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Speaking Rate among Adult Hebrew Speakers: A Preliminary Observation

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Abstract

Background: Speaking rate is an important basic temporal characteristic of speech, essential for research as well as clinical applications. Accordingly, it has become a common measure in studies conducted in various fields, such as speech science, speech pathology, behavioral psychology, neuropsychology and emotions. Yet, normative speaking rate data, which are language specific, are still required. This study was aimed to provide preliminary data on speaking-rate and articulation-rate among Hebrew speaking adults, and to examine differences between genders and age-groups.

Methods and Findings: Recordings of 78 Hebrew speaking adults (39 men and 39 women) in three age-groups (20-40 years, 41-60 and 61-above) were analyzed. All recordings were obtained from radio broadcast interviews. Speaking rate and articulation rate were quantified using two metrics: syllable-per-second (SPS) and word-per-minute (WPM). Results revealed a mean overall speaking rate of 5.60 SPS and 154.11 WPM, while articulation rate was 6.26 SPS and 175.70 WPM. A gradual reduction in both metrics was observed between the three age-groups. This reduction reached a statistical significance only between the younger and older age-groups ($p<0.001$). In contrast, no differences in speaking- and articulation-rate were found between men and women.

Conclusions: This study provides preliminary data on speaking- and articulation-rate values for adult Hebrew speakers. Data support previous reports on a general reduction in speech rate of the older age group, while demonstrating a lack of gender difference. Results facilitate a comparison of rate measurements performed in Hebrew with those obtained in other languages. Data also provide a baseline for future comparison of speech and fluency characteristics in various pathological groups with normally fluent speakers.

Keywords: Adult; Speech; Communication; Neuro-muscular

Introduction

Speech is a complex motor and communicational behavior, produced rapidly. Therefore, speech rate is an important and basic temporal characteristic [1]. Speaking rate underpins intelligibility, fluency and communication efficiency and is associated with various speech disorders, such as stuttering, cluttering, dysarthria and dyspraxia [2-4]. Speaking rate has also been shown to correlate with various developmental, social and emotional functions. Smith et al. [5], for example, have demonstrated that speaking rate at a younger age is associated with probable development of reading disorders. In another study, listeners were shown to be affected by the speakers' speaking rate in their judgment of personality [6].

Speaking rate has also been shown to decrease under specific conditions, in speakers with social anxiety [7], and to affect listeners' perception of various emotional conditions [8,9]. Consequently, speaking rate has become a common measure in studies examining acoustic features of speech related to emotions. In addition to its direct effect on communication, speaking rate has also been shown to be associated with physiological changes. This was demonstrated, for example, by Friedmann et al. [10], who reported that speakers' blood pressure increased when they spoke faster, compared to their habitual speaking rate.

Due to the marked clinical impact of speaking rate on communication, intelligibility and speakers' perception, many speech-therapy paradigms target speaking rate, and attempt to modify it. Thus, normative data on speaking rate is essential to enable a comparison of a specific speaker to known norms in clinical settings, for training professional speakers, and for research purposes [2,11]. Despite the importance of this measure, universal speaking rate norms cannot be established.

This is due to the differences in syllable and word structure between languages and even between dialects of the same language [12]. For example, native speakers of British English were reported to exhibit a speaking rate of 3.16-5.33 SPS, whereas French speakers used a rate of 4.31-5.73, Portuguese 6.57 and Spanish 7.81 [13].

Different languages favour different combinations of vowels and consonants within syllables and words. Such languages also use different syntactic rules for sentence construction.

These differences directly influence speaking rate and raise the need for language specific data.

The common syllable structures used by Hebrew speakers are CVC (consonant-vowel-consonant) and CV (Consonant-Vowel). The vowel's nucleus is obligatory, whereas the other components ('coda' and 'onset') are optional. Consonant clusters, as well as vowel diphthongs, are rare [14]. Monosyllabic and bi-syllabic words are the most common structures in spoken Hebrew. Specifically, studies show that natural speech comprises of 45% mono-syllabic words, 41% bi-syllabic words and 14% tri-syllabic words [15,16].

Despite these reports on specific features of spoken Hebrew, published information on speaking rate among Hebrew speakers is scarce. In fact, the only published study that directly examined speaking rate in adult Hebrew speakers, has examined a relatively small group of professional radio newscasters [17]. Average speaking rate among these speakers was reported to be 5.90 syllable-per-second (SPS), whereas average articulation rate was 6.42 SPS. Clearly, because all participants in that study were professional newscasters, these values cannot be taken as representing adults' speaking rate in Hebrew, and the need for additional data remains.

The source for the observed interpersonal differences in speaking rate was previously attributed to either individual neuromuscular differences or to sociolinguistic differences [18]. Speakers were reported to exhibit a constant ratio between habitual and maximal speaking rate. Hence, it was argued that given an individual speaker's habitual speaking rate; his/her maximal speaking rate could be reliably estimated. This was interpreted as supporting the neuromuscular theory, suggesting an inherent timing mechanism which dictates an individual's speaking rate.

Interpersonal differences in speaking rate were also incorporated into theoretical models of speech production, such as the DIVA model [19,20]. Such models provide a theoretical framework to explain how different speakers may control speaking rate, by adjusting consonant and vowel production velocity.

In general, speaking rate is calculated based on the total time used for communicating a message [21]. It is derived from the number of spoken units (typically words or syllables) divided by time (minute/second). Thus, speaking rate is measured, globally, across continuous speech segments, including all pauses or disfluency [22]. As such, speaking rate is considered a global measure of verbal output and language proficiency [23]. In contrast, Articulation rate quantifies production rate in perceptually fluent speech. In this context, perceptually fluent speech segments are defined as utterances that exclude any kind of disfluency or pauses, which are longer than a defined duration [22,24,25]. Therefore, articulation rate is thought to reduce linguistic effects, and is mainly viewed as representing articulatory motor control [26].

Review of the literature reveals various factors affecting speaking- and articulation-rate. These include intra-speaker factors, such as speaking task, linguistic complexity and emotional status, as well as inter-speaker factors, such as education, spoken language or dialect, age and gender. It is beyond the scope of this study to provide a comprehensive discussion of these factors. Therefore, and in light of the preliminary nature of our study, only the effects of gender, age and speaking-task will be discussed here briefly.

Previous research has explored the effect of gender on speech rate. In a large review of the literature on this topic, van Borsel and De Maesschalk [27] have concluded that approximately half of the reviewed studies reported faster speaking rate in men, whereas the other half reported no gender differences in speaking rate. Jacewicz et al. [28], for example, compared speaking rate in adult male and female speakers in two age groups (20-34 and 51-65 years), and reported that men produced faster speaking rate than women in a conversation task, with no gender differences in a reading task.

Only two published studies have provided limited information on gender differences in speaking- or articulation-rate among Hebrew speakers. The first was a large cross-sectional study on articulation rate among Hebrew speaking children and adolescents [11]. The other study, mentioned above, examined Hebrew-speaking radio newscasters [17]. Both studies did not find rate differences between male and female speakers. Yet, it should be noted that the first study has examined children (and not adults); and that the second study was limited to examining professional speakers, but not naïve (untrained) speakers. Hence, information on gender differences in speech rate among Hebrew naïve speakers is still needed.

The effect of age on speech rate has been examined in many studies. Specifically, speaking- as well as articulation-rate have been shown to increase from early childhood to adulthood in various languages [11,29-31]. This increase in rate was attributed primarily to biological factors, i.e. general neuro- and neuro-muscular maturity.

The increase in rate was also attributed to improved linguistic skills and oral-motor skills, such as semantic, lexical and phonological development and improved specificity in motor planning [32]. It has also been suggested that children increase their speaking rate with age, due to a gradual cognitive and linguistic development, which facilitates more fluent speech by reducing disfluency. This, in turn, leads to the observed overall increase in speaking rate [32].

In contrast to children, the exploration of speaking rate changes in adults has yielded contradictory results. Bruckl and Sendlmeier [33], for example, have reported no effect of age on speaking rate in adults. Others, however, have suggested that older speakers exhibit a slower speaking rate [13]. Additionally, listeners were shown to perceive speakers who use slower speaking rate as older than those who use a faster speaking rate [34,35].

Moreover, it was suggested that adults exhibit large individual differences in speaking rate, which leads to inconclusive findings in such studies, and to insignificant age differences [28]. Therefore, the effect of age on speaking rate among adults still warrants further exploration.

Past research has demonstrated that speaking rate varies with task. Different studies have examined speaking rate in a monolog, conversation, reading task and picture description task. Clearly, such task differences involve different levels of memory span, attention, executive functions, reading skills, language skills and emotional involvement [17]. Accordingly, speakers produce different speaking rates during these tasks (for a review on this topic, [36]). Therefore, any comparison of speaking rate values obtained from different studies should consider the task performed, and the extent of its naturalness.

In summary, speaking rate has become a prominent and common measure in research and clinical applications in the fields of speech science and speech pathology. It is also regularly used in many other research fields, which correlate speaking rate with other behavioral, psychological or physiological measures.

Therefore, in light of the need for baseline information on speaking rate in Hebrew, and because different languages and dialects also differ in speaking rate, the present study has been designed as a preliminary observation on speaking rate and articulation rate among adult Hebrew speakers. Accordingly, it was deemed desirable to collect data from recorded conversations, rather than from less natural tasks, such as a monologue or a reading task.

Methods

Speakers

After obtaining the approval from our Institutional Ethics Committee, ninety audio recordings of speakers who participated in five different radio talk-shows were screened for this study. Following this initial evaluation, twelve recordings were excluded, due to technical considerations or speakers' characteristics (excessive ambient noise, insufficient recording quality, and foreign accent or speech disturbances).

Consequently, 78 speakers were eventually included in the study (39 men and 39 women). All recordings were evaluated by two experienced speech-language pathologists, who judged all speakers as proficient Hebrew speakers, with no foreign accent, no speech impairments nor fluency or voice disorders.

Recordings were obtained from open-access radio archives, which are freely available over the internet, through the radio stations' websites. Special consideration was given to include a variety of radio programs, with different characteristics. Therefore, recordings were obtained from five popular radio talk-shows, which are broadcast on different radio-stations, at different times of the day, having different themes, thus targeting different audiences.

The five radio programs included the following: (A) a radio program in which the audience is invited to comment on current local or global events broadcast on a major national radio station, once a week, from 16:00-17:00. In this program, the broadcaster typically allows speakers to talk freely, with few interruptions, while asking leading questions; (B) a radio program in which the audience is invited to share personal and private stories, events, distress or experiences.

It is broadcast daily, from 23:00-03:00, on a popular regional radio station. In this program, the broadcaster is mostly a passive listener, and occasionally asks questions, while maintaining a very calm demeanor, without limiting the time given to each speaker; (C) a radio program through which listeners attempt to renew connections with people from their past. It is broadcast once a week from 14:00-15:00 on a national radio station, and speakers are allowed to talk freely for a few minutes.

The broadcaster typically asks only short questions, in an empathetic tone of voice; (D) a radio program in which the audience is invited to comment and discuss current political events. It is broadcast daily on a popular regional radio station, from 12:00-14:00. The broadcaster typically presents his own opinion in response to the listener's, and does that in a provocative manner. Discussions are often loaded and rather turbulent. Speakers are given a few minutes to talk, and they are often interrupted by the broadcaster while speaking; (E) a radio program in which the audience is invited to share funny, comical or embarrassing anecdotes.

Table 1: Number of recorded speakers in each of the five radio programs, arranged by gender and age-groups.

Gender	Age Group	Radio Programs					
		A	B	C	D	E	Total
Men	I	3	8	2	0	0	13
	II	9	1	2	0	1	13
	III	2	2	5	0	4	13
	Overall	14	11	9	0	5	39
Women	I	0	2	3	8	0	13
	II	5	6	1	0	1	13
	III	1	1	5	0	6	13
	Overall	6	9	9	8	7	39
All	I	3	10	5	8	0	26
	II	14	7	3	0	2	26
	III	3	3	10	0	10	26
	Overall	20	20	18	8	12	78

It is broadcast daily on a popular local radio station from 07:00-09:30. Speakers are given a limited time to tell their story, while the two broadcasters often comment or remark simultaneously.

Speakers were assigned to one of three age groups: (I) age 21-40 years, (II) age 41-60 years, and (III) 61 years and older. Assignment to age groups was based on the information gathered from the recorded interview. In most cases, speakers explicitly noted their age during the conversation. In other

cases, reliable age estimations were obtained using the information given during the interview. For example, a speaker who noted graduating from high-school twenty-five years ago was estimated to be 43 years old, thus assigned to group II; or a speaker who noted celebrating her grandchild's 19th birthday recently, was assigned to group III.

Speakers, whose age could not be clearly and directly estimated from their recording, were excluded. Gender was identified on the basis of linguistic markers, which are inherent in Hebrew, and enable accurate gender demarcation. **Table 1** presents speakers' distribution in the five radio programs within this cohort, arranged by gender and age-group.

Recordings

As noted, all recordings were taken from public open-access archives of the five radio stations. Each interview was first downloaded, played and monitored on a computer, using Audacity® 2.0.1 software [37]. It was then stored, for further analysis, as an individual sound file, with a sampling rate of 44.1 kHz (16 bit) on a single (mono) channel.

Rate measurements

Thirty consecutive utterances were extracted from the recording of each speaker. To that end, an utterance was defined as a sequence of three words or more, bounded by a single intonation contour, conveying an idea and being grammatically accepted [26]. To reduce possible bias effects, the first five utterances of each recording were not included in the analysis.

All recordings were phonetically transcribed, first, by an experienced speech-language pathologist. Following, transcriptions were re-examined and confirmed by an additional speech-language pathologist. In specific cases, where disagreement arose, the two listeners discussed it, and re-listened to the recording together until full agreement was reached.

Acoustic analyses were performed using Praat software, Ver. 5.4 [38]. Duration measurements were performed from the combined time-wave display and the wide-band spectrogram. The onset and offset of each utterance were identified as the corresponding evidence of speech-related spectral energy within the displayed signal, and were also confirmed perceptually. The duration of each utterance was then calculated by subtracting the onset time measurement from that of the offset measurement.

Measurements of speaking- and articulation-rate was performed following the detailed description available in Amir and Grinfeld [11] and in Hall et al. [24]. In essence, the number of words and syllables in each utterance were obtained from the transcripts. Then, utterances containing any type of perceivable disfluency (e.g. hesitations, prolongations, repetitions, pauses longer than 250 ms) were marked, for distinction between fluent and disfluent utterances. Following, speaking rate was calculated for all utterances, whereas articulation rate were calculated only for fluent utterances. Rate calculations were performed using two metrics: word per minute (WPM) and syllable per second (SPS).

Individual speaking-rate was, first, calculated in both WPM and SPS, for each speaker, as the mean value derived from all utterances obtained from the recording (either fluent or disfluent). Individual articulation-rate was calculated, for each speaker, as the mean value derived only from the utterances marked as fluent. Then, group means were calculated. **Table 2** presents mean utterance duration, as well as mean utterance length in words and syllables, for men and women in each age-group.

Table 2: Mean values and standard deviations (in parentheses) for utterance duration (in sec.), number of words and number of syllables in each age-group.

Gender	Age Group	All utterances (for calculating speaking rate)			Fluent utterances (for calculating articulation rate)		
		Duration (sec)	Words (n)	Syllables (n)	Duration (sec.)	Words (n)	Syllables (n)
Men	I	2.24 (0.35)	5.19 (0.79)	11.71 (1.39)	1.61 (0.36)	4.92 (0.79)	10.89 (1.94)
	II	2.40 (0.45)	5.70 (0.68)	12.79 (1.71)	1.87 (0.43)	5.36 (0.74)	11.57 (1.94)
	III	2.25 (0.40)	4.85 (0.68)	10.96 (1.77)	1.88 (0.30)	4.68 (0.63)	10.58 (1.52)
	Total	2.29 (0.40)	5.25 (0.78)	11.82 (1.76)	1.79 (0.38)	4.99 (0.76)	11.02 (1.81)
Women	I	1.90 (0.31)	4.88 (0.65)	11.05 (1.22)	1.61 (0.23)	4.83 (0.62)	10.74 (1.11)
	II	2.17 (0.49)	5.24 (0.71)	11.57 (1.44)	1.79 (0.37)	4.94 (0.82)	10.68 (1.72)
	III	2.20 (0.48)	4.65 (0.92)	10.50 (2.52)	1.88 (0.42)	4.51 (0.84)	9.89 (2.06)
	Total	2.09 (0.45)	4.92 (0.79)	11.04 (1.82)	1.76 (0.36)	4.76 (0.77)	10.44 (1.68)
Overall		2.19 (0.43)	5.08 (0.80)	11.43 (1.82)	1.77 (0.37)	4.87 (0.77)	10.73 (1.76)

Results

Table 3 presents mean values and standard deviations for speaking rate and articulation rate for men and women in all three age-groups.

Table 3: Mean values and standard deviations (in parentheses) for speaking-rate and articulation-rate, calculated in syllable-per-second (SPS) and word-per-minute (WPM) for men and women in the three age-groups.

Gender	Age Group	Speaking-rate		Articulation-rate	
		SPS	WPM	SPS	WPM
Men	I	5.82 (0.85)	159.20 (28.84)	6.98 (1.13)	195.27 (34.90)
	II	5.72 (0.55)	159.09 (19.11)	6.42 (0.70)	184.39 (28.01)
	III	5.23 (0.82)	142.06 (24.21)	5.82 (1.01)	158.49 (32.96)
	Total	5.59 (0.78)	153.45 (25.09)	6.41 (1.05)	179.38 (34.92)
Women	I	6.13 (0.62)	167.26 (22.97)	6.77 (0.70)	187.33 (23.52)
	II	5.72 (0.58)	159.75 (19.75)	6.18 (0.67)	175.68 (23.64)
	III	4.99 (0.48)	137.27 (15.47)	5.39 (0.74)	153.06 (23.27)
	Total	5.61 (0.73)	154.76 (23.07)	6.12 (0.89)	172.02 (27.02)
Combined	I	5.97 (0.75)	163.23 (25.87)	6.88 (0.93)	191.30 (29.44)
	II	5.72 (0.56)	159.42 (19.04)	6.30 (0.68)	180.03 (25.78)
	III	5.11 (0.67)	139.67 (20.05)	5.61 (0.90)	155.77 (28.09)
	Overall	5.60 (0.75)	154.11 (23.95)	6.26 (0.98)	175.70 (31.24)

Prior to evaluating gender and age differences, data were examined for possible rate differences among the five radio programs. To that end, four separate analyses-of-variance were performed (speaking rate, using SPS and WPM, and articulation rate, using SPS and WPM). In these analyses, program, as well as gender and age-group were treated as the between-subject factors, and rate-measurement were treated as the dependent variable. Results revealed that, despite the special attention given to maintaining a diversity of the radio programs (considering time of day, type of radio station, characteristics of the radio program and target audience), no significant rate differences were found between the five talk-shows. This result was consistent for both speaking rate and articulation rate, using both SPS and WPM metrics [(F(4.56)=0.37, p=0.82); (F(4.56)=0.44, p=0.77) and (F(4.56)=0.35, p=0.82); (F(4.56)=0.09, p=0.98), respectively]. Therefore, all data collected from the different programs were combined for all further analyses.

As shown in **Table 3**, a general decrease in rate was observed in the older age-groups. Four separate analyses-of-variance revealed a significant main effect for age-group in both speaking rate metrics {SPS: [F(2.72)=11.61, p<0.001], WPM: [F(2.72)=8.49, p<0.001]} and in both articulation rate metrics {SPS: [F(2.72)=14.74, p<0.001], WPM: [F(2.72)=10.84, p<0.001]}. A Bonferroni post-hoc analysis, with a correction for multiple analyses (α=0.016), revealed a significant difference between age-group III and the other younger age-groups (I and II), whereas no significant differences were found between the two younger age-groups. These results are illustrated in **Figure 1**.

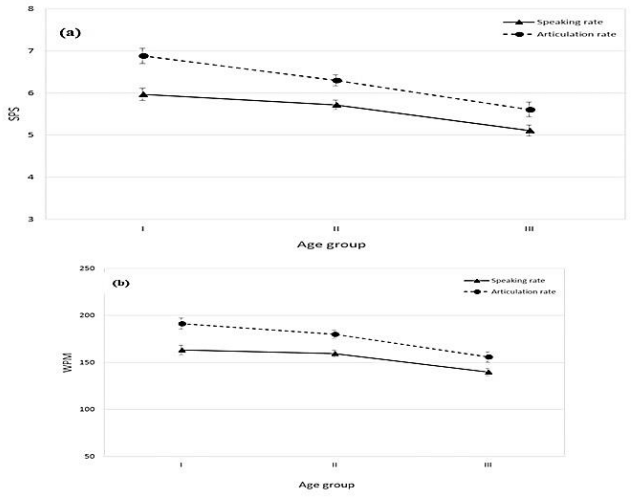

Figure 1: Overall mean values (± 1 SE bars) for speaking-rate and articulation-rate in the three age-groups, using the SPS metric (a), and the WPM metric (b).

No gender differences were found for speaking rate {SPS: [F(1.72)=0.021, p=0.885]; WPM: [F(1.72)=0.068, p=0.794]} nor

for articulation-rate {SPS: [F(1.72)=2.312, p=0.133]; WPM: [F(1.72)=1.337, p=0.251]}.

Finally, no Gender X Age-group interaction was found for both speaking rate {SPS: [F(2.72)=1.090, p=0.342]; WPM: [F(2.72)=0.552, p=0.578]} and articulation rate {SPS: [F(2.72)=0.135, p=0.874]; WPM: [F(2.72)=0.024, p=0.976]}.

Discussion

The primary aim of this study was to provide preliminary observational data for characterizing speaking rate and articulation rate among adult Hebrew speakers. First, results demonstrated that mean speaking rate (i.e. based on all utterances) varied between 5.11-5.97 SPS and between 139.67-163.23 WPM. Mean articulation rate (i.e. based on fluent utterances alone) varied between 5.39-6.98 SPS and between 153.06-195.27 WPM. In general, results indicated that both speaking- and articulation-rate measures decrease with age, and that men and women exhibit similar values. These observations are of interest, since this is the first time direct speaking rate measurements have been made in adult Hebrew speakers.

Prior to discussing current results, the ecological validity of this study should be noted. As described in the Methods section, all recordings were taken from conversations made during radio broadcasts. It could have been argued that during these conversations, some of our speakers could have been nervous or excited, such that this setting might not be viewed as "natural". To address this possible caveat, two measures were taken.

First, the five opening phrases of each conversation were not analyzed. This was done, to allow speakers to adjust to the situation, and reduce possible effects of the novelty of the setting on their speech. Second, special attention was given to collect recordings from five different radio programs. These programs were chosen because they varied in the time-of-day they are broadcast, in their conversational pattern, in their emotional/communicational atmosphere, in the topics discussed and in the radio station on which they are aired. Moreover, the five radio programs also target different audience, as reflected by the age and gender distribution of the speakers recorded for this study **(Table 1)**.

However, as shown in the Results section, our findings have demonstrated that despite these cautionary measures, no speech rate differences were found between the five radio programs. This can be interpreted as indicating that, within the context of our study, the differences between the programs did not lead to speaking rate differences. Hence, pooling these speech samples together was appropriate. Additionally, as all recordings were taken from open-access public databases, our data collection procedure did not present any special ethical considerations, which simplified methodology for collecting representative speech samples.

Speaking Rate and Gender

Our data did not reveal significant rate differences between men and women. This result was consistent for both speaking rate and articulation rate, using both the SPS and WPM metrics. Moreover, no statistically significant Gender X Age-group interaction was found.

Literature provides contradictory reports on speaking rate differences between genders. A few studies have suggested that men produce faster speaking rate than women [13,28]. Yet, after ensuring that their findings cannot be attributed to differences in utterance length, these studies failed to provide an explanation for this result. In contrast, the majority of studies performed on English speakers has shown that men and women use similar speaking rate [21,32,39].

The only two previous studies that have examined this question among Hebrew speakers [11,17] have reached similar conclusions, indicating no gender differences in speaking rate. However, although rate measurements and speech segmentation were performed similarly in these studies; generalization of the results from the above studies can only be made reservedly, due to other methodological limitations. Specifically, in one study [17], a relatively small group of 19 professional Hebrew speaking radio newscasters were used, and no gender differences were found in their speaking rate. Nonetheless, the authors could not assert whether the lack of gender differences should be taken as a general trend, or whether it should be attributed to the fact that their speakers were all professional radio newscasters, which can be expected to diminish inter-speaker differences.

The other study on articulation rate among Hebrew speakers has examined a large group of 140 children between the ages of 3-17 years [11]. That study, which did not include a group of adults, has also reported no gender difference between boys and girls, and no gender X age-group interaction. Thus, although these two previous studies have provided preliminary reference data on speech rate in Hebrew, they could not be taken as representing adults' typical speaking rate. In conclusion, current results support previous preliminary findings on Hebrew, as well as established results on other languages, suggesting that speaking rate is not affected by gender.

Speaking Rate and Age

Beyond the primary aim of this study, characterizing speaking rate among adult Hebrew speakers, it was also aimed to examine whether speaking rate changes with age. Our findings revealed a slower speaking rate among older speakers, with a statistically significant difference between group III (age ≥ 61 years) and the two younger age groups. These findings are reminiscent of the Ramig [40] study. In her study, Ramig examined speaking rate among adult speakers in three age groups (25-35, 45-55 and 65-75 years), and reported significant differences between the young and old age-groups, whereas the middle-age group did not significantly differ from

the other two. In general, our findings support Ramig's conclusion on a reduction in speaking rate in older age.

On the other hand, the significant reduction in speaking rate in our study was evident only for the oldest age-group, compared to the younger groups, whereas the reduction in speaking rate between group I and II (e.g. 5.97 versus 5.72 SPS, respectively) has failed to reach statistical significance. These minor differences between our findings and those of Ramig's [40] could be attributed to methodological differences in data collection, as well as to age-group categorization differences. It is noteworthy that our findings are further supported by those of Jacewicz et al. [28], who examined speaking rate development as a function of age. They, too, concluded that speaking rate reduces significantly only after reaching middle-age (i.e. after the age of 45 years, in their study).

The present study was not designed to explore the mechanism underlying the reduction in speaking rate with age in adults, as it is beyond the scope of this study. Yet, previous research has associated this slowing in speaking rate to the normal aging process. It was reported that this process includes a slowing in neuro-processing time, a general neuromuscular speed reduction, a peripheral deterioration in the accuracy and speed performance of the oral-motor mechanism, as well as a reduction in psychosocial functions [40]. Illnesses and general minor medical conditions, which are more common in older age, were also suggested as additional factors that could increase neurogenic vulnerability, and may contribute to a decrease in speaking rate with age [41].

Current versus Previous Results in Hebrew

In contrast with the vast literature on speaking rate among English speakers, only two previously published studies have been conducted with the intent of quantifying speaking- or articulation-rate among Hebrew speakers. Two additional relevant studies were published, in which speaking rate measurements were taken as a secondary measure for characterizing specific emotional conditions. Therefore, evaluating current results in the context of these studies is of interest.

In the first study [11], articulation rate was studied in children divided to seven age-groups (3-17 years). Articulation rate during a constructed conversation task was reported to gradually increase from a mean value of 4.43 SPS in the 3 year-old group, to 7.72 SPS in the 17 year-old group. In that study, the authors demonstrated that, in contrast with previous reports [42-44]), articulation rate continuously increases through childhood into late adolescence, even after puberty.

Mean articulation rate in the 17 year-old group in the Amir and Grinfeld study [11] was 7.72 SPS (SD=0.97), whereas it was 6.88 SPS (0.93) in the younger age group (age 20-40 years) in the present study. As shown, this difference extends approximately to one standard deviation. Therefore, although this observation is purely qualitative and should be considered accordingly, it could suggest that articulation rate increases from childhood into adolescence, and then decreases gradually though adulthood.

This interpretation is supported by Jacewicz et al. [28], who reported that speaking rate gradually increases from childhood to the third decade of life. Nonetheless, the methodological differences between the two studies should be considered when evaluating this conclusion. The children in the Amir and Grinfeld study were recorded during a face-to-face conversation with an experimenter, while the speakers in the present study were recorded during a radio program. It is possible, therefore, that the differences in the settings could affect differences in rate measurements.

The second previous study that observed speaking rate in Hebrew speakers examined recorded speech samples of radio newscasters [17]. In that study, 19 professional newscasters were divided into two age-groups: "younger" (under 30 years) and "older" (over 58 years). Results indicated a lack of age difference in speaking- and articulation-rate, as well as no gender differences. Interestingly, overall mean speaking rate among the newscasters (5.50 SPS, SD=0.33) was close to that of the participants in the present study (5.60 SPS, SD=0.75). Overall articulation rate values were also similar in the two studies (i.e., 6.42 SPS among the newscasters, compared to 6.26 SPS in the present study).

The lack of age differences in speaking rate among radio newscasters was attributed, in that study, to the speakers' professional training and experience [17]. It was suggested that professional training reduces inter-speaker effects, thus promoting uniformity in speech patterns and in speaking rate. This is further supported by the fact that standard deviation values among the newscasters were approximately 50% smaller than those obtained among the non-professional speakers in our study. Hence, professional newscasters appear to maintain a relatively steady speaking rate throughout life, unlike non-professional speakers, who slow their speaking rate with age.

The only other two studies that reported partial data on articulation- and speaking-rate among Hebrew speakers have examined young women (age range 22-24 years, and 21-26 years) during conversations made under elicited emotional conditions, compared to conversations made during a neutral emotional condition [45,46]. Hence, comparison of these studies enables the evaluation of the measurements taken during the neutral emotional condition, in conjunction with the values obtained from Group I (the younger group) in our study.

Accordingly, inspection of the Rochman et al. study [45] reveals an articulation rate of 190.09 WPM, which compares to a value of 191.30 WPM (SD=29.44) in Group I in the present study. Similarly, in the Diamond et al. study [46], a speaking rate of 5.90 SPS was reported, which compares to a value of 5.97 SPS (SD=0.75) in Group I in the present study. The similarity between the values reported in these studies and those obtained in the present study support our results, especially in light of the methodological differences between the studies.

In conclusion, only a limited number of published studies have provided documented observations on speaking- or articulation-rate in Hebrew. Yet, a qualitative inspection of our results in light of these previous reports, reveals close similarity in rate values obtained in comparable age groups. This strengthens the present findings and places them well in context. Our findings also support previous reports from other languages, demonstrating the effect of aging on speaking rate and the lack of gender effect on speaking rate. Moreover, results provide essential data on speaking- and articulation-rate among Hebrew speakers, which can be used as a reference for clinical application, as well as for future research.

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