, and respiratory). The rate at which speech is produced (speaking rate) also influences the degree of speech intelligibility. Speaking rate is defined as the speed at which an individual produces articulatory movements for the production of speech (Robb, Maclagan, & Chen, 2004). It is measured by either speech rate or articulation rate, both defined as “the number of output units per unit of time” (Tsao, Weismer, & Iqbal, 2006, pg.1156). Although there has been some debate on the differences between these measures, nowadays it is generally agreed that speech rate includes pause intervals, whereas articulation rate does not (Jacewicz, Fox, & O’Neill, 2009).

The most common units of measuring rate are words per minute (WPM), syllables per minute (SPM), and syllables per second (SPS), although there are other units of measure that some studies have used, such as phonemes or morae per second (e.g. Nishio & Niimi, 2006). Measuring speaking rate with WPM is less precise than using SPM or SPS as the measure, as words vary in the number of syllables they contain depending on a variety of different factors, such as education, age, language, culture, and the topic being discussed. For example, Australian studies that have used WPM as a measure have typically assumed that 100 words contain 140 syllables, however American English studies generally assume that 100 words contain 150 syllables (Andrews & Ingham, 1971). Compound words can also cause problems – for example are ice cream and air stream (ice-cream, airstream) considered to be one word or two? (Hewlett & Beck, 2006). Difficulties also arise when measuring in syllables or phonemes as it is often difficult to tell how many there are in a word and in running speech the unstressed

syllables are often elided. So, for example, when chocolate is pronounced clearly, there are three syllables (choc-o-late), but in casual speech it is often pronounced with two (choc-late) (Hewlett & Beck, 2006).

A large number of studies have investigated speech rate of children and younger adults. These studies have found that speech rate increases with age from childhood to adulthood. For example, children aged from 3 to 5 years have an average speech rate of 148 SPM (i.e. approximately 100 WPM), or average articulation rate of 179 SPM (Pindzola, Jenkins & Lokken, 1989), while young adults speech rate is approximately 167 WPM (Guitar, 1998) to 194 WPM (Horton et al., 2010). Kail (1992) tested 9- and 19-year old participants and found that as age increases, most cognitive processes are executed more rapidly, which in turn allows words to be processed faster and articulation rate to increase. More familiar words are also processed more rapidly, and as words become more familiar with age, they can be articulated at a faster speed (Kail, 1992).

Less attention has been focused on speech rate changes associated with healthy ageing. However, ageing involves a variety of changes that can affect older adults speech production abilities (Smith, Wasowicz, & Preston, 1987). Smith et al. (1987) state that obtaining information regarding the speech production characteristics of typical aging adults is necessary in order to provide a basis for evaluating clinical data, and note that often comparisons are made between older and much younger adults, as there is little data comparing impaired and unimpaired older adults. Since their 1987 study, there has been some, but not a great deal, of research in this area, and the importance of this is increasing with the ageing population (Andrade & Martins, 2010). Due to this larger population of adults over the age of 80 years, speech pathologists are faced with an increasing number of clients with disorders commonly associated with elderly individuals such as Parkinson's disease, dysarthria, aphasia, and dementia. A number of these

disorders are associated with speech-timing problems (Yorkston, Bourgeois, & Baylor, 2010).

To identify and treat speech-timing disorders, speech rate and articulation rate data are highly valuable (Hall, Amir, & Yairi, 1999). These two components are both important in speech rehabilitation. For example, a common therapy technique is to decrease speaking rate in clients with hypokinetic dysarthria, where a rapid speaking rate is prominent and there is a loss of control of the articulatory movements (Hammen & Yorkston, 1996); or in the treatment of stuttering, where a slower speaking rate allows the stutterer to have more control over their speech systems and coordinate speech sound transitions. An important goal for individuals with speech timing disorders is to reach a normal speaking rate (Robb et al., 2004). Without a clear understanding, clinically, of the bounds of normal variation, goal setting and treatment planning are difficult. Hence, studies that delineate the bounds of normal variation in speaking rate are needed.

However, obtaining normative data is difficult as speaking rate varies by language (e.g. Brazilian Portuguese and Spanish individuals have a faster articulation rate than Dutch or Norwegian speakers) and dialect (e.g. Dutch speakers in the Netherlands speak 16% faster than Dutch speakers in Belgium (Verhoeven et al., 2004)). The same is true for dialects of English. For example, British English (BE) varieties are spoken at a faster rate than Australian English (AuE) (Tauroza & Allison, 1990; Block & Killen, 1996), in both read and spontaneous speech, and AuE is thought to be spoken at a slower rate than American English (AE) (Robb et al., 2004). As speaking rates differ across the different varieties of English, it is necessary to obtain normative speech rate data from the different varieties in order for clinicians to set appropriate goals for their clients.

New Zealand English (NZE) is the newest native-speaker variety of English in the world today. It started to develop when English speakers began to migrate from

Britain in 1840 (Trudgill, Gordon, Lewis, & Maclagan, 2000). Robb et al. (2004) is the only study – to the author’s knowledge – that has obtained speech rate data specific to NZE. Their study measured the speech and articulation rates of AE and NZE speakers in read speech in order to provide normative rate data and determine if AE speech rate differed from NZE speech rate. They found that American and New Zealand young to middle aged adults speak at different rates, with NZE speakers speaking significantly faster (speech rate: 280 SPM) than AE speakers (speech rate: 250 SPM). They concluded that an important clinical variable when setting goals and treating individuals with speech timing disorders should be the variety of English spoken by that client. Their study was restricted by only including adults aged 18-46 years, therefore the speaking rate norms of older NZE adults is still unknown. Collection of speaking and articulation rate data for elderly NZE speakers could not only provide useful data for clinicians in the assessment and treatment of NZE clients in this age category, but also help to describe the prosodic characteristics of the language (Robb et al., 2004).

This thesis seeks to provide normative data regarding the speech and articulation rate of elderly NZE speaking adults and to examine how age, sex, years of education, and lexical frequency affect speech and articulation rate within this group..

1.1.1) *Speech rate*

Speech rate is calculated by dividing the total number of output units that are being measured (e.g. syllables, words, phonemes, or morae) in a speech sample by the total time the speaker takes to complete the speech sample (Duchin & Mysak, 1987; Martins & Andrade, 2008). However, it is important to note that there are two factors that are used to describe differences in speech rate, these being: “(a) the speed of articulatory gestures throughout an utterance and (b) pause frequency (the number of pauses) and pause intervals that typically separate uninterrupted articulatory sequences” (Tsao et al.,

2006, p.1156). As well as pause intervals, other studies further clarify that the measurement of speech rate also includes other speaker characteristics that interrupt the fluency of a speaker and define their specific communication style, such as the use of fillers (for example, “um”, “I mean” and “you know”) and the use of laughter (Verhoeven et al., 2004; Jacewicz et al., 2009).

A number of different factors influence overall speech rate. For example, the frequency and duration of pauses and hesitations in an individual’s speech stream is one such influence, as fast speech typically has shorter and fewer pauses than slower speech (Koreman, 2006). The amount of stress placed on words by a speaker is another influencing factor, as the more stress used in speech correlates to a slower speech rate (Howell & Kadi-Hanifi, 1991). Consonant and vowel length are yet another influence of overall speech rate. Benjamin (1982) found that older adults (aged 68 to 82 years), who have commonly been shown to have slower speech rates than younger adults (e.g. Smith, et al., 1987), had significantly longer vowel and consonant durations than the younger adults (aged 21 to 32 years). Similarly, Robb et al. (2004) suggested that one of the reasons NZE has faster speech and articulation rates than AE is because vowel raising occurs in NZE, which may be a contributing factor to shorter vowel durations (Watson, MacLagan, & Harrington, 2000). In their study, Horton, Spieler, & Shriberg (2010), found that slower speech rates were also associated with a greater rate of fillers. They follow Clark & Fox Tree’s (2002) suggestion that the added delay presented by the fillers could be part of the reason for the slower speech rates. However, as Shriberg (2001) found, even when fillers are not included in the calculation of speech rate, generally slower speech rates are still often found.

Another consideration is that although each individual has a regular speaking rate that is comfortable for him or her, they are also able to alter their speech rate by speaking faster or slower in different situations. Mefferd & Corder (2014) explain that there are a

variety of movement strategies that speakers employ in order to achieve faster speech, “some speakers reduce their articulatory displacement while holding speed constant or they reduce speed along with displacement... Others increase speed while maintaining movement displacement... or increase speed while reducing displacement” (p. 348). Following this, Nishio & Niimi (2006) state that even if an individual produces inaccurate articulatory movements during the speech sample, speech rate will still be maintained.

It is generally agreed that due to the large amount of variability associated with the pause intervals, fillers, etc. of a speaker, speech rate merely provides an overall estimate of verbal output, and this is likely to vary greatly depending on a variety of both within and between speaker factors, such as the emotional state of the speaker, the type of speaking context, and the age and sex of the speaker (Robb et al., 2004; Quené, 2008).

The factors that influence speech rate make it impossible to give one standard norm for the whole population, although some studies attempt to do this, without specifying to which population they are referring, or including a generous range so more individuals will be included. For example, Andrews & Ingham (1971) state that the habitual speaking rate of an individual should be approximately 140 WPM, plus or minus 24. This differs slightly from Guitar’s (as cited in Searl, Gabel, & Fulks, 2002) suggestion that younger adults have a speech rate of approximately 167 WPM. As previously mentioned, using WPM as a measure for speaking rate is much less precise than measures such as SPM, which is one of the many factors that could have influenced the differences between these two studies. Hewlett & Beck (2006) suggested that research literature indicates a normal speech rate of around 3 to 5.5 SPS, although again it is unknown to which population they are referring, or if they include the norms of all ages, gender, race, sociological background, etc. in their statement. Studies such as these make

it clear that due to the wide variety of influencing factors on speech rate it is difficult for clinicians to find normative speech rate data that pertains to each individual client.

1.1.2) *Articulation rate*

Articulation rate, or “absolute speech rate”, is the speed at which segments of speech are produced, irrespective of pauses (Goldman-Eisler, 1961). However, whether disfluencies (such as fillers and emotional expressions) should be included or excluded is less clear (e.g. Koreman, 2006; Nishio & Niimi, 2006; and Verhoeven et al., 2004 do not discuss this issue). This has led to a variety of definitions and makes it difficult to make comparisons between studies. Tsao et al. (2006) measured articulation rate for individual runs through a passage, which they described as “a stretch of speech between two pauses” (p. 1158). However they did not state whether they included disfluencies in their calculation. Jacewicz et al. (2009) specified that speaker-specific characteristics (e.g. pauses, hesitations and emotional expressions) were excluded from their calculation of articulation rate. However, they failed to specify whether *all* disfluencies (e.g. repetitions, prolongations, or revisions) should be excluded. Finally, in their paper, Chon, Kraft, Zhang, Loucks & Ambrose (2013) defined articulation rate as “the number of perceptually fluent content syllables divided by the duration of fluent speech in seconds for each utterance based on the acoustic record” (p. 429). The current study will utilize this definition, in that, when measuring articulation rate, all disfluencies will be subtracted from the total duration of the speech sample.

Like speech rate, there are many factors that affect articulation rate. Tsao & Weismer (2006) investigated the differences in articulation rate between slow and fast speakers of the same language. In their study they found that when slow talkers speak at their fastest possible rate, their articulation rates are similar to fast talkers habitual rates. They also found that the habitual articulation rate of a speaker is a predictor of their

fastest possible articulation rate. They argue that there are neuromuscular limitations within each individual that contribute towards their habitual articulation rate. Studies have also shown that the rate of articulation changes with practice; therefore an increase in articulation rate indicates an increased use of practiced, well learned and prepared speech, such as clichés, professional jargon and vernacular speech (Goldman-Eisler, 1961). Phrase length is also a consideration in the measurement of articulation rate. Shorter phrases have fewer syllables than longer phrases and thus they tend to be spoken slower, which in turn lengthens syllable durations and produces a slower articulation rate (Jacewicz et al., 2009).

Syllable structure varies slightly across languages. This makes it difficult to compare studies that examine the articulation rates of speakers of different languages (Hewlett & Rendall, 1998). Studies have shown that the average articulation rates of some languages such as French (ranging between 4.31 SPS – 5.73 SPS) and Dutch (5.2 SPS) still lie in the range of most English accents (Verhoeven et al., 2004); however Spanish and Brazilian Portuguese have much faster articulation rates (7.81 SPS and 6.57 SPS respectively) (Rebollo Couto, cited in Verhoeven et al., 2004). Despite the wide variety of factors that influence articulation rate, most studies agree that average English articulation rates tend to fall between 4.4 and 5.9 SPS in conversational speech (Goldman-Eisler, 1961). For example, average English articulation rates that have been suggested are 5.3 SPS (Laver, 1994), 5.5 SPS for Scottish English speakers (Hewlett & Rendall, 1998), and 316 SPM (5.2 SPS) for AE speakers and 342 SPM (5.7 SPS) for NZE speakers (Robb et al., 2004). This is quite a wide range, and like speech rate, due to the influencing factors on articulation rate, clinicians would benefit from having normative articulation rate data that can be applied to each individual client.

As mentioned above, there is no universal agreement about the definition of articulation rate, however most studies agree that hesitations and pauses are excluded in

the calculation. One problem with this is that there is also no set agreement on the period of time that represents a pause, so the following section has been included to discuss this in more detail and offer a working definition.

1.1.3) *Silent periods (pauses)*

Measuring pauses is essential in the calculation of speech and articulation rates, however there is some controversy in the literature about the length of time that constitutes a pause. Hieke, Kowal & O'Connell (1983) argued that the cut-off point for silent pauses is important when measuring articulation rate as the higher the cut-off point for pause time, the slower the articulation rate, as this is determined by the speed of syllable production, excluding pause time. Furthermore, a higher cut-off point results in longer mean phrase and pause length as there will be less and longer pauses recorded. Cut-off times range from anything above 250ms (e.g. Chon et al., 2013) and 200ms (e.g. Nishio & Niimi, 2006), to 100ms (e.g. Howell & Kadi-Hanifi, 1991) and 50ms (e.g. Robb et al., 2004). Hieke et al. (1983) maintain that due to the differences in criteria that have been employed in pause analysis, it is difficult to interpret and compare data in this field.

Although there is a wide range of cut-off pause times that have been proposed, the literature generally accepts that there are two categories of silent pauses, these being articulatory pauses and hesitation pauses (Rochester, 1973). Hesitation pauses are most often agreed to be a silent interval that lasts between 250ms and 3000ms, and are typically associated with cognitive decision-making of some type during language production (Rochester, 1973). Articulatory pauses, on the other hand, are any silent intervals less than 250ms and are “associated with peripheral events occurring in the vocal tract during speech production. These pauses can be caused by respiratory, phonatory, or articulatory processes” (Deputy, Nakasone, & Tosi, 1982, pg.44). Therefore, as both pauses and articulatory processes such as stop closures have quiescent

waveforms, when deleting silent intervals less than 250ms it is likely that some articulatory events will also be removed (Hewlett & Beck, 2006).

It has been suggested that not all silent intervals less than 250ms are a direct result of articulatory movement (Deputy et al., 1982), and instead they are a combination of hesitation pauses and articulatory pauses (Robb et al., 2004). Therefore, Robb et al. (2004) propose that silent intervals above 250ms signify solely hesitancy pauses, between 50ms and 250ms signify both hesitancy and articulatory pauses, and below 50ms signify solely articulatory processes. Although there is a lot of discrepancy about pause time cut-offs, this study will use Robb et al.'s (2004) definition, where any silent period 50ms or above is defined as a pause, in order to obtain a better comparison of NZE data.

1.2) Factors influencing Speech and Articulation rates

Speech and articulation rates are influenced by both social (e.g. Jacewicz et al. 2009) and within speaker variation (e.g. Tsao et al. 2006). As Jacewicz et al. (2009) explained, within speaker variation includes factors such as formality, communication style in various contexts (such as over a long distance or in a noisy environment), length of utterance, mood, etc., while social variation factors include age, sex, education, socioeconomic status, occupation, place or residence and geographic region of origin. Although there are many possible influencing factors, this study looks at a select few of these, namely context, speaker age, sex, linguistic complexity, and years of education. The first four of these factors were chosen as a focus in this paper as previous studies have demonstrated that they have an effect on speech and articulation rates in other dialects, however, it is unknown to what extent they influence older NZE speakers. There are few, if any, studies that have investigated the effect years of education has on speech and articulation rates, though it has been speculated that it may be a source of variation (Jacewicz et al. 2009).

1.2.1) *Context – Read vs. Conversational Speech*

Differing speech context (for example, read versus conversational speech) have been shown to influence speaking rates—though data are equivocal regarding the extent of the influence. Duchin & Mysak (1987) noted that oral reading, picture description and conversational speech represent different levels of language demand, which therefore suggests that the levels of stress on fluency will vary depending on the context. Seventy-five white male individuals aged between 21 and 91 years of age, with varied socioeconomic levels and occupations and from Philadelphia, United States, participated in the study. It found that, irrespective of age, speech rate between contexts differed significantly, with oral reading fastest at 4.02 SPS (188.8 WPM), conversation second at 3.44 SPS (158.7 WPM) and picture description slowest at 3.02 SPS (135.1 WPM). Although this study suggests there is a difference between contexts, due to the limited selection criteria of participants, results cannot be reliably generalized to other populations. Robb et al. (2004) also discussed a variety of older studies that investigated speech and articulation rates in AE speakers and state that the combined results of these studies indicate a lower approximate speech rate of 220 SPM for conversational speech tasks and higher speech rate of 260 SPM for reading tasks (see: Chermak & Schneiderman, 1986; Crystal & House, 1990; Kent & Forner, 1980; Kowal, O’Connel, & Sabin, 1975; Sharf & Lehman, 1984; Tsao & Weismer, 1997; Walker, 1988). Howell & Kadi-Hanifi (1991) found that read speech has fewer pauses, which contributes to a faster speech rate. However their study was small (two groups of three speakers) and only included academics and medical physicists, which again does not allow for further generalization.

In contrast, studies have also noted a lack of difference in rate in read versus conversational speech. For example, Tauroza & Allison (1990) measured speech rate in conversational speech and reading tasks and found that when the data were collapsed

across gender, results indicated a speech rate of 250 SPM for reading and 263 SPM for conversational speech, with no significant difference between these contexts. Similarly, Block & Killen (1996) measured speech rate in reading via the Rainbow Passage and in spontaneous speech for 60 AuE adults aged between 21 and 30 years. They found that the average reading rate was 230 SPM, while spontaneous speech rate was slightly, but insignificantly higher at 237 SPM. Robb et al. (2004) also used the Rainbow Passage to measure speech rate with their sample of 40 NZE speakers aged 18 to 24 years and reported an average read speech rate of 280 SPM, which is a lot faster than Block and Killen's (1996) finding of 230 SPM. However, it remains unclear how context influences speech rate, as none of the studies that have examined this have both controlled for other possible influences and included enough participants so results can be generalized.

Articulation rate across contexts has received less attention. The approximate articulation rate for oral reading in studies by Crystal & House (1990) and Tsao & Weismer (1997) was 300 SPM, although there was no comparison with conversational speech. Jacewicz et al. (2009) measured articulation rate for read sentences and conversational speech in 94 adults from Wisconsin and North Carolina in the United States. Results showed that the overall articulation rate for read sentences was 3.40 SPS, as opposed to conversational speech, which was 5.12 SPS (51% faster). Interestingly these findings oppose the findings of studies measuring speech rate, that is, when measuring speech rate read speech is faster than conversational speech, but when measuring articulation rate, conversational speech is faster. One plausible reason for this is due to the difference in the methods of the studies. In their study, in order to better control fluency and stress placement, Jacewicz et al. (2009) used read sentences as opposed to a longer passage of read discourse (i.e. the samples used in studies of speech rate). As this would affect within-speaker variability (e.g. reading style and tempo) it is not surprising that findings are contradicting. However articulation rate and speech rate

are different measurements (the former concerning the speed of movement of articulators and the latter looking at the overall speed of speech), therefore it is also likely that there will be variation among them in different contexts, as different contexts have more, or less, disfluencies and pause time. Hewlett & Rendall (1998) state that a faster articulation rate in conversation than in reading can be expected, as conversational speech is likely to have a greater amount of time spent in pausing. Due to the discrepancies in the literature further research would be highly beneficial in order to further understand what typical speech and articulation rates New Zealand speakers have in read speech versus conversational speech.

1.2.2) *Speaker age*

Speaker age is perhaps the most documented influence on speech and articulation rates, with literature agreeing that speech rate declines with age (e.g. Searl et al., 2002; Yuan, Liberman & Cieri, 2006; Martins & Andrade, 2008). Horton et al. (2010) state that older adults speak more slowly and are less fluent than younger adults during single word production, as well as during the production of open-ended tasks (Bortfeld et al., 2001) and isolated sentences (Spieler & Griffin, 2006). Guitar (1998) suggested that a normal speaking rate for younger adults was approximately 167 WPM, however Horton et al. (2010) found that 20-year-old speakers in their study had an average speech rate of 194 WPM, while 60-year-old speakers spoke at a rate of 169 WPM; and Searl et al. (2002) found speech rates of adults over 100 years of age ranged from 101-135 WPM. Guitar's (2008) suggestion appears out of line with the other studies, however as previously mentioned, the use of WPM makes comparison difficult.

Literature examining the effects of age on speaking rates covers a range of areas. As well as finding speech rate to decline with age, Ramig (1983) found age-related differences to be more prominent in subjects with a poor physiological condition. This

finding was supported by Duchin & Mysak (1987) who concluded that clinicians should expect clients with a good physical health rating to have faster speech rates than those with poor health. In another study, Ryan (1972) found that old-aged adult males (70-79 years) spoke significantly slower than middle-aged male participants (40-49 years) in read speech, and there was a general, albeit non-significant, decline in conversational speech with age. Similarly, Smith et al. (1987) found that elderly participants (66-75 years) sentence duration was 22% longer than that of young adult participants (24-27 years) in a normal speaking rate condition, and 26% longer in a fast speaking rate condition. This finding differs from a more recent study by Verhoeven et al. (2004), which found that in spontaneous speech, younger speakers (<40 years) speak only 5% faster than older speakers (>45 years) (that is articulation rate: 4.52 SPS vs. 4.78 SPS, and speech rate: 4.01 SPS vs. 4.23 SPS); and yet another study by Jacewicz et al. (2009) found that older adults (51-65 years) articulation rate in reading sentences was 11% slower than that of young adults (20-34 years). However, when comparing subjects from Wisconsin and North Carolina, only subjects from Wisconsin demonstrated a significant age effect for conversational speech, in that older Wisconsin adults had an articulation rate 6% slower than that of young Wisconsin adults. This highlights the importance of having normative data available that is specific to individual clients, and although these studies all agree that speech and articulation rates decrease with age, they also reinforce that age is not the only influence, and clinicians must be aware of this when treating clients.

Various researchers have offered suggestions as to why there is a correlation between age and speech rate. For example, Ramig (1983) suggests factors such as general neuromuscular slowing, processing time, peripheral degeneration of the speech mechanism, psychosocial variables, and visual acuity. Verhoeven et al. (2004) state that the elderly speak more slowly than younger speakers, as there is a neurological effect of aging. That is, with age, the neurological control over speech production may need more

time to be executed and will become more difficult. Also, Mefferd & Corder (2014) measured lip and jaw speeds in young (22-27 years), middle-aged (45-55 years), and older (65-74 years) adults. They found that “older adults may have more difficulty with stiffness regulation and adequate force production when producing fast syllable repetition rates. Thus, slowed speech may be primarily a compensatory movement strategy to maintain speech accuracy in the presence of diminished articulatory control” (pg.358).

To date, there has been limited study of speech and articulation rate in ageing speakers of NZE adult population. However, Fletcher, McAuliffe, Lansford & Liss’s (2015) study of 149 participants found that between the ages of 65 and 90 there are significant increases in average vowel duration of NZE speakers. Participants with longer average vowel durations had a slower speech rate and typically produced more acoustically distinct vowels. Their paper provides some evidence that slower speech rate may be a behavioral strategy older speakers implement so they are able to maintain articulatory precision. In any case, these studies reinforce that there are various possible explanations as to why speech rate declines with age.

1.2.3) *Sex*

Currently there is no clear consensus on differences in speech and articulation rates across sex. In general, males are reported to speak faster than females (Jacewicz et al., 2009; Lutz & Mallard, 1986; Verhoeven et al., 2004; Whiteside, 1996); however, the opposite has also been reported (Ryan, 1992), and there are also reports of no difference between the sexes (Robb et al., 2004; Block & Killen, 1996).

To the author’s knowledge, there are very few studies that have found females to speak faster than males. One study by Ryan (1992) examined the speech rates of stuttering and non-stuttering preschool children. He found that non-stuttering preschool

females spoke at an average rate of 176 SPM, while males spoke at 164 SPM. This effect size was small, and because of this, it is not unexpected for other studies to find no significant difference in speaking rates across sex. For example, Robb et al.'s (2004) study found an average NZE male read speech rate of 277 SPM, vs. female 284 SPM, while male articulation rate was 346 SPM, vs. female 341 SPM. There were no significant differences for sex in either read speech or articulation rates in their study.

Studies that did show a significant difference of men speaking faster than women also generally agreed that the effect size was small, which indicates that although gender may influence speech and articulation rates, this influence is not major (Jacewicz et al., 2009). For example, Whiteside (1996) examined the articulation rates of three men and three women BE speakers in read speech. She reported significantly faster articulation rates for men (4.10 SPS versus 3.38 SPS), and noted that women also paused more frequently and had longer mean sentence durations than men did. This finding is consistent with research by Verhoeven et al. (2004), who examined the spontaneous speech of 160 male and female Dutch speakers and reported that men speak on average 6% faster than women (Speech rate: men= 4.23 SPS versus women= 4.01 SPS; and articulation rate: men= 4.79 SPS versus women= 4.50 SPS). Chon et al. (2013) also found similar results, and Yuan et al.'s (2006) study of English and Chinese speakers reported a small (2%), but significant difference of a faster male conversational articulation rate, while Jacewicz et al. (2009) noted that articulation rate was 4.5% faster for men than for women. These reports all differ slightly about how much faster male articulation rate is than female, although it tends to be low – between 2% and 6%. There are a number of reasons that could account for these differences, namely the differences in the studies, as they did not all examine similar variables (such as context (reading versus conversation), the age of participants and the geographical location and language spoken).

One study by Byrd (1994) examined the speech rate of 630 male and female speakers in the TIMIT corpus (a corpus which is comprised of read sentences). She found that women had an average speech rate of 4.42 SPS, while the average rate for men was 4.69 SPS, which is in line with most other studies. In her article she discusses possible reasons for this sex difference. For example, she highlights a study by Ryalis et al. (1994) that found that, in statements, men had a shorter mean final syllable duration (264ms) than women (288ms), which could account for a faster male speech rate as the shorter the amount of time it takes to produce a syllable, the more syllables will be able to fit into a second. Men also appear to reduce endings of words, for example, studies show that females have more ‘-ing’ endings than ‘-in’ endings than males (for example see Smith, 1979, as cited in Byrd, 1994). Finally, Byrd notes that, in general, females tend to use less reduced forms than males; that is, their speech tends to be “slower” and “more careful”. Overall, the majority of studies that examine the influence of sex on speaking rates agree that males speak faster than females. However, further research is necessary in order to understand whether different populations of speakers demonstrate similar effects.

1.2.4) *Linguistic Complexity*

Every language contains certain words that are more and less frequent than others. Studies have shown that a word’s frequency influences the speed at which it is accessed (e.g. Newman & Bernstein Ratner, 2007). Oldfield & Wingfield (1965) first discovered the word frequency effect in speech production. In their study of 12 adult subjects (aged 20-42 years), they found that pictures with high-frequency names (such as *shoe*) took a significantly shorter amount of time to produce than pictures with low-frequency names (such as *gyroscope*). Lexical frequency effects have often been examined by using single word naming tasks of high- and low-frequency words (Feyereisen, Demaeght, & Samson,

1998), however less research has been conducted that investigates the lexical frequency effects on conversational speech rate. Horton et al. (2010) found that in conversational speech, a slower speech rate and high levels of disfluency were related to the use of lower frequency words; or, in other words, the more unique words used in conversational speech, the slower the speech rate. Similarly, Spieler & Balota (2000) examined the read speech of old and young adults and found that less frequent words are read slower and less accurately than more frequent words. Studies of normal disfluencies and of people who stutter are useful in the research of speech rate as the more disfluencies that occur in a speech segment, the slower the speech rate will be. One such study by Quarrington, Conway, & Siegel (1962) found that when frequency had been controlled for, in conversational speech nouns tended to be less stuttered than other content words.

It should be cautioned again that other factors must also be taken into account when measuring the effects of lexical factors on speech rate. Newman & German (2005) suggested that factors such as impairment and age are likely to be two such influences, as they found that older adults show a greater difference than younger adults when accurately naming high- and low-familiarity words, even though both groups of participants were more accurate at naming the high-familiarity words. Another study by Kavé, Samuel-Enoch, & Adiv (2009) examined whether the lexical frequency of the nouns that are selected for production are influenced by the word retrieval difficulties that are often associated with aging (e.g. Burke & Shafto, 2004). Their study included 136 Hebrew speakers between 20 and 85 years of age who completed a picture-naming task, a semantic fluency task, and a picture description task. In the picture description task, the verbs participants spontaneously produced had a higher frequency than the nouns produced, thus they chose to focus solely on the production of nouns. They found that when describing a picture, older participants used more infrequent words than younger participants, and they ruled out the possible explanation that older adults use more

infrequent nouns than younger adults because infrequent nouns are more common in the lexicon of the older adults. They suggest instead that older adults have a larger vocabulary than younger adults, meaning they have a greater selection of words they can produce, and are thus able to access low-frequency words easier. This finding is similar to reports by Horton et al (2010), Uttl (2002) and Verhaeghen (2003) who also state that with age, vocabulary knowledge is either maintained or increases. Although speech rate was not measured in Kavé et al.'s (2009) study, it would be reasonable to hypothesize that there is a relationship between the typically found slower speech rate in older speakers and their use of more infrequent words.

Jescheniak & Levelt (1994) used the Celex database (a lexical database created for English, German and Dutch languages) in seven different experiments that investigated the effects of word frequency in speech production. They state that low-frequency words are words that occur less than twelve times in one million in the Celex database, while words that are produced more than 60 in one million times are considered high frequency. Lexical frequency is not the only influencing linguistic factor on speech rate; grammatical complexity and topics of conversation have also been shown to cause some effect. For example, Yuan et al. (2006) found that unpredictable or important sections of speech are spoken at a slower rate, and some topics of conversation had a slower speech rate and longer speaker turns than others. Another study by Horton et al. (2010), who also used the Celex database, used clause density and utterance length as their measures, and examined age-related changes in grammatical complexity. They found that not only was speaker age associated with slower speech, but also with greater lexical diversity and longer utterances. They concluded that a decreased speech rate and more disfluencies seem to be more acceptable to older adults than simplifying the lexical content used in their speech production.

Together, these studies provide some evidence that linguistic complexity does influence speech rate, particularly in older adults, in that more frequent words are produced at a faster rate than less frequent words. However, further research is required in this area.

1.2.5) *Years of Education*

There are no studies, known to the author, that have investigated the effect years of education has on speech and articulation rates. However, it would be reasonable to predict that individuals with a higher level of education may be predisposed to using more complex words in their conversational speech. Given the possible relationship with lexical frequency, it may therefore be expected that individuals with a higher level of education would have a slower speech rate than individuals with low education levels (Horton et al., 2010). It may also be the case that individuals with a higher level of education become more familiar with reading more complex words. The possible relationship to lexical frequency would suggest that in reading, speech rate might increase with the number of years of education (Spieler & Balota, 2000). Further research in this area would be beneficial to help understand these possible relationships.

1.3) Conclusion and Hypotheses

This review has focused on speech rate and articulation rate in ageing adults, and on some factors that may influence these. While some trends are evident, much of the data is conflicting. Furthermore, comparing across studies is difficult due to the wide variety of definitions and units of measurement employed. It is clear that speaking rate varies across language and dialect, and if clinicians are to set realistic goals for their clients, they require normative data specific to their clients native language. As there are such a wide variety of influences on speaking rate, studies that account for these are particularly

useful for clinicians when comparing their clients to the norms. However there are very few reports currently available that explore more than two influences, and none, to the author's knowledge, that discuss normative data for NZE adults over the age of 60 years. As well as the clinical benefits, an understanding of normative data from aging NZE adults would be useful in describing the prosodic characteristics of the language. This paper explores the speech and articulation rates of older NZE adults aged between 64 and 91 years of age and seeks to answer the questions:

- 1.) Do speech rate and articulation rate differ across different contexts (i.e. reading and conversation) in older speakers?
- 2.) Are age, sex, years of education, and lexical frequency predictive of an individual's speech or articulation rate?

It is hypothesized that speech rate will be faster during oral reading than in conversational speech, and articulation rate will show opposite effects, with conversational speech faster than oral reading. This is due to the fact that studies (for example, Howell & Kadi-Hanifi, 1991; Hewlett & Rendall, 1998) have suggested that the amount of time typically spent pausing in conversational speech (as opposed to read speech) slows speech rate. When these pauses (and disfluencies) are removed in order to calculate articulation rate, the movement of the articulators in conversational speech should be faster than in read speech (Jacewicz et al., 2009).

It is also hypothesized that a variety of factors will influence speech and articulation rates and specifically: (1) they will both decline with age (e.g. Searl et al., 2002; Yuan, Liberman & Cieri, 2006; Martins & Andrade, 2008); (2) men will speak faster than women (Jacewicz et al., 2009; Verhoeven et al., 2004; Whiteside, 1996); (3) as the number of years of education increase, speech and articulation rate also increase in read speech but

decrease in conversational speech (Spieler & Balota, 2000; Horton et al., 2010); and (4) adults who use more low-frequency words have a slower speech rate than those who use more high-frequency words (Horton et al., 2010).

2) METHODOLOGY

2.1) Participants

This study included a total of 112 New Zealand English (NZE) speakers aged between 64 and 91 years. 41 participants were aged 64-69 years, 40 participants were aged 70-74 years, 20 participants were aged 75-79 years, 8 participants were aged 80-84 years, 1 participant was aged 85-89 years, and 2 participants were aged 90-100 years. Of the 112 participants, 30 were male and 82 female, and years of education ranged from 7 to 21 years. All participants scored equal to or greater than 26 (i.e. within the normal range) on the Montreal Cognitive Assessment, and none reported a previous history of speech and language disorders or neurological impairment. Any participants who previously lived outside New Zealand past the age of 7 years were excluded from the study, due to possible dialectal differences. At the time of recording, no participants reported any cold, flu, or respiratory issues that may have affected their speech. See Appendix A for a detailed table of participant biographical information.

2.2) Recording procedure and stimulus materials

Each participant attended a single session. The data was collected as part of a larger investigation—with the speech-recording portion of the study lasting approximately 15 minutes. Recordings were conducted with participants seated at a table in a quiet room with a researcher present. Participants' speech was recorded using a Zoom H4n recorder that was placed on the table approximately 30 centimeters from each participant. Digital audio recordings of the speakers were made with 16 bits of quantization at 22.05 kHz.

Two types of recorded speech were acquired: conversational and read speech. Conversational speech consisted of each participant conversing with the researcher about a childhood memory.

For a sample of read speech, participants were given time to familiarize themselves with ‘The Grandfather Passage’ (see Appendix B), and then asked to read this aloud in their normal speaking voice (i.e. typical mode and tempo).

2.3) Data analysis

2.3.1) Extraction of data

Prior to data analysis, each interview was transcribed and the Hidden Markov Model Toolkit (HTK) (Young et al., 2002) was used to automatically segment the transcripts at phoneme level. Phoneme segments were marked in Praat (Boersma & Weenink, 2015) and this data was subsequently stored in the New Zealand Institute of Language, Brain and Behaviour’s Language and Ageing Speech Corpus using LaBB-CAT (Fromont & Hay, 2008).

A team of two researchers extracted participant text grids and audio recordings from LaBB-CAT and opened them individually using Praat (Boersma & Weenink, 2015). The researchers then checked the accuracy of all phoneme boundaries within the conversation and Grandfather Passage by using auditory cues and visual inspection of the waveform and wide-band spectrogram. Conversational speech samples consisted of the middle 150-words, not including any disfluencies. Therefore, if a participant spoke less than 150 fluent words in their conversation, they were excluded from the study. Disfluencies that were unable to be reliably automatically annotated (see Appendix C), were manually annotated by the two researchers using Praat. Other disfluencies, including pauses greater than or equal to 50ms (Robb et al., 2004), were then automatically annotated using LaBB-CAT.

2.3.2) *Speech rate*

The speech rates of each participant were measured in syllables per second (SPS) for both conversational and read speech. This was calculated by dividing the total number of syllables in each speech sample (i.e. conversation versus read speech) by the total time the speaker took to complete each sample (Duchin & Mysak, 1987; Martins & Andrade, 2008). Syllable onset was taken to be each point the acoustic energy of the participant was first detected (i.e. excluding any interviewer turns). Final syllable offset were the points where acoustic energy of the participant was no longer detected (Fletcher et al., 2015). Any disfluencies and other speaker characteristics (such as pausing, laughter, and tongue clicking) were also included in the total time for each sample (Verhoeven et al., 2004; Jacewicz et al., 2009).

2.3.3) *Articulation rate*

Articulation rate was also measured in SPS and was determined by dividing the number of fluent content syllables by the total duration of fluent speech in each sample (Chon et al., 2013). That is, any disfluencies, pauses equal to or greater than 50ms (Robb et al., 2004), and other speaker characteristics (e.g. laughing, coughing, tongue clicking), were subtracted from the total speech sample duration. As for the measurement of speech rate, syllable onset was taken to be the points at which acoustic energy of the participant was first detected, and syllable offset were the points at which acoustic energy was no longer detected (Fletcher et al., 2015).

2.3.4) *Lexical frequency*

Word-form *Cob* frequency values of individual words within the conversation speech samples were extracted from the CELEX database. This database contained approximately 17.9 million words in the early 1991 version (Baayen, Piepenbrock, &

Gulikers, 1996), and the *Cob* word-form value given for each individual word was the number of times that word occurred in the database (i.e. the raw count). The average frequency of all word tokens was then automatically calculated for each participant.

2.4) Reliability

To determine the inter-rater reliability of acoustic measurement, 20% of randomly selected text-grids were manually re-coded by both researchers. Analysis showed reliability to be high, at Kappa = 0.90.

2.5) Statistical analysis

Welch's t-test was used to compare differences in speech and articulation rate across contexts. Next, the strength of relationships between the variables of age, sex, years of education, and lexical frequency (lexical frequency in conversation only) and speech and articulation rate were examined with Pearson's correlation. Finally, backward stepwise multiple regression was used to determine whether, in combination, these four factors influence speech articulation rates in conversation and reading.

3) RESULTS

The current study was interested in whether there were differences in speech and articulation rates in conversational versus read speech. Figure 1 shows the overall mean speech and articulation rates of conversational speech and read speech of all 112 participants. The difference between speech rate in conversation ($M = 3.72\text{SPS}$) and speech rate in reading ($M = 3.58\text{SPS}$) was not significant ($t(202.66) = 1.7, p = .08$ ($p > .05$), indicating that there was no difference in speech rate across the two contexts. However, articulation rate in conversation ($M = 4.93\text{SPS}$) was significantly faster ($t(215.76) = 7.67, p = <.001$) than articulation rate in reading ($M = 4.38\text{SPS}$).

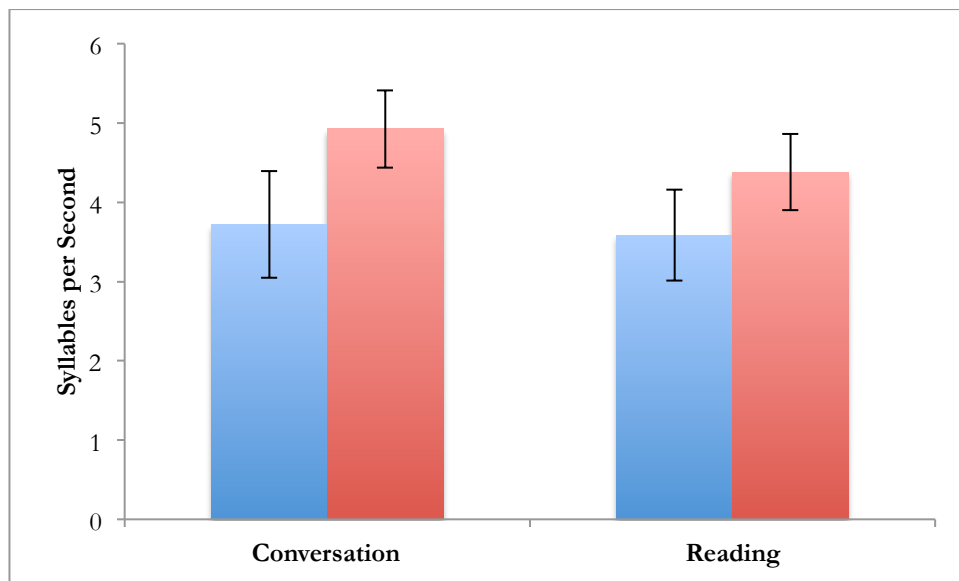


Figure 9. Mean speech rate (blue) and articulation rates (red) of conversational speech and read speech. Error bars represent standard errors to one standard deviation.

3.1) Factors Influencing Speech and Articulation Rate in Conversation

Of interest to the current study was whether the parameters of age, sex, years of education, and lexical frequency influenced speech and articulation rates in conversational speech. Figure 2 contains a diagrammatic representation of the

relationship between age and both speech and articulation rates in conversational speech. Although there appeared to be a slight negative correlation between the parameters for each variable, this association appeared to be minimal. Pearson's r correlation analysis confirmed this lack of association for both speech rate, $r(110) = -.12, p = .21$ ($p > .05$), and articulation rate, $r(110) = -.14, p = .13$ ($p > .05$), thereby suggesting that speech and articulation rates in conversational speech do not change significantly with age for adults aged between 64 and 91 years.

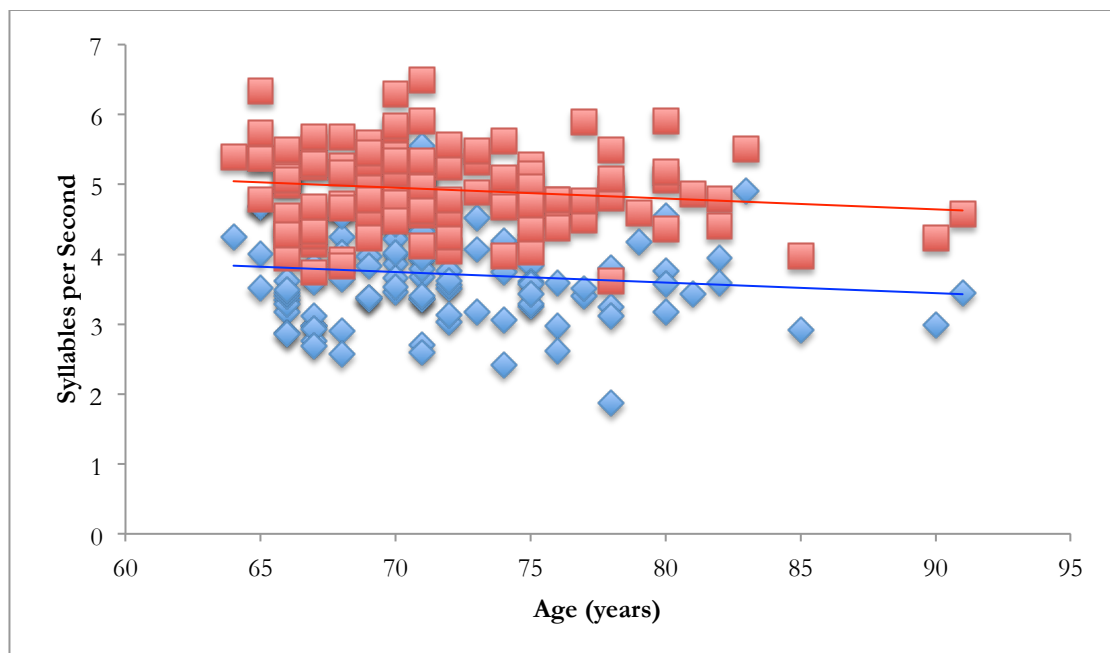


Figure 10. *The relationship between age and speech (blue) and articulation (red) rates in conversational speech. Regression lines are also depicted in red (articulation rate) and blue (speech rate).*

As Figure 3 shows, the differences in speech and articulation rates also did not appear to differ by sex in conversation. A Two Sample t -test found a trend towards female speech rate ($M = 3.79$) being slightly faster than male speech rate (3.54), however this difference was not significant, $t(62.98) = 1.92, p = .06$. There was also no significant difference between articulation rates for males ($M = 4.98$) and females ($M = 4.90$) in conversation,

$t(54.39) = -0.68, p = .50$ ($p > .05$). This lack of effect indicates that sex has a minimal effect on speech and articulation rates in conversational speech.

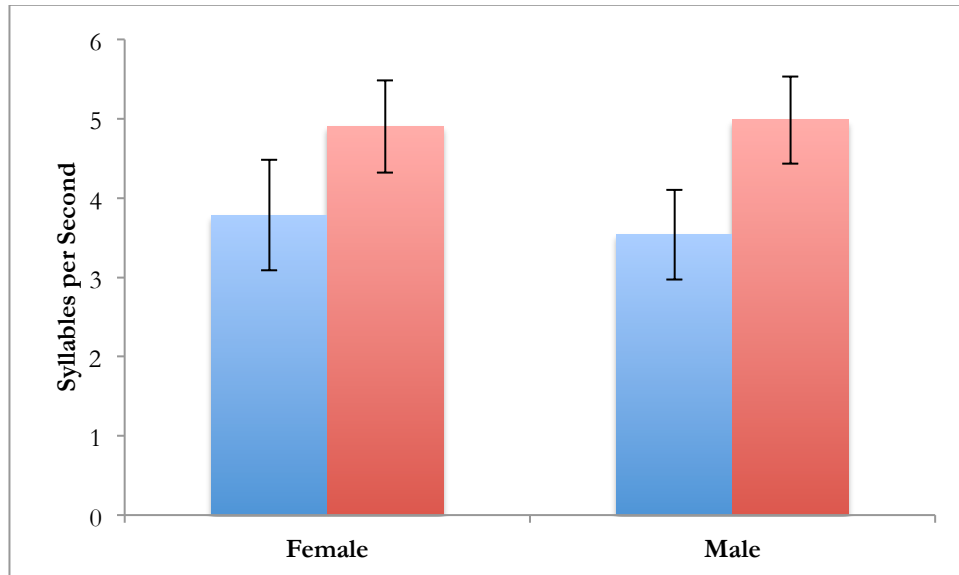


Figure 11. *The effects of sex on speech rate (blue) and articulation rate (red) in conversational speech. Error bars represent standard errors to one standard deviation.*

Figure 4 demonstrates the relationship between years of education and both speech and articulation rates in conversational speech. Again, there appeared to be minimal difference in rates across education levels, and Pearson's r correlation analysis confirmed this lack of association for both speech rate, $r(110) = .06, p = .55$ ($p > .05$), and articulation rate, $r(110) = .10, p = .29$ ($p > .05$), indicating that the number of years of education an individual completes had no significant effect on their speech or articulation rates in conversational speech.

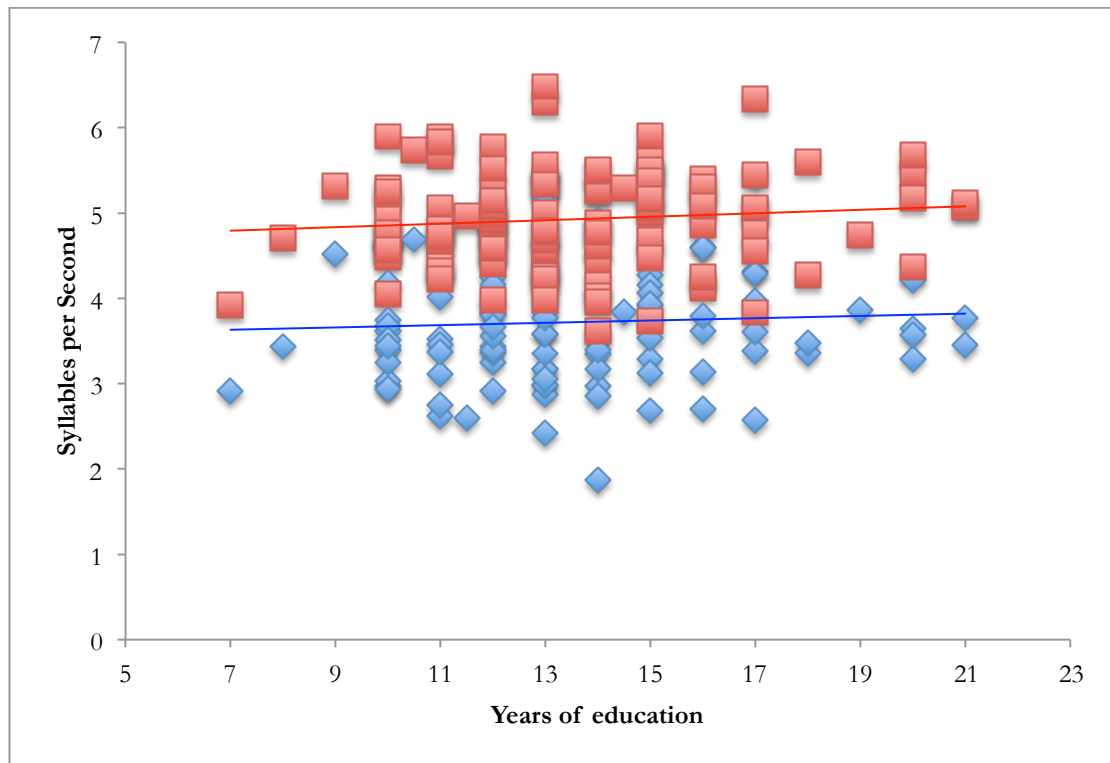


Figure 12. *The relationship between years of education and speech (blue) and articulation (red) rates in conversational speech. Regression lines are also depicted in red (articulation rate) and blue (speech rate).*

The relationship between the frequency of words used in conversation and speech and articulation rates is demonstrated in Figure 5. Once again there appeared to minimal association between the parameters for either variable, and Pearson's r correlation analysis confirmed this lack of association for both speech rate, $r(110) = .01, p = .91$ ($p > .05$), and articulation rate, $r(110) = .12, p = .23$ ($p > .05$). This indicates that using high frequency, or low frequency words in conversation has no significant impact on an individual's speech or articulation rates.

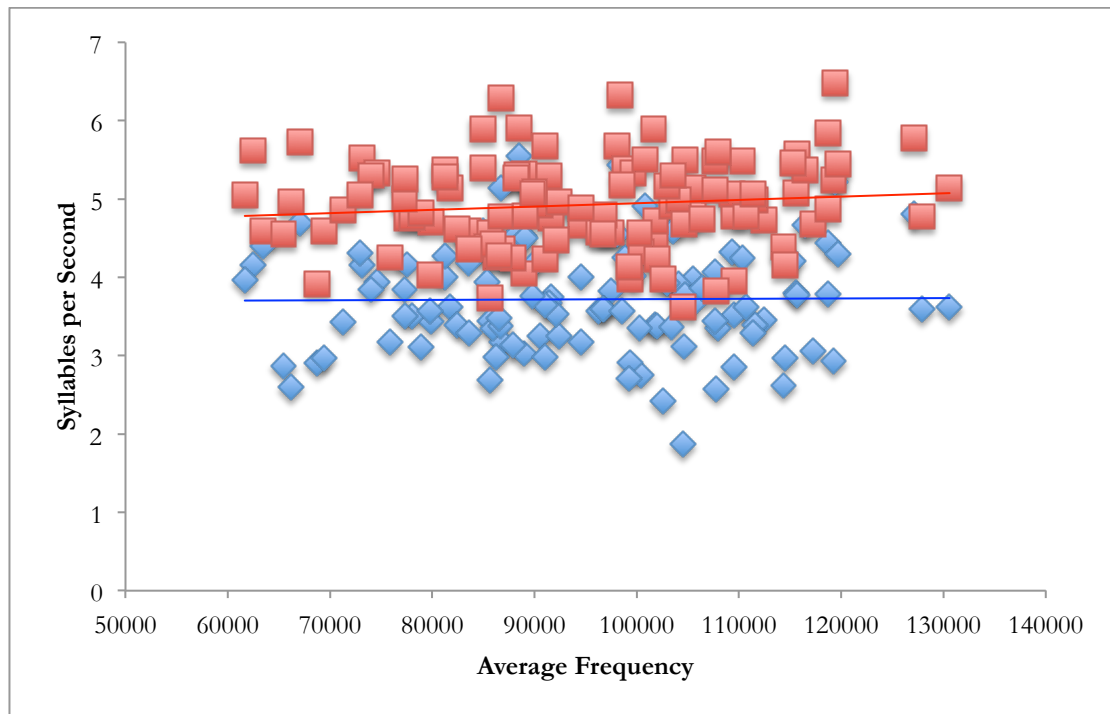


Figure 13. *The relationship between the average frequencies of words used in conversation and speech (blue) and articulation (red) rates. Regression lines are also depicted in red (articulation rate) and blue (speech rate).*

In order to determine whether these variables, in combination, exhibit any influence on speech and articulation rate in conversation, separate multiple regression analysis were run. For both models, the analysis began with a full model consisting of the fixed effects of age, sex, years of education, and lexical frequency. Model evaluation then proceeded by eliminating non-significant factors as warranted based on a p -value of .05. For speech rate, the final model revealed no significant influences on speech rate in conversation, however a trend towards differences in sex was observed, $F(1, 110) = 3.034, p = .084, R^2 = .018$. For articulation rate the analysis revealed that none of the observed fixed effects were a significant predictor of articulation rate.

3.2) Factors Influencing Speech and Articulation Rate in Reading

Also of interest to the current study was whether the parameters of age, sex, and years of education influenced speech and articulation rates in read speech. A diagrammatic representation of the relationship between age and speech and articulation rates in read speech is presented in Figure 6. Pearson's r correlation analysis showed a significant negative correlation for speech rate in reading, $r(110) = -.21, p = .028$ ($p < .05$), indicating that speech rate in reading was significantly slower with age. A trend for articulation rate in reading to decline with age was also observed, however this relationship was not significant, $r(110) = -.18, p = .055$ ($p > .05$).

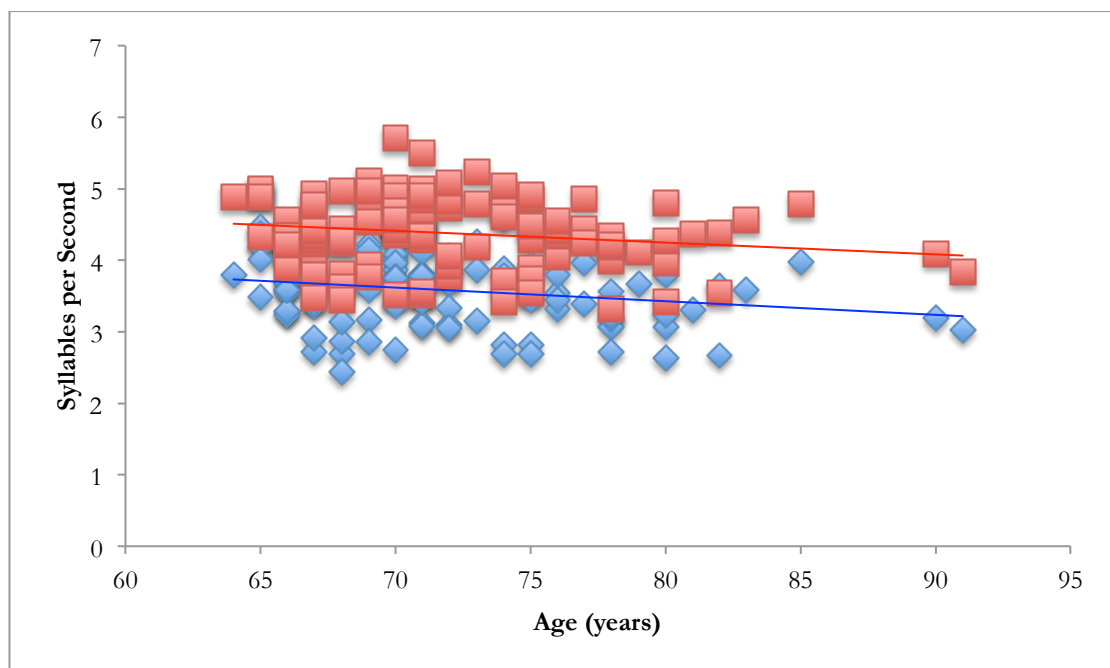


Figure 14. *The relationship between age and speech (blue) and articulation (red) rates in read speech. Regression lines are also depicted in red (articulation rate) and blue (speech rate).*

Figure 7 demonstrates the association between speech and articulation rates across sex in read speech. Two Sample t -tests found no significant difference between female speech rate ($M = 3.60$) and male speech rate ($M = 3.54$), in read speech $t(53.66) = 0.58, p = .56$ ($p > .05$), or female articulation rate ($M = 4.34$) and male articulation rate ($M = 4.50$) in

read speech, $t(48.37) = -1.50, p = .14 (p > .05)$, indicating that sex had very little effect on speech and articulation rates in oral reading for older adults.

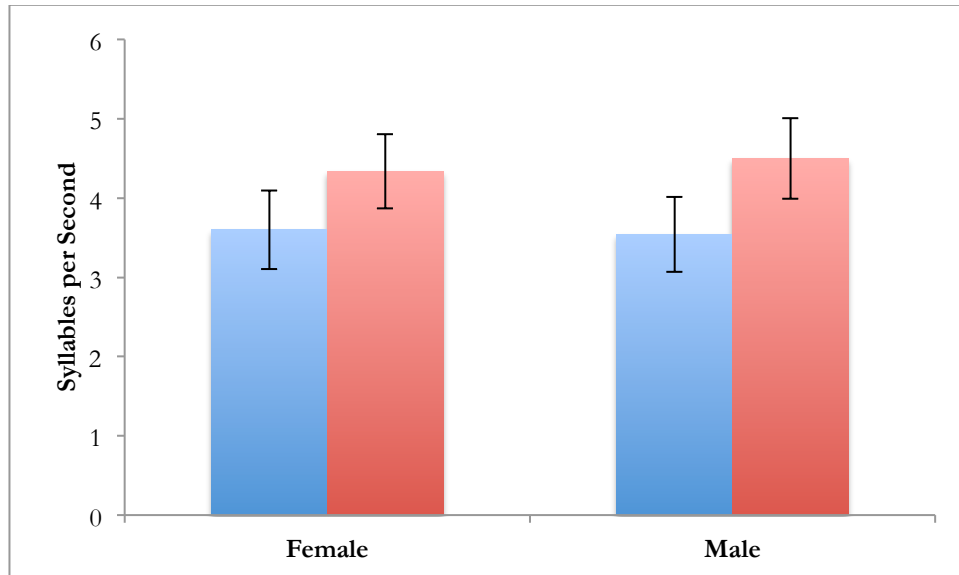


Figure 15. *The effects of sex on speech rate (blue) and articulation rate (red) in read speech. Error bars represent standard errors to one standard deviation.*

The relationship between years of education and speech and articulation rates in read speech is depicted in Figure 8. Pearson's r correlation analysis found no significant effect for the years of education on speech rate, $r(110) = .10, p = .30 (p > .05)$, or articulation rate $r(110) = .15, p = .11 (p > .05)$ in read speech, thereby suggesting that years of education does not significantly influence speech or articulation rates in oral reading.

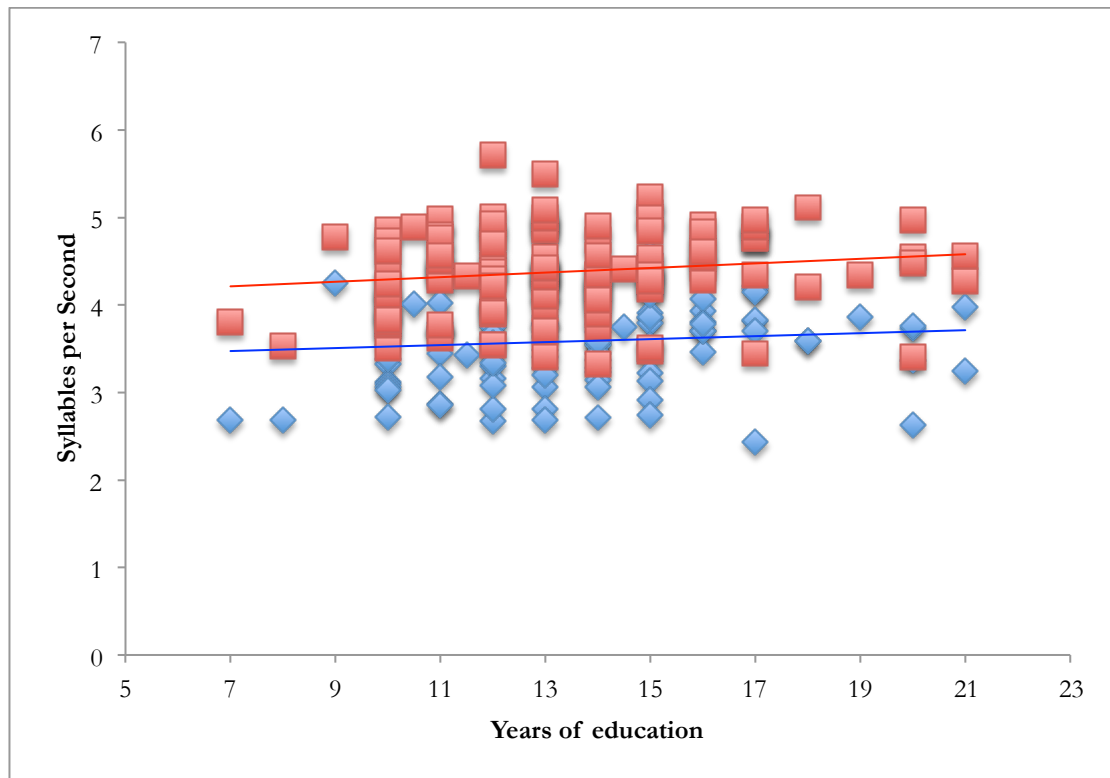


Figure 16. *The relationship between years of education and speech (blue) and articulation (red) rates in read speech. Regression lines are also depicted in red (articulation rate) and blue (speech rate).*

As for conversational speech, separate multiple regression analysis were conducted in order to determine whether age, sex, and years of education, in combination, have any influence on speech and articulation rate in read speech. Analysis was carried out in the same fashion as for conversational speech, where it began with a full model consisting of the fixed effects of age, sex, and years of education, and progressed by pruning non-significant factors based on a p -value of .05. For speech rate, the final model revealed a significant effect of age on speech rate in reading, $F(1, 110) = 4.983, p = .028, R^2 = .035$, indicating that age was a small, but significant, predictor of speech rate in reading ($Estimate = -.208, SE = .093$).

For articulation rate the final model is presented in Table 1. This model revealed that combined, age and sex account for a small but significant proportion of the variability in articulation rate in read speech, $F(2, 109) = 3.46, p = .035, R^2 = .042$. As Table 1

demonstrates, there is a trend for females to have a faster articulation rate than males, and this difference decreases with age.

Fixed effects	Estimate	SE	<i>t</i>	Pr (> <i>t</i>)
Intercept	-0.099	0.108	-0.911	.365
Age	-0.196	0.093	-2.107	.037
SexM	0.368	0.210	1.754	.082

Table 2. *Coefficients of a multiple regression model for articulation rate in read speech.*

4) DISCUSSION

This study gathered normative speech and articulation rate data from a group of 112 NZE speakers aged 64 to 91 years. The first aim was to examine whether there were any differences in speech and articulation rates across contexts (i.e. conversation and oral reading). Results showed no significant difference between speech rate in conversational and read speech, thus failing to support the hypothesis that speech rate in oral reading is faster than in conversation. However, as hypothesized there was a significant difference across contexts for articulation rate, with conversational speech spoken faster than read speech.

This study also investigated whether age, sex, years of education, and lexical frequency were associated with an individual's speech and articulation rate. For age, the results indicated speech and articulation rates in conversation did not differ significantly, however a trend towards read speech and articulation rates decreasing with age was observed. Sex was not a significant predictor of speech or articulation rate. However, contrary to expectations, there was a trend toward females speaking faster than males in some situations, suggesting that NZE may differ from other variations of English in this respect. Neither years of education nor lexical frequency showed any relationship with speech or articulation rates. In combination, the results showed a trend towards speech rate in conversation to differ across sex, and speech rate in reading to decline with age. They also revealed that combined, age and sex were small, but significant predictors of articulation rate in read speech.

4.1) Changes in Speech and Articulation Rates across Contexts

4.1.1) *Speech rate*

The current investigation found no significant difference between the average speech rate in conversation (3.72 SPS (223 SPM)) and in reading (3.58 SPS (215 SPM)). This was not entirely surprising based on the general finding of prior studies that found some read speech rates to be faster than conversational speech (Duchin & Mysak, 1987; Robb et al., 2004), and others to show no significant difference (Tauroza & Allison, 1990; Block & Killen, 1996). Interestingly, although the average conversational speech rate in this study was similar to other studies, the average speech rate in reading was considerably slower. Methodological differences may account for some of the differences, however it is also possible that older NZE adults have a slower speech rate in reading than other varieties of English. The results from this study also question Howell & Kadi-Hanifi's (1991) assertion that read speech has fewer pauses than conversational speech, thus contributing to a faster speech rate. This appears to be a logical statement, as in conversational speech it would be reasonable to assume that the speaker adds pauses and disfluencies to their speech as they have the higher order task of continuously generating the messages they want to convey before formulating and articulating them (Levelt, Roelofs & Meyer, 1999); while in read speech the message is already conveyed on paper, so the pauses and disfluencies that occur when the speaker is unsure of what to say/how to say it, should be reduced. However, there are a couple of plausible explanations why the results of some studies, including the present one, did not adhere to this theory. Firstly, the methodologies differed across these studies. Participant selection criteria varied greatly, for example, Duchin & Mysak's (1987) study included American males aged between 21 and 91 years, compared to the current study, which included New Zealand male and female participants aged between 64 and 91 years. Also reading and conversation tasks differed across studies, which would account for some differences in speech rates.

Secondly, none of these studies have been large enough to allow for further generalization of results, therefore definite conclusions are difficult.

4.1.2) *Articulation Rate*

As predicted, the average articulation rate of participants in conversational speech was faster (4.93 SPS (296 SPM)) than oral reading (4.38 SPS (263 SPM)). This finding is similar to Jacewicz et al. (2009) who reported average articulation rates in conversation as 5.12 SPS (307 SPM), and in reading as 3.40 SPS (204 SPM). Although these studies agree read speech has a slower articulation rate, there are notable differences within the same context across these studies, particularly in oral reading. A likely reason for this is because the stimuli used by Jacewicz et al. were read sentences as opposed to a passage, however other factors may also have affected results, such as participant country of birth and age. Due to these differences it is difficult to directly compare the studies for read speech. Studies by Crystal & House (1990) and Tsao & Weismer (1997) found an approximate articulation rate of 300 SPM in read speech, which differs greatly from the results of both Jacewicz et al. (2009) and the present study. This difference does not necessarily suggest that the articulation rate of American adults in read speech is a lot faster than older New Zealand adults as methodological differences again make comparisons difficult. It does suggest however, that there is a wide range of 'normal' articulation rates for oral reading, and stresses the importance of studies such as this, as data appears to vary greatly across populations.

For conversational speech, the results of this study show a slightly slower average articulation rate than that found by Jacewicz et al. (2009). Again, it is difficult to make direct comparisons between these studies. However, it does highlight the importance that clinicians need to be aware of these differences when planning treatment for their

clients as older NZE adults have differing articulation rates across context and using non-NZE studies as a comparison is likely to be inaccurate.

4.2) Effect of Age on Speech and Articulation Rates

The results of this study showed a general decline in conversational speech and articulation rates with age, however this was not significant. Comparing the present results with other studies it can be seen that although speech and articulation rates are generally understood to decline with age, it is not uncommon to find no significant differences in conversation. For example, Ryan (1972) found no significant difference in conversational speech rate across age, and Jacewicz et al. (2009) found no differences in articulation rate for speakers from North Carolina. Studies that have found a decrease in conversational speech and articulation rates with age often report a small difference. Verhoeven et al. (2004), for example, reported that older speakers (aged >45 years) spoke 5% slower than younger speakers (aged <40 years); while Jacewicz et al. (2009) found a 6% decrease in articulation rate for older Wisconsin speakers (aged 51-65 years) compared to younger Wisconsin speakers (aged 20-34 years).

In the current study, speech rate in reading did show a significant decrease with age, although this effect size was relatively small. This suggests that although read speech rate in NZE adults does decrease from 64 to 91 years of age, it does not decrease rapidly or by a large amount. Similar results have also been found in various other studies. For example, Ramig (1983) found older adults (65-75 years) to have a read speech rate of 3.92 SPS, vs. younger adults (25-35 years) 4.12 SPS; and Ryan (1972) concluded that the read speech rate of older adults (70-79 years) was significantly slower to that of middle-aged adults (40-49 years). A trend was also found in the current study for articulation rate in read speech to decrease with age, however this was not significant. It is difficult to compare this result to other studies, as there are very few that have investigated

articulation rates in read speech. In their study, Jacewicz et al. (2009) found the articulation rate of younger adults in read sentences to be 11% faster than that of older adults; however, as previously mentioned, speakers are likely to have differing articulation rates in read sentences as opposed to reading a passage. Another difference constraining comparisons between the current study and previous studies is that other studies typically organized participants into age groups and investigated the difference between older adults and young or middle-aged adults. This study, on the other hand, solely investigated the differences in older adults.

This study did not investigate possible causes for the similarities and differences found, however results from other studies offer a chance to speculate. Fletcher et al. (2015) found average vowel duration of vowels produced in the Grandfather Passage to increase with age, thus suggesting that slower speech rate is a behavioral strategy individuals use to maintain articulatory precision. The results of this study suggest that if this is the case, as they get older, aging NZE adults may be more careful to maintain articulatory precision in read speech than in conversational speech, as there was only a significant decline in speech rate in read speech. Another possible reason for the more significant difference in reading is that visual acuity, which is required for reading, declines with age (Ramig, 1983). Other studies have suggested that speaking rate declines with age due to factors such as neuromuscular slowing (Ramig, 1983; Mefferd & Corder, 2014), and a decrease in neurological control over the speech mechanism (Verhoeven et al., 2004). This study suggests that from the ages of 64-91 years, in healthy aging adults there is some, but very little degeneration of the speech mechanisms.

Although this study has provided evidence that age is a small predictor of speech and articulation rate in reading, the results suggest that there may be other influencing factors that have not been investigated.

4.3) Effect of Sex on Speech and Articulation Rates

Although this study found no significant differences between male and female speakers for speech or articulation rate in conversation or reading, there was a trend for female speech rate to be faster than male speech rate in conversation (female: 3.79 SPS (227 SPM); male (3.54 SPS (212 SPM))). Similar to the results of this study, there has been a variety of research that report no significant differences across sex. For example, Robb et al., 2004, investigated read speech and articulation rates of NZE speakers aged 18-24 years and found no significant difference between males (speech rate: 277 SPM; articulation rate: 346 SPM) and females (speech rate: 284 SPM; articulation rate: 341 SPM). These speaking rates are faster than those found in the current study (male speech rate: 3.54 SPS (212 SPM); male articulation rate: 4.50 SPS (270 SPM); female speech rate: 3.60 SPS (216 SPM); female articulation rate: 4.34 SPS (260 SPM)), which may be due to other influencing factors, such as the age of participants. However they are similar in that they show no significant differences in read speech.

It was mentioned previously that the results from previously published studies regarding speaking rates and sex have been equivocal. There have been very few studies, to the author's knowledge, that have found females to speak faster than males. One report that did reach this conclusion examined the speech rates of male and female preschool children (Ryan, 1992). Due to the differences in participant selection a comparison to the current study would not be accurate, however it does suggest that it is not unusual for female speech rate to be faster than that of males. Contradictory to the findings by Ryan (1992) and the trend found in the current study, if a significant difference is found in investigations for an influence of sex on speech and articulation rates, there is typically a tendency for males to speak slightly faster than females (for example Jacewicz et al., 2009; Lutz & Mallard, 1986; Verhoeven et al., 2004; and Whiteside, 1996). Although these studies support Byrd (1994) and Ryalis et al.'s (1994)

suggestion that male speech rate is faster than females as they have a shorter final syllable duration and reduce the endings of words more often, this theory is not supported by the results of the current study. There are a few possible reasons for this. Firstly, in the current study there were only 30 male participants, as opposed to 82 female participants; therefore it is possible that the lesser amount of male participants affected results. It may also be that NZE speakers do not apply this theory, and instead male speakers may pause marginally more often in conversational speech than female speakers, which would slow their speech rate. In any case, the results from this study contribute to the growing evidence that sex plays a very small role in influencing speech and articulation rates.

4.4) Effect of Years of Education on Speech and Articulation Rates

This study found that years of education had no association with speech or articulation rates for older speakers of NZE. As there is no literature in this area, to the author's knowledge, it is not possible to compare this finding to previous studies. It was hypothesized that speaking rates would increase with years of education in read speech, but decrease in conversational speech. These predictions were based on the premise that there was a relationship with lexical frequency (Horton et al., 2010; Spieler & Balota, 2000). It is interesting that no significant result was also found for lexical frequency to be an influencing factor of speaking rates. This suggests that there may still be a relationship between years of education and lexical frequency, however more data is necessary. Although the results fail to support the hypothesis, it is not unexpected as the data is new in this field. What the results of this study do indicate is the number of years of education an elderly NZE adult has completed in his/her life do not significantly affect their speech or articulation rate in either conversation or reading.

4.5) Effect of Lexical Frequency on Speech and Articulation Rates

The results of this study found no significant relationship between lexical frequency and speech and articulation rates in conversational speech of older NZE speakers. In contrast to the current findings, previous studies have indicated that speech rate declines with the use of less frequent words (Jescheniak & Levelt, 1994; Feyereisen, Demaeght, & Samson, 1998; Spieler & Balota, 2000). One explanation for this difference in results is that most studies have solely employed picture-naming tasks as stimulus material, and not looked at speech rate in conversation. Horton et al. (2010) conducted one study that did examine lexical frequency effects in conversational speech, reporting similar results to the picture naming tasks. However, their study solely measured the frequency of nouns used in conversations, whereas the present study included all words classes. Their study also used telephone conversations from a corpus where participants discussed topics such as air pollution. Topics of conversation have been found to have an effect on speech rate, with more complex topics being discussed at a slower speech rate (Yuan et al., 2006). The topics of conversation used in the current study were relatively simple in comparison (i.e. discussing a childhood memory), therefore participants were less likely to employ as many low frequency words than they would, for example, in a conversation about politics. Overall, this study has provided some evidence that in a simple conversation, the frequency of words does not influence speech or articulation rate in older NZE adults.

4.6) Conclusions, Limitations, Future Research, and Clinical Implications

This study has provided insight into the speech and articulation rates of typical aging NZE adults. The findings indicate that articulation rates in conversational speech are faster than those in read speech; as individuals age, their speech rate declines in oral reading; sex is not a significant predictor of speech or articulation rate, however there is a

trend for females to speak faster than males in some situations; and years of education and lexical frequency are not significant predictors of speaking rates.

Any conclusions from this study must be considered in context, as there are various limitations that hinder generalizations. Firstly, the participant sample sizes were not evenly spread: there were only 11 participants over the age of 80 years, and only 30 males as opposed to 82 females. It is possible that a sample that included a larger number of older participants and a greater proportion of male participants, would have yielded different results, and perhaps shown more significance. Secondly, the conversation sample size of 150 words may have restricted possible differences in speaking rates. To the author's knowledge, previous studies do not state how long their conversation samples were, however it may be the case that longer conversations demonstrate differing results. Thirdly, the topic of conversation was relatively simple, which did not offer the opportunity for participants to use a larger number of low frequency words than they may have used, had they been discussing a more complex topic.

This study offers a starting point for research into the speech and articulation rates of aging NZE adults. Future investigations could look at possible influencing factors more in depth in order to observe whether there are more distinct differences. For example, researchers could consider topics of conversation or cognition as an influencing factor in relation to linguistic complexity and lexical frequency. Future research could also involve a greater number of participants over the age of 80, which would offer a better understanding of normative data for older NZE adults.

The results of this study offer normative data for clinicians diagnosing and planning treatment for NZE clients in this age group (i.e. 64-91 years). Small effect sizes and the lack of correlation between many of the predicted influencing factors make it easier for clinicians, as these results suggest there is not a large amount of variation in speech and articulation rates for older NZE adults. Therefore, clinical practitioners are

able to refer to a single baseline for therapy, instead of also catering for a variety of influencing factors. Overall, this information provides a better understanding of speech and articulation rates in older NZE speakers and can enhance clinical decision-making.

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APPENDIX

Appendix A: Table of biographical information of all participants

Participant	Sex	Age	Occupation	Years of ed.	MOCA
1000SCN	F	76	Typist	10	26
1004SCN	F	68	Clerical work	12	29
1005SCN	F	72	Dental nurse	14	28
1007SCN	F	66	Research supervisor	13	29
1010SCN	M	66	Accountant	14	29
1013SCN	F	68	Hotel worker	7	28
1015SCN	F	75	Secretary	15	26
1018SCN	F	77	Nurse	10	29
1022SCN	F	68	Manager	14	30
1025SCN	F	76	Physiotherapist	14	26
1028SCN	F	70	Cytotechnologist	12	27
1029SCN	F	69	Biochemist	17	27
1030SCN	M	85	Business owner	12	26
1035SCN	F	71	Grocer	15	26
1040SCN	F	69	Accountant	12	30
1045SCN	F	64	Housewife	13	26
1046SCN	F	66	Phlebotomist	13	26
1064SCN	F	67	Primary school teacher	14	29
1070SCN	F	69	Lawyer	17	30
1090SCN	F	73	Acupuncturist	9	29
1093SCN	M	67	Agricultural researcher	17	26
1094SCN	F	76	Office accounts clerk	11	30
1097SCN	F	82	Teacher	12	28
1098SCN	M	77	Business owner	10	27
1105SCN	F	68	New Zealand post counter staff	11	29
1106SCN	F	70	Housewife	12	26
1111SCN	M	70	Electronics technician	16	28
1127SCN	F	80	Teacher	13	30
1128SCN	M	80	Minister of religion	21	30
1130SCN	F	74	Administrator	10	28
1141SCN	F	73	Professional actress	14	29
1145SCN	F	70	Architectural draftsman	12	30
1149SCN	F	66	Office worker	10	29
1152SCN	F	66	Medical laboratory technician	15	28
1155SCN	M	67	Farmer	13	28
1161SCN	M	70	Aircraft engineer	20	28
1162SCN	F	70	Lawyer	19	26
1163SCN	F	70	Dietician, market researcher	13	27
1164SCN	F	71	Accounts clerk	10	26
1165SCN	F	71	Typist	10	28
1168SCN	F	71	Housewife, counselor	16	28
1175SCN	M	70	Travel agent	12	29
1197SCN	M	90	Pilot, air traffic controller	13	26
1240SCN	F	67	Physiotherapist	12	29

1252SCN	M	81	Cabinet maker	12	26
1256SCN	F	74	Teacher	15	29
1273SCN	F	75	Librarian	13	27
1278SCN	M	75	Farming and agriculture	16	28
1283SCN	M	75	Aircraft engineer	12	29
1292SCN	F	72	Homemaker	10	27
1304SCN	M	78	Farmer	10	27
1306SCN	F	65	Nurse aide	11	29
1310SCN	M	68	Bank work	17	28
1344SCN	F	71	Housewife	11	30
1347SCN	F	71	Pharmacist	16	29
1360SCN	F	71	Nurse	13	27
1374SCN	F	75	Journalist	14	27
1376SCN	M	75	Accounting	20	28
1377SCN	F	80	Librarian	11	27
1384SCN	F	74	Secretary	13	29
1385SCN	M	78	Railway engine driver	11	27
1386SCN	F	67	Retail assistant	11	29
1387SCN	M	73	Teacher	15	26
1391SCN	F	78	Teacher	15	26
1395SCN	F	65	IT technician	17	30
1396SCN	F	65	Broadcaster; postgrad coordinator	15	27
1398SCN	F	66	School teacher	14	29
1403SCN	F	75	Lab assistant	8	27
1407SCN	M	71	Boiler operator	12	28
1409SCN	F	69	Physiotherapist	16	30
1413SCN	F	76	Nurse	13	28
1425SCN	F	66	Teacher	12	29
1430SCN	M	66	High school counselor	21	28
1435SCN	F	66	Registered nurse	17	28
1440SCN	F	67	Adult educator	15	28
1442SCN	F	74	Teacher	13	28
1451SCN	F	66	Physiotherapist	14	30
1453SCN	M	68	Teacher	20	29
1456SCN	F	80	Teacher	20	27
1459SCN	F	78	Homemaker	12	29
1461SCN	F	68	Teacher	15	27
1463SCN	M	67	Photographer	10	27
1472SCN	F	82	Homemaker	13	26
1474SCN	M	72	Veterinary surgeon	16	27
1478SCN	M	69	Engineer	18	26
1483SCN	M	71	Minister of religion	13	26
1492SCN	F	72	Midwife	12	30
1494SCN	F	69	Nurse	17	28
1506SCN	M	65	Wool industry	13	26
1507SCN	F	67	Homemaker	15	28
1524SCN	M	70	Farmer	11	27
1525SCN	F	70	Real estate agent	12	28
1528SCN	F	71	Author; lace spinner/weaver	15	27

1543SCN	F	79	Manager/Business owner	10	27
1547SCN	M	72	Computer industry	13	26
1551SCN	F	67	Physiotherapist	14.5	27
1555SCN	F	77	Teacher aide	10	28
1558SCN	M	71	Consultant	11.5	26
1559SCN	F	71	Teacher	13	26
1564SCN	F	67	Office administration	11	28
1565SCN	M	70	Property investor	13	28
1573SCN	F	66	Teacher	18	28
1578SCN	F	70	Clerk	11	28
1583SCN	F	83	Teacher	14	29
1586SCN	F	78	Teacher	14	26
1590SCN	F	65	Retail	10.5	27
1595SCN	F	74	University lecturer	16	27
1597SCN	F	71	Social worker	14	27
1606SCN	F	69	Office worker/dress designer	11	27
1620SCN	F	70	Teacher	15	27
1625SCN	F	72	Clerk	14	28
1630SCN	F	91	Homemaker	10	26

Appendix B: The Grandfather passage

You wish to know all about my grandfather. Well, he is nearly ninety-three years old, yet he still thinks as swiftly as ever. He dresses himself in an old, black frock coat, usually with several buttons missing. A long beard clings to his chin, giving those who observe him a pronounced feeling of the utmost respect. Twice each day he plays skillfully and with zest upon a small organ. Except in the winter, when the snow or ice prevents, he slowly takes a short walk in the open air each day. We have often urged him to walk more and smoke less but he always answers, "Banana oil!" Grandfather likes to be modern in his language.

Appendix C: Coding protocol

TYPE OF DISFLUENCIES	CODE	EXAMPLE
STUTTERING-LIKE DISFLUENCIES		
Sound Repetition*	SoR	Where is the c-c-c-cup ? The first sound of a word occurs twice or more.
Syllable Repetition*	SyR	Where is the cu-cu-cu-cup ? The first syllable of a word occurs twice or more.
Mono-syllabic Word Repetition	WR	Where is is is the cup? It was a a a a bear. Single syllable word occurs twice or more.
Prolongations	Pro	(Sssss)omething is prolonged. Sound or airflow continues, but movement of articulators is stopped. An audible extension of a sound. Fricatives and affricates /f/, /s/, 'sh', 'th', 'ch' longer than 30ms. Vowels longer than 50ms. Does not include interjections that have sounds prolonged e.g., "uhhhhhhh".
Blocks*	B	...Something is blocked. (there is a buildup of pressure/tension, no sound is coming out or the sound that comes out is unrelated to the word) And abrupt stopping of the flow of air or voice usually at the beginning of words.
NORMAL DISFLUENCIES		
multi-syllabic word repetition	MSR	Bring me the guitar guitar . A word with more than one syllable occurs twice or more.
Interjection/filler	Int	Bring me the um guitar. Sounds: "um, uh, ah, er, mmm" Words: "like, well, so" Phrases: "You know" "I mean"
Disfluent Pause	P	It is ...\$300 . A silent period longer than 1 second.
Articulation Rate Pause	ARP	A silent period equal to or greater than 50ms.
Revision*	R	There is a ball, a snowball . A sentence is interrupted with a change in a word or phrase.
Broken Words*	BW	There is a snow_ball . (usually happens when the person is thinking or wants to stress about something; no tension buildup)

		A silent gap or stopping within a word equal to or greater than 250ms
Part-sentence Repetition	PSR	He is coming, he is coming , home. Phrase repeated once or more.
Unfinished Sentence*	US	I went to... It was fun. Abandoned sentence.

* Manually coded disfluencies

Additional criteria adapted from Manning and Monte (1981) and Roberts, Meltzer and Wilding (2009) were also used to determine disfluencies:

- 1) A word revision was counted if the speaker began to say a word and then changed it to another word before completing the initial word.
- 2) If the speaker paused and repeated part of the phrase following a filler, it was counted as a phrase revision: “it is uh, . . it is really enjoyable.”
- 3) If the speaker interjected a phrase it was not counted as a disfluency: “I’d sit in the water about, it’s a heated pool, stay in the water about five minutes.”
- 4) Questions asked by the speaker were counted as part of the speech sample.
- 5) If the experimenter’s questions or prompt caused the speaker to pause and repeat a phrase it was not counted as a fluency break.
- 6) “Um” and “uh” were counted as fillers when the speaker could not immediately remember something.
- 7) If the speaker changes a word which seemed to be a cause of lapse of memory it was not counted as a fluency break: “She is eighty, eighty-two years old.”
- 8) If a word was repeated for emphasis it was not counted as a disfluency: “it was really really nice.”

- 9) If a word was repeated as part of a response to the experimenter's question it was not counted as a disfluency: "yes, yes."
- 10) Instances in which the speaker corrects an error (pronunciation or grammar) or begins an utterance but does not complete it was counted as a revision.