A Continuum of Speech: The Difference Between Speech in Conversation, Interview, and Lecture

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Abstract

Humans can intuitively distinguish between spontaneous and speech read out loud. However, is there such a strict distinction between read and spontaneous speaking styles, or is it more like a continuum of speech? Furthermore, few research is performed on naturally produced speech. The aim of the current research is to show the differences between speaking styles for acoustic variables and to find out if there is a continuum of speech. Six speakers and three speaking styles (spontaneous, semi-spontaneous and non-spontaneous) were included, which led to the prosodic analyses of 18 audio fragments of naturally produced speech. The speech was transcribed and articulation rate, boundary tones and pauses were manually annotated in the speech-analysis tool PRAAT. Furthermore, pitch analysis were retrieved from an automatic script in PRAAT. Statistical analyses showed that overall, pitch and filled pauses were influenced by speaking style: pitch was higher at non-spontaneous speaking style and filled pauses occurred more at the semi-spontaneous speaking style compared to the other speaking styles. It is concluded that there is a difference between speaking styles, though this difference does not show a continuum of speech. The discussion suggests a hierarchy of acoustic cues per speaking style and discusses the other findings and several remarks.

1. Introduction

Humans can intuitively distinguish between spontaneous speech and speech read out loud (e.g., Labov, 1972; Blaauw, 1994; Laan, 1997; Dellwo, Leemann & Kolly, 2015). It does not seem to be a difficult classification task, as can be seen in the amount of studies that show significant results for this task. Humans can even significantly indicate on a scale how rehearsed the speech sounds (Dellwo et al., 2015). Most research only focused on the difference between acoustic cues in spontaneous and read speaking styles, which showed that it is not clear what acoustic cues people focus on when classifying the speaking style. This strict distinction between spontaneous and read speaking styles might not be the best way to differ between different speaking styles.

Research on the different acoustic variables within speaking styles can be important for the development of signal processing schemes. These schemes can be used for the training of hearing-impaired persons and for the development of speech-enhancement algorithms and speech technology applications. Those algorithms and applications can be, and are already used, for example, in the train for the announcement of a next station. However, this speech in the train now still sounds unnatural, which might be altered by the current research. Furthermore, such algorithms and applications can be used for the automatic transcription or summarization of for example meetings (Burger, MacLaren & Yu, 2002). Moreover, spokespersons and actors want to appear as natural and spontaneous speakers while they actually are reading a prepared text out loud from their memory. In high school, students are taught to give presentations and to speak fluently – which is suggested to be without 'ehms', pauses and word repetitions. Recent research (Corley, MacGregor & Donaldson, 2007) showed that presentations are better followed and remembered when there are hesitations (i.e., (filled) pauses, disfluency). These hesitations are seen as more spontaneous, while read speech is seen as monotonous and thus boring. This thesis will focus on the differences between speaking styles, and thus will show how natural speech is created – by analysing different acoustic cues of speech.

Language learners are another group who might benefit from research on spontaneous versus read speech. Second language learners want to acquire another language that they want to use in spontaneous conversations. However, current educational programs often tend to focus on learning and speaking from written text, and thus through a read speaking style. Scientific research on speaking styles is mostly based on read speech, which is seen as fundamentally different from spontaneous speech – if one considers the classification tasks of several studies on spontaneous and read speaking styles. Language learners might benefit more from research on spontaneous speech than from read speech. Therefore, the difference between the acoustic variables associated with spontaneous and read speech became a field for study. It can be questioned if there is such a strict distinction between a spontaneous versus a read speaking style, it may be that both are more like the endpoints of a continuum?

In the following, I will discuss the background literature and research conducted on the difference between spontaneous and read speech, and on the acoustic variables related to the speaking styles. Former research in this area had the aim to study which prosodic cues related to which speaking style, and this will also be the focus of current research. Furthermore, the current research is described, and will focus on the possibility of a continuum of speech.

2. Background literature

2.1 Spontaneous versus read speech

According to Labov (1972) speech is casual or spontaneous when there is 'a change in tempo, a change in pitch range, a change in volume or rate of breathing' (p. 95). When none of these aspects occur in an utterance, Labov classifies the speech as careful or read. But, how should actors be classified; as read or as spontaneous? Actors want to be classified as spontaneous speakers; they pretend to speak spontaneously as they prepared the text and speak from their memory. This thesis will focus on the difference between different speaking styles, which will be relevant for actors to speak as spontaneous as possible during their performance. For the analysis of speaking styles, research sometimes focused on the difference between the pronunciation of words in isolation (e.g., Pitrelli, Fong, Wong, Spitz & Leung, 1995; Fowler, 1988). For example, when the speakers are illiterate and cannot read out loud the transcribed story. Therefore, DiCanio, Hosung, Amith, Castillo García and Whalen (2015), who examined an endangered language, used elicited words, for which participants had to repeat the investigator. However, the context of a text might also be of influence on the pronunciation of the words, which subsequently can be of influence for the classification of the speech to spontaneous or read speaking style. Therefore, the designs of the research on speech altered and included the context of speech, for example by letting participants tell a story about a certain topic and read the same text out loud (see the studies described below).

Nowadays, spontaneous speech is in most studies operationalized by asking participants to tell a story about a certain topic. Read speech, on the other hand, is mostly the spontaneous speech produced by participants, transcribed and read out loud (e.g. Laan, 1997; Howell & Kadi-Hanifi, 1991; De Ruiter, 2015). For example, in Laan (1997), two male speakers spoke spontaneously about their favourite dish or their career, and afterwards read the transcribed text out loud. The participant task in Howell and Kadi-Hanifi's study (1991) is comparable: the participants had to describe a room of their choice, and read the transcribed text out loud. There is also some variation in the design of studies, which is seen in De Ruiter (2015). In that study, participants were asked to tell a constructed picture story by their own imagination or by reading out loud the sentences underneath the pictures. This might influence the spontaneity of the speech, because the picture story is constructed for the speaker. I.e., the speakers in this study should not create an own story, but the story has to refer to

the pictures which might limit their spontaneity of speech. Reading a text out loud can already be seen as an improvement of the design of research on speaking styles compared to studies on isolated words, because it takes a text and thus the context into account. Limitations of the design of this research area are still presented in the literature (e.g., Beckman, 1997).

An often-heard limitation of these studies is that the speech is produced in a laboratory setting (also called *lab speech*), instead of being as spontaneous as in a daily conversation. One could suggest that these studies are not all representative or generalizable to natural speech in daily conversations, for the speech in the studies is elicited in the laboratory and this speaking style is not natural. Natural speech occurs when a person speaks without being forced to speak. Thus, in most former research on the analysis of speaking styles, the speech is unnatural because the study asked the participants to speak about a certain topic, for example. Spontaneous speech can be either natural, i.e., produced in daily life, or unnatural, i.e., produced in a laboratory. Lickley, Schepman and Ladd (2005) show in their study that the production of intonation in questions is affected in the same way for task-oriented dialogue and read speech data. And, therefore, they suggest that read speech experiments are a valid means for the examination of intonation contours. Thus, according to Lickley et al. (2005), read speech can be collected in a laboratory setting to study intonation instead of collecting naturally produced speech outside of a laboratory. Furthermore, according to Xu (2010), there is no unnatural speech, because all speech is produced by humans who already know how to pronounce and produce the speech. However, research on the exact difference or effect between naturally produced and lab speech is not available yet. Therefore, the current research will examine (already recorded) naturally produced speech to avoid the possible influence of lab speech (for the description of the material used, see section 3.1).

Naturally produced speech can occur through different speaking styles, for example, speech can be controlled to be more or less spontaneous (Xu, 2010). Furthermore, Smiljanic and Bradlow (2009) suggest that people sometimes alter their spontaneous speech to create more clear speech, for example, when people are aware of difficulty of speech perception from the conversation partner. Their review thus suggests speech to be more like a continuum. This suggestion of speech as a continuum will be elaborated in the next section.

2.2 Continuum of speech

As Krause and Braida (2004) mention; 'the question of whether and how many types of (clear) speech exist have yet to be explored' (p. 15, authors' parenthesis). While previous research mostly focussed on the distinction between read and spontaneous speech, Labov (1972) already mentioned the possibility of overlap between both read and spontaneous speaking styles – which indicates a continuum of speech. According to Labov (1972), there is a continuum of speech from minimal pairs

to casual speech (minimal pairs – word lists – reading – careful – casual). In his view, this continuum can be defined in terms of the attention paid to the speech. In minimal pairs, only two words are presented, which will lead to more attention paid to the pronunciation of the words. These two words only differ in one prosodic cue: e.g. 'pin' and 'bin'. In word lists, several different words are presented, which mostly are not related to each other and thus also lead to more attention paid to the pronunciation. This attention will be somewhat less than at minimal pairs, because more words should be read out loud by the speaker. Reading refers to reading out loud a written text, while with careful speech the spontaneous speech is altered by giving the speakers an extra task to make sure the listener will hear and will be able to decode the speech. Lastly, Labov mentions casual speech, which refers to spontaneously produced speech. At first sight, Beckman (1997) supports the distinction between read speech and spontaneous speech. However, Beckman also suggest that spontaneous speech is not homogenous, meaning that speech can differ regarding to the situation, communicative purposes and other contextual factors. Beckman suggests that

> 'We [researchers on spontaneous speech] must think carefully about how different types of spontaneous speech are likely to differ from read speech, about whether those differences will make the spontaneous speech a useful source of data for extending our knowledge beyond the range of prosodic phenomena or values on which our models are based.' (Beckman, 1997: p.8)

Hereby, Beckman states that more types of spontaneous speech exist – and thus suggests a continuum of speech instead of a strict distinction between read and spontaneous speaking styles. Several other researchers of read and spontaneous speaking styles also suggested a possibility for a continuum of speech in their discussions (e.g., Blaauw, 1994; Swerts, Strangert & Heldner, 1996a; Fujisaki, 1997), which were described in different ways. For example, Fujisaki (1997) mentions a continuum of the degree of spontaneity, while others only suggest that there is no strict distinction between both speaking styles (e.g., Blaauw, 1994; Dellwo et al., 2015). Fujisaki (1997) and Swerts et al. (1996a) both suggest that the continuum is based on the preparedness of the speech and that spontaneous speech should not be contrasted with read speech, as spontaneous speech contains more variety than read speech. Fujisaki proposed a continuum of five speaking styles: recitation, reading, simulated dialogue, controlled dialogue, and free dialogue, which are scaled from most well-prepared to least well-prepared. Thus, the amount of preparedness seems an important factor to take into account by creating a continuum of speech.

The influence of preparedness of speech is also shown by Koch (2008), who divided three speaking styles: spontaneous conversation, single elicited utterances and scripted (or read) conversation, where the last two are both seen as belonging to the read speaking style. Elicited

utterances were collected by asking participants 'how do you pronounce X in your mother tongue?', and mostly involved translation. The study shows that elicited utterances and spontaneous conversation significantly differ from read conversation, and thus that spontaneous conversation and elicited utterances are closer related than elicited utterances and read conversation. Koch (2008) investigated this by analysing different acoustic variables of the three speaking styles for two female speakers of Salish language dialect, which were gathered through a corpus analysis. It might be that the preparedness of the utterances had influence on the results: while the read conversation sentences were scripted on paper, the elicited and spontaneous conversation utterances were spoken from the mind.

These three different scales of speaking styles from Labov (1972), Fujisaki (1997) and Koch (2008) have some overlap in their distinction. For example, the terms minimal pairs and word lists (Labov, 1972) are similar to the speaking style recitation suggested by Fujisaki (1997). However, these methods are outdated, as research showed the importance of the context of speech for the analysis of the differences between speaking styles on acoustic cues (e.g., Beckman, 1997). Similarly, the elicitation of single utterances, used in Koch (2008), is quite outdated, because it does not take the context of speech into account. Thus, the current research will not take these speaking styles into account, and will include the speaking styles from reading or non-spontaneous speaking style on in the continuums of Labov (1972), Fujisaki (1997) and Koch (2008). The following condition might be careful speech (Labov, 1972), or simulated/controlled dialogue (Fujisaki, 1997). The current research will call this semi-spontaneous speech, as the speech is both by Labov and Fujisaki mentioned to be somewhat controlled or prepared for – for example as in an interview. The speech is thus spontaneous, but as the topic of the interview is already announced, the speaker could have prepared some answers on possible questions that might occur in the interview. The last condition will be the spontaneous speaking style, which refers to casual speech (Labov, 1972), free dialogue (Fujisaki, 1997), or spontaneous conversation (Koch, 2008). Thus, the continuum of speech might be analysed through a distinction of three speaking styles from not prepared to well-prepared: spontaneous, semi-spontaneous and non-spontaneous. The differences between speaking styles can be examined through analysing the acoustic variables of the speech.

2.3 Acoustic variables

For this thesis, the acoustic variables which appear to be most influential for the differentiation of speaking styles were analysed. It is important to note that several studies suggested that the acoustic variables may influence each other as well and thus that looking at one variable might not be sufficient (e.g., Swerts et al., 1996a; Laan, 1997; Dellwo et al., 2015). Furthermore, it should also be noted that several studies mention the speaker variability of the influence speaking styles have on acoustic cues

(e.g., Blaauw, 1994; Krause & Braida, 2004; Koch, 2008; Dellwo et al., 2015; among others). For example, Howell and Kadi-Hanifi (1991) examined the difference between read and spontaneous speech by letting new speakers also read out loud a text they did not produce spontaneously themselves. The results of that study showed that the difference between read and spontaneous will be more significant when one reads a text out loud from another speaker compared with the spontaneously produced speech. The current study takes this suggestion into account by comparing speaking styles produced by one speaker (see section 3.1 for a complete description).

The combination of different acoustic variables in speaking styles seems to be influential for the classification. This section will define the different acoustic variables and gives a review on the literature on these variables. For a clear structure of the current research, a dichotomy is created between variables that are included in fluency of speech and variables that are included in intonation. Fluency of speech means whether or not one speaks with (filled) pauses, repeats parts of the same word or utterance, or the rate with which one speaks. This can be measured through the acoustic variables articulation rate, speech rate and pauses, while the intonation can be measured through pitch range, mean pitch and boundary tones. The next section will discuss these acoustic variables based on several studies on read and spontaneous speech.

2.3.1 Fluency of speech

Articulation rate

In this study, articulation rate is measured as a function of the amount of syllables one speaks per second, while speech rate is measured as the amount of syllables spoken per second based on the duration of speech signal – thus without taking the silent and filled pauses into account (e.g., Dellwo et al., 2015). According to Fujisaki (1997), it has been shown in several studies that spontaneous speech has a higher speaking rate with reduced articulation. For example, in the study of Dellwo et al. (2015), articulation rate seemed to be a relevant variable to distinguish speaking styles. For spontaneous speech, the articulation rate did seem to be influential for the classification of the speaking style, which suggests a hierarchy of speaking styles, i.e., an acoustic cue can be influenced by a speaking style, while another acoustic cue can be influenced by another speaking style (Dellwo et al., 2015). Dellwo et al. (2015) conducted two experiments to come to this conclusion. Eight speakers of Zurich German told a story and read out loud the transcribed version. One utterance of both speaking styles was randomly selected and, hereby, 128 stimuli were created (8 speakers, for each speaker 8 read and 8 spontaneous utterances). In the first study, these utterances were classified by 26 participants as either read or spontaneously spoken speech, while the second experiment only took the read speech stimuli and asked the same participants to rate the speech on a scale from more to less read. The analysis included measurements of the performance of the participants by using the Signal Detection Theory, the bias

of the performances and eight acoustic variables, of the latter the current research will only include the analysis on articulation rate, mean pitch and pitch variability as the other acoustic variables are not included in the current research. The Signal Detection Theory was used to measure listeners' classification performance. This program could measure whether the classification appeared to be above chance, including the bias of this chance. The results showed that the classification task was performed well above chance ($\alpha = 0.82$), while there was no difference between the classifications of spontaneous or read speech. In the analysis of the eight acoustic variables that might explain the classification results, Dellwo et al. (2015) showed that mainly articulation rate and pitch could predict the accuracy of classification (the results of the latter will be reported in the paragraph *Pitch*). The results of the regression analysis showed that for spontaneous speech, the accuracy of the classification can be attributed to the articulation rate of the speech. However, the prediction of accuracy is quite low: 25% of the accuracy variance can be predicted in spontaneous speech. This means that 25% of the classification of the speaking styles can be predicted by articulation rate. In the second experiment, Dellwo et al. (2015) asked the same participants to scale how much the speech sounded as though it were being read. Results showed that the less read the speech sounded, the higher the articulation rate was. This result suggests that the articulation rate is higher in spontaneous speech in comparison with read speech. Thus, according to Dellwo et al. (2015), articulation rate might be a determinant for the spontaneous speaking style, which is why the acoustic variable is included in the current research to compare speaking styles. Dellwo et al. (2015) did not compare the articulation rates of spontaneous and read speech. They only conducted a regression analysis to be able to show whether the accuracy of the classification task could be predicted by an acoustic cue such as articulation rate.

A study that already compared the speech rates of spontaneous and read speaking style, is the one performed by Trouvain, Koreman, Erriquez and Braun (2001). They showed that speech rate is higher in spontaneous speech than in read speech, by analysing the speech rates from the German KielCorpus for Read and Spontaneous Speech. This database consists of four hours of read speech, single utterances and two short stories, and four hours of spontaneous speech, i.e. appointment-making dialogues. Trouvain et al. (2001) collected the speech that was already labelled segmentally and prosodically in the corpus, and calculated the articulation rate with realised phones per second and excluding pauses. This differs from the definition of articulation and speech rate described above. Therefore, in the current article I will refer to speech rate, while in Trouvain et al. (2001) it is referred to as articulation rate. The mean speech rates show that spontaneous speech is slightly faster than read speech. However, the authors do not give the significance of these measures, and the difference they report is quite small (resp. 13.24 vs. 13.06 for inter-pause stretch and 13.18 vs. 13.01 for intonation phrase). Furthermore, the measured speech rates seem to be of the duration of the inter-

pause stretches and intonation phrases, but not of the total text. Therefore, Trouvain et al. (2001) probably used the number of phones per second instead of syllables per second. Though, for the current research, it will not be necessary to look at smaller units than syllables for the analysis of articulation and speech rate. Therefore, the Trouvain et al.'s (2001) formula is not used for the current research. From the studies described above, it can be concluded that speech and articulation rate are influenced by speaking style. However, the exact difference between speaking styles for this measurement is not included in the research described above, and also not in combination with other acoustic cues. The current research will take these limitations of the research thus far into account.

Pauses

In research on spontaneous and read speaking styles, participants often have to read out loud the transcription of their spontaneous speech. In these transcriptions, the text is mostly made grammatically correct and without filled pauses (e.g., Howell & Kadi-Hanifi, 1991). Therefore, in studies analysing the difference between read and spontaneous speech, with the design of reading the transcribed spontaneous speech out loud, have manipulated the text to make the comparison possible. Thus, few studies included the natural read speech with grammatically incorrect utterances or filled pauses – which is not rare to happen in this speaking style. Hesitations, on the other side, can be included in the transcriptions to make the read out loud speech more casual or spontaneous. Read speech created in the laboratory mostly does not include filled pauses or repetitions, which makes a comparison between spontaneous and read speaking styles less reliable than when naturally produced speech is used. This suggests that one can better analyse 'real life' speech in different situations to be able to show differences in the fluency of speech between speaking styles.

Trouvain et al. (2001) did mention the difference between read and spontaneous speech on pauses: pauses occur at syntactic boundaries in read speech, for example at the end of an utterance or when a comma is present in the written text. In spontaneous speech, on the other side, more hesitations occur. However, they did not examine this through statistical analyses of the pauses. Howell and Kadi-Hanifi (1991) did examine pauses in spontaneous and read speech for six English speakers (2 male, 4 female), who described a room and three months later read out loud their story and the stories of the other speakers. The pauses were measured by hearing by a trained listener, and later these pauses were checked by acoustic measurements. The pauses were transcribed per 100 milliseconds duration. The results showed that read speaking style included less pauses than spontaneous speech. However, in their definition of pauses, Howell and Kadi-Hanifi (1991) only included silent pauses, and thus left out the filled pauses unless they were associated with the silent pauses. This was chosen, because the method to create read speech did not allow for filled pauses, which made comparison between the speaking styles on filled pauses impossible. After all, filled pause

do occur in natural and spontaneously produced speech (e.g., Howell & Kadi-Hanifi, 1991; Dellwo et al., 2015), and they can mark the discourse structure of the speech (Swerts, Wichmann & Beun, 1996b). Therefore, several studies focused on the automatic speech analysis for (filled) pauses (e.g., Wu & Yan, 2004; De Jong & Wempe, 2009). These models thus only focus on the spontaneous speaking style, while the difference between non-spontaneous and spontaneous speaking styles are investigated less. The current research aims to provide the difference between the pauses in three speaking styles.

An example of a research on the differences in fluency of speech in naturally produced speaking style, is the study of Burger et al. (2002). Their study analysed disfluencies in five types of meetings: project planning, work planning, games, chatting and topic discussion. In the first two meeting conditions, participants planned a project or discussed work on several projects. In the meeting group games, the speakers had to perform a game-oriented task within a certain time, for example building an object. In the chatting meeting, participants were placed in a room with each other without instructions. However, for this meeting the participants were friends, so that they would probably be able to start a conversation. Lastly, in the meeting with a topic discussion, participants were given topics to be able to start a discussion. A meeting is described as a minimum of three individuals speaking to each other, and the meetings used for analyses in their research are retrieved from the Interactive Systems Labs (ISL) corpus (Burger et al., 2002). For comparison with the current research, these speaking styles in the meetings can be ordered from spontaneous to non-spontaneous speaking styles in the following scale: chatting – topic discussion – games – project/work planning. Results showed that disfluencies were found most in game meetings, and least in project planning. In particular, pauses were shown to have the highest number in topic discussion meetings, and the lowest number of pauses occurred in meetings of project planning. Thus, according to this research, pauses and fluency of speech decrease in number when the spontaneity of speech decreases. Unfortunately, Burger et al. (2002) did not report the significance of these differences and did not make a distinction between different types of pauses, which the current research will include in the analyses of pauses.

2.3.2 Intonation

As described above, the acoustic variables are divided into two groups. The second group is intonation, which includes measures of pitch range and mean pitch, and the boundary tones of the speech.

Pitch

Pitch is referred to in different contexts: it is also called fundamental frequency (F0) and among other things can be used to measure intonation, for example by examining factors such as pitch accents, mean pitch (mean F0) and pitch range (F0 contour). In this thesis, the terms pitch range and mean pitch are analysed, which are considered to be represented by F0 range and mean.

Humans use pitch to indicate the prominence of words: a higher pitch means that the word is more important than other words in an utterance. This is seen in referent studies, such as De Ruiter (2015), who questioned whether intonation levels of new, given and accessible referents differed across spontaneous and read speaking styles. Therefore, picture stories were created, either with or without text underneath it. Referents are defined as words referring to a certain object, which can, for example, in the new condition be 'a girl', and in the given and accessible conditions 'she'. New referents occur for the first time, while given and accessible referents occur after the new referent. Given and accessible referents differ in that given referents occur in the picture after the new referent, while accessible referents occur four or five pictures later. In the two studies reported in De Ruiter (2015), participants had to either spontaneously tell the picture story, or read out loud the text underneath the pictures. The pictures were shown to the participants after each other and varied in length from five to eight pictures, in order to prevent the participants to anticipate the end of the story and to prevent the use of boundary tones for different discourse segments (see the next section for an explanation of boundary tones). Additional to this control, the target referents were all disyllabic and animals. The target referents occurred in the last picture, and were thus either new, given or accessible. In the first study, 28 participants spontaneously told the picture story, and in the second study, 8 (other) female participants read out loud the sentences underneath the picture story. The data acquired by both studies are thus speech from different speakers, which is a limitation of the research. For the comparison of speech, it should be within one speaker, as there occurs to be speaker variability on the acoustic cues (e.g., Blaauw, 1994, among others). The texts from the study of De Ruiter (2015) were analysed using PRAAT, a program for speech analyses (Boersma & Weenink, 2015), and the target word was labelled following (German) Tones and Break Indices (GToBI) guidelines. Results showed that intonation differed between spontaneous and read speaking style; in spontaneous speech, new referents were always accented, whereas in read speech this did not always occur. Furthermore, pitch accents varied more in spontaneous speaking style than in read speaking style. Thus, the target words were accented less consistently in spontaneous speech than in read speech. However, De Ruiter (2015) only focuses on the accents that indicate the referents and not on how the pitch range and mean pitch differed between spontaneous and read speech.

A study that did focus on the pitch variability is performed by Dellwo et al. (2015), examining Zurich German. However, they did not focus on the differences between the pitch ranges of spontaneous and read speech, but rather focused on the possibility to predict the accuracy of classification of the speaking style by listeners through a regression analysis. Dellwo et al. (2015) extracted the pitch contour from PRAAT and separated it by gender. For each speaker, the mean and the range of the pitch were obtained from the program. The results of this regression analysis showed that pitch variability could predict the accuracy of the classification of speech as either spontaneous

or read, although the result is quite low (8% of accuracy variance can be predicted). The exact difference between read and spontaneous speech is not yet investigated within these studies, but Koch (2008) did find a difference between spontaneous and read speaking styles regarding the highest pitch in the utterances. Koch (2008) analysed a Salish language dialect on the intonation of spontaneous conversation, elicited utterances, and read conversation. ANOVAs on the utterances of two female speakers showed that the highest pitch occurred in read utterances. The pitch was significantly higher in read utterances than in elicited and spontaneous utterances. However, from the method described in Koch (2008), it is not clear what the amount of analysed utterances is. The appendix shows different numbers of analysed utterances (54 spontaneous conversation, 22 single elicited, and 30 read conversation utterances and respectively 49, 23 and 31). The intonation, amplitude and duration were measured for two stressed lexical vowels of two words in one utterance, one at the left edge and one at the right edge of an utterance. These analyses were performed by the use of the speech-analysis tool PRAAT (Boersma & Weenink, 2015), and were controlled by selecting the utterances that were completed in one breath. The results showed comparable intonation in both single elicited utterances and spontaneous conversation utterances. However, for the right edge words the result was only significant for one of the speakers, which shows the importance of taking speaker variability into account. For the current research, the results of these studies will be further analysed, through measuring the pitch range and mean pitch for the different speaking styles – as these seem to be influenced per speaking style.

Furthermore, focusing on the pitch range and mean pitch, several studies found a declination effect in speech meaning that the pitch decreases in an utterance and the next utterance is reset again to a higher pitch (e.g., Swerts et al., 1996a). An exception is a question, which will have a rising pitch at the end of an utterance (Lickley et al., 2005). Swerts et al. (1996a) performed a case study, in which two texts (spontaneous and read) of a male Swedish speaker were analysed. Firstly, the speaker read a news telegram out loud and afterwards retold the news, which was analysed as spontaneous speech. They analysed the pitch contour by estimating the slope of the declination of utterances and phrases. From this analysis, it occurred that both spontaneous and read speech showed the declination effect. However, for read speech this effect was stronger than for spontaneous speech: the slope of declination was steeper in the read speaking style than in the spontaneous speaking style (Swerts et al., 1996a). This study focused on only one speaker, and thus cannot be generalized for other speakers. Nevertheless, it can be suggested that this effect occurs more for read speech than for spontaneous speech, which will be analysed further in the current research.

Boundary tones

A second acoustic variable that is included in the measurement of intonation, are boundary tones. Boundary tones occur at the end of utterances, and emphasize the different syntactic parts of an utterance, for example when one utters two clauses with in between a boundary tone or a pause. Different boundary tones occur for example when one utters the following sentences 'You work at a bank' or 'You work at a bank?!'. These sentences have different communicative functions: the first sentence is a declarative utterance, while the second sentence is an exclamative utterance as a reaction. These sentences have different boundary tones, and, therefore, the intonation of the utterances differ. Boundary tones can be falling, neutral or rising. Falling boundary tones announce the end of an utterance, when the speech unit has been completed, while rising boundary tones signal continuation of speech or a question (e.g., Blaauw, 1994; Swerts & Zerbian, 2010; Lickley et al., 2005). Blaauw (1994) investigated the boundary tones produced by five Dutch male speakers who spoke spontaneously and read the same text out loud. One of the differences found in the analysis in Blaauw (1994) was that within-utterance boundaries are characteristic for spontaneous speech, and occur mostly before a highly informative word. Several studies support that in spontaneous speech utterances end with high/rising tones, whereas in read speaking style, utterances end with low/falling boundary tones (e.g., Blaauw, 1994; Bauman & Riester, 2013; De Ruiter, 2015). In addition, boundaries between tone units occur at different places of the utterance in spontaneous speech in comparison with read speech (Howell & Kadi-Hanifi, 1991). Boundary tones thus occur before a pause, which can be transcribed for example as a comma or a full stop (Howell & Kadi-Hanifi, 1991). These sentences between pauses can be divided into intonation phrases (IP) and intermediate phrases (ip) (e.g., Prieto, del Mar Vanrell, Astruc, Payne & Post, 2012). Intonation phrases occur before a pause of 200 milliseconds or more, while intermediate phrases occur before a pause of 200 milliseconds or less (following Prieto et al., 2012).

The study of Swerts et al. (1996a), which focused on analysing one Swedish speaker, showed that a declination effect occurs at the end of an utterance. This shows that this effect might relate to the occurrence of boundary tones. Thus, at the end of the utterance a boundary tone occurs, which is seen by the higher pitch level at the beginning of the next utterance. Swerts et al. (1996a) also showed that for this speaker, it occurred more strongly for read speech than for spontaneous speech and did not occur for phrases within an utterance.

2.4 Research question and hypotheses

The current research focuses on the various acoustic variables described above for creating a possible continuum of speaking styles. The studies described above mostly took one acoustic variable into account, however, they suggested that there is a possibility that acoustic cues also influence each other

in different speaking styles (e.g., Laan, 1997; Dellwo et al., 2015; among others). Thus, the combination of acoustic cues seems important, which is included in this study by looking at four acoustic variables in three speaking styles.

Fujisaki (1997) noted the degree of spontaneity in speaking styles. Fujisaki suggested that one can speak spontaneously either formally or informally, where formal spontaneous speech is suggested to be less spontaneous than informal spontaneous speech. This distinction seems important and, therefore, the current study will not only take spontaneity of speech into account, but also the context in which it was elicited. For the examination whether or not there is a continuum of speaking styles instead of a strict distinction of spontaneous and read speech, three different speaking styles are analysed in the current study: spontaneous (S), semi-spontaneous (SS) and non-spontaneous (NS). For the current research, the attempt is to create an answer for the following two research questions:

RQ1: What are the differences between spontaneous (S), semi-spontaneous (SS) and non-spontaneous (NS) speaking style regarding the acoustic variables discussed above?

RQ2: Is there a continuum of speech according to the differences in the acoustic variables of the speaking styles?

From the literature described above, several hypotheses can be formulated, which are summarized in Table 1. There is a dichotomy of the acoustic variables included in the current research, as described above. Hypotheses 1 to 4 are created for RQ1, in which H1 and H2 refer to the fluency of speech, and H3 and 4 refer to the intonation. H5 corresponds to RQ2.

RQ1

Fluency of speech

H1: People speak faster when the speech is more spontaneous, measured by both articulation rate and speech rate:

a. The articulation rate is fastest in the spontaneous speaking style, and becomes slower when the spontaneity of speech decreases (based on Dellwo et al., 2015).
b. The speech rate is fastest in the spontaneous speaking style, and becomes slower when the spontaneity of speech decreases (based on Trouvain et al., 2001 and Fujisaki, 1997).

H2:

a. The spontaneous speaking style contains more pauses than the semi-spontaneous speaking style, which, in turn, contains more pauses than the non-spontaneous speaking style (based on Burger et al., 2002 and Howell & Kadi-Hanifi, 1991).

b. The duration of pauses is longer when the speaking style becomes less spontaneous.
c. There is a negative correlation between speaking style and fluency of speech: when the speaking style becomes more spontaneous, filled pauses occur more and hereby the fluency of speech decreases (based on Burger et al., 2002).

Table 1

Summary of the hypotheses.

	Variable	Hypothesis
	Fluency of speech	
H1a	Articulation rate	S > SS > NS
H1b	Speech rate	S > SS > NS
H2a	Number of pauses	S > SS > NS
H2b	Duration of pauses	S < SS < NS
H2c	Number of filled pauses (in comparison with silent pauses)	S > SS > NS
	Intonation	
H3a	Pitch range	S < SS < NS
H3b	Pitch mean	S < SS < NS
H4a	Number of boundary tones	S > SS > NS
H4b	Number of falling boundary tones	S < SS < NS
	Number of rising boundary tones	S > SS > NS
H5	Continuum of speech	S – SS – NS

Intonation

H3: Pitch will be higher when spontaneity of speech decreases, which can be seen both for pitch range and pitch mean (based on Koch, 2008 and Swerts et al. 1996a):

a. Pitch range for the non-spontaneous speaking style will be larger than for the semi-spontaneous speaking style, which, in turn, will be larger than the spontaneous speaking style.

b. Pitch mean will be higher for the non-spontaneous speaking style in comparison with the semi-spontaneous and spontaneous speaking styles, while the last two are expected to be similar.

H4:

a. Boundary tones occur more when the spontaneity of speech increases (based on Blaauw, 1994).
b. Falling boundary tones occur more in non-spontaneous speech, followed by semi-spontaneous and spontaneous speech, while the opposite occurs for rising boundary tones (based on Blaauw, 1994; Bauman & Riester, 2013; De Ruiter, 2015; among others).

RQ2

H5: The continuum of speech exists: the acoustic variables decrease or increase from S to SS to NS (based on Labov, 1972; Fujisaki, 1997; Koch, 2008; among others).

3. Method

3.1 Speech material

3.1.1 Speakers

Six Dutch male speakers were selected based on the fact that video or audio fragments already existed online for the conditions relevant for the current research in which they are speaking in a natural environment. They were split into two groups based on profession: three politicians and three newsreaders. These groups were chosen, because they represent trained speakers, are mostly recorded with professional equipment and their video and/or audio fragments are freely available. The speakers were all male to avoid the possible influence of gender differences. The mean age of the speakers was 49.3 (*SD* = 6.68, minimum = 43, maximum = 66). The following speakers were included for analysis (with abbreviations): Alexander Pechtold (AP), King Willem-Alexander (WA), Wouter Bos (WB), Philip Freriks (PF), Rik van de Westelaken (RW) and Twan Huys (TH). The first three mentioned speakers are politicians, while the last three are newsreaders. The King is considered as a politician, because the chosen fragments relate to politics and the King speaks for the government.

3.1.2 Fragments

For the purpose of this research, a natural speaking environment was important to avoid that the speech was lab speech. Speech fragments of all speakers were selected to match the characteristic of the three conditions that were introduced previously: spontaneous (S), semi-spontaneous (SS) and

non-spontaneous (NS). The fragments, which are approximately 30 seconds long, are mostly part of a longer conversation, and were selected to contain one topic and complete sentences. The mean length of the fragments is presented in Table 2. For the context and a more detailed description of the fragments, see Appendix A.

Table 2

The mean, minimum and maximum duration of the audio fragments in seconds, and their standard deviation, per speaking style.

	Mean (in Ms)	*SD*	Minimum (in Ms)	Maximum (in Ms)
Spontaneous	23.03	6.23	12.24	28.46
Semi-spontaneous	28.69	8.92	22.81	46.10
Non-spontaneous	28.15	7.22	21.02	41.51

In the non-spontaneous speaking style, the speakers are reading the news from an autocue or giving a prepared speech or lecture read out loud or from their memory (only WB). The semi-spontaneous speaking style consists of interview in a quasi-formal setting, where the speaker does not read a text out loud from an autocue. However, the speaker has prepared the interview and knew the topic of the interview. Topics of the interviews were, for example, an annual review of the news (RW), a five-year retrospect of his career (AP), or change of rule (WA). The spontaneous speaking style fragments were selected by the criteria of an informal setting. The speaker spoke in a familiar environment, for example with the presence of family or friends (WA, TH). Topics of the conversations were for example a painting (AP), dialects (TH), or coated peanuts (WB). For speaker WA it was difficult to find a fragment in this speaking style, which resulted in the shortest fragment (12.24 Ms).

3.1.3 Procedure

The audio fragments were extracted from the YouTube videos and converted to wave-files (Clip Converter, 2015). Within this procedure, only the approximate duration of the fragments selected for the prosodic analyses could be converted. The videos of npo.nl could not be converted through the same procedure, but were recorded with Audacity® (2015). For this procedure, the Tascam® soundcard of an Asus notebook™ was selected and by playing the sound from the original video it was automatically recorded in Audacity®.

The wave-files were then adjusted to fit the selected fragments by cutting them in Audacity®. In semi-spontaneous speaking style, the interview setting made it for speaker TH difficult to extract a 30 seconds fragment, because he was the interviewer and did not talk too much. Therefore, two

different parts of the YouTube video were extracted and put after each other. These two parts were related to the same topic, but excluded the interruption of the interviewee. The same procedure was used for another speaker in the spontaneous speaking style (WB), where the speaker was interrupted and afterwards continued with the same topic.

3.2 Prosodic analyses

The prosodic analyses were performed using PRAAT (Boersma & Weenink, 2015). In this program to analyse speech prosodically, the speech was transcribed by listening and manual annotation. Figure 1 illustrates part of the analyses. It represents a selection of a fragment including the wave-form, spectrum and pitch and different tiers for transcription, syllables, pauses, boundary types, and pitch range and mean pitch. The first tier is the transcription of the phrases *bijeenkomsten namelijk familiebijeenkomsten* 'gatherings namely family gatherings', while the second tiers contains the syllable transcription. Four prosodic features were analysed, which are visible in the tiers in Figure 1 and will be described below. These prosodic features were sometimes analysed manually, while for others a script was included in PRAAT which made automatic analyses possible. The following sections will describe these analyses for the acoustic variables included in this study in the dichotomy of fluency of speech and intonation.

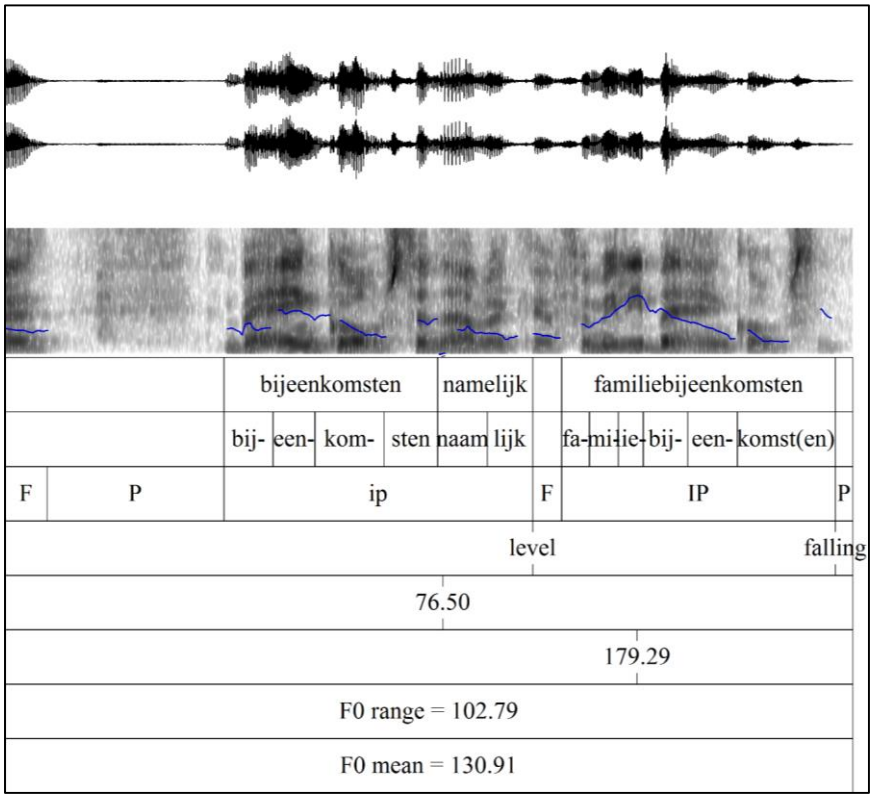

Figure 1

Wave-form, spectrum, pitch contour and labelling schema used for the phrases *bijeenkomsten namelijk familiebijeenkomsten* 'gatherings namely family gatherings' (speaker TH, condition S).

3.2.1 Fluency of speech

Articulation rate

For the prosodic features articulation and speech rate, syllables were segmented from the transcription by listening and manual annotation (second tier, Figure 1). The syllables of one fragment in each condition were manually and independently checked by an additional speech analyst, and all fragments were checked by means of an automatic script for detecting nuclei and speech rate measurement (De Jong & Wempe, 2009). The outcome of this script gives the number of syllables, but the filled pauses also occur as syllables. Therefore, it was checked manually when syllables occurred in a pause (see the next section for explanation of the segmentation of pauses). When this occurred, the syllables were deducted from the number of syllables retrieved from the script. Paired-samples t-test revealed that on average, the author of the current research segmented the transcriptions into more syllables (M = 134.33, SE = 10.85) than the script of De Jong and Wempe (2009) (M = 106.06, SE = 7.80). This difference was significant, $t(17) = 6.297$, $p < .001$. This significant difference can be explained by the limitations of the script. The script uses the pitch contours to detect the nuclei, and these pitch contours were not always visible in PRAAT for the used audio fragments (see also Figure 1). This could have led to the lower number of syllables in the fragments retrieved from the script. Furthermore, the authors of the script explain that noise should be extracted from the fragments for the script to perform optimally. However, due to the sources of the fragments used in this research it was impossible to completely take out all other sounds than the speech produced by the target speaker. The control by the additional speech analyst for three of the fragments did agree for 97,1% with the author's transcription of syllables.

From the number of syllables, articulation rate and speech rate were calculated. Articulation rate was calculated by dividing the number of syllables in each fragment by its duration in milliseconds, while the speech rate was calculated by dividing the number of syllables in each fragment by the duration of the fragment without all pauses (based on the definition in Dellwo et al. (2015) and described further in the next section).

Pauses

Pauses were annotated manually and by listening, and were marked either as a filled pause (F) or a silent pause (P) (tier three, Figure 1). When a silent pause and a filled pause occurred immediately after each other, they were not combined into one category. This was done to show whether there is a difference between speaking styles for the amount of filled versus silent pauses. Filled pauses can have a different purpose than silent pauses: in a non-spontaneous speaking style for example, silent pauses might be used to emphasize what is said and to let the audience think about what is said, while filled pauses may occur as a non-finality marker.

For all pauses, the duration was measured by selecting the pause in PRAAT, which then automatically showed the duration of the pause in milliseconds. Afterwards, the pauses were transformed into percentages for filled, silent and all pauses through the following formula: filled, silent, or total pause duration / number of pauses. The normalisation of pause duration in this way was used to make further comparison between pauses between fragments possible. Furthermore, it was calculated what proportion of fragment duration and pause duration was, by creating a percentage of pause duration for the whole fragment duration through the following formula: filled, silent, or total pause duration / total duration of the fragment * 100 %.

3.2.2 Intonation

Pitch

For the analysis of pitch, minimum and maximum pitch were retrieved from PRAAT through the options 'get minimum/maximum pitch' and 'move cursor to minimum/maximum pitch' in the view and edit window (see tiers five and six in Figure 1). The results of this option were checked through zooming in to the part where the minimum or maximum pitch occurred and repeating the same procedure to avoid pitch jumps. Pitch jumps are excluded from the analysis, because these are not included in the pitch contour of the speech. By subtracting the minimum pitch from the maximum pitch, the pitch range was calculated (tier seven, Figure 1). Furthermore, the mean pitch was retrieved from PRAAT through the option 'get pitch' in the view and edit window (tier eight, Figure 1).

Boundary Tones

The boundary tones are based on intonation phrases (IP) and intermediate phrases (ip): at the end each of these phrases, a boundary tone occurs with the last pitch accent (based on Prieto et al., 2012). Following Prieto et al. (2012: 687), an IP boundary was placed before a pause of 200 milliseconds or more, while an ip boundary was followed by a pause of less than 200 milliseconds. The third tier in Figure 1 marks whether the phrase is an intermediate phrase (ip) or an intonation phrase (IP). For each boundary tone, the author manually annotated whether it was a falling, neutral or rising boundary tone (following Blaauw, 1994: 367). An example of the decision for boundary types is presented in the fourth tier of Figure 1. In the analysis of the boundary tones, only falling and rising boundary tones are taken into account. According to Blaauw (1994: 370) level boundary tones occur with phonological boundary tones, but have no influence on the speaking style with intonation phrases. In the fragments used for the current research, the boundary tones occur with intonation phrases or intermediate phrases and not with phonological phrases. Therefore, percentages were created of boundary tones per fragment for falling and rising boundary tones to make comparison between the two types possible. However, for the comparison of the total number of boundary tones between speaking styles,

the level boundary tones were taken into account. To compare the number of boundary tones per speaking style, the number of boundary tones per second was calculated by dividing the duration of the fragment from the total number of boundary tones.

This section described the different measures used for the research. With these prosodic analyses, it is made possible to perform a statistical analyses between the measurements in the three conditions. In the next section, the results of the statistical analyses will be reported.

Table 3

Means and standard deviations per speaking style for the variables articulation and speech rate, pause duration, pitch mean and range and rising and falling boundary tones.

	S Mean (*SD*)	SS Mean (*SD*)	NS Mean (*SD*)
Fluency of speech			
Articulation rate	6.06 (0.86)	6.00 (0.82)	5.50 (0.54)
Speech rate	4.87 (0.87)	4.55 (0.99)	4.26 (0.78)
Pause duration (%)	19.90 (7.54)	24.93 (8.27)	22.67 (9.78)
Silent pause duration (%)	16.61 (6.64)	16.55 (2.03)	22.13 (9.95)
Filled pause duration (%)	3.25 (2.91)	8.21 (7.98)	0.52 (1.28)
Pause duration (milliseconds)	0.43 (0.06)	0.53 (0.12)	0.507 (0.20)
Silent pause duration (milliseconds)	0.46 (0.08)	0.560(0.16)	0.520 (0.19)
Filled pause duration (milliseconds)	0.25 (0.23)	0.41 (0.25)	0.036 (0.09)
Intonation			
Pitch mean (Hz)	116.24 (19.74)	118.40 (25.77)	138.60 (21.60)
Pitch range (Hz)	121.00 (38.46)	161.11 (71.28)	167.72 (51.08)
Rising boundary tones (%)	58.33 (38.17)	68.33 (21.87)	42.20 (34.20)
Falling boundary tones (%)	41.67 (38.17)	31.67 (21.87)	57.80 (34.20)
Boundary tones per second	0.47 (0.07)	0.47 (0.11)	0.45 (0.09)

4. Results

The statistical analyses will be reported in this section, and will show which speaking style has influence on which prosodic features and if and how the speaking styles differ from each other. The results will be reported in the dichotomy of the acoustic variables mentioned in the theoretical background: firstly, by reporting the results related to fluency of speech, i.e., the articulation rate and analyses of pauses. And secondly, by reporting the results related to intonation, i.e., pitch range, mean pitch and boundary

tones. For these variables, one-way repeated measures ANOVAs were performed with speaking style as a within-subjects factor (three levels: spontaneous (S), semi-spontaneous (SS) and non-spontaneous (NS)). The means and standard deviations of the dependent variables are given per speaking style in Table 3. In the following subsections, the significance of the differences between speaking styles for each acoustic variable is reported.

4.1 Fluency of speech

As mentioned above, fluency of speech was measured through articulation and speech rate and the analyses of pauses. First, consider the articulation and speech rate. The results showed that articulation rate was not significantly affected by speaking style, $F_{(2, 10)} = 2.126$, $p = .170$, $\eta_p^2 = .298$, nor was speech rate, $F_{(2, 10)} = 1.534$, $p = .262$, $\eta_p^2 = .235$.

Next to articulation and speech rate, several repeated measures ANOVAs were performed for the analyses of the pauses in the fragments. The analysis on the total number of pauses showed no significant main effect of speaking style, $F_{(2, 10)} = 1.731$, $p = .226$, $\eta_p^2 = .257$. A repeated measures ANOVA showed that the number of silent pauses were not significantly affected by speaking style, $F_{(2, 10)} = 2.389$, $p = .142$, $\eta_p^2 = .323$, but the number of filled pauses approached significance, $F_{(2, 10)} = 3.847$, $p = .058$, $\eta_p^2 = .435$. Pairwise comparisons showed that the difference between the silent pauses of S and NS approached significance ($p = .090$).

The mean duration of the silent, filled and total number of pauses was measured by dividing the total duration of the fragments from the duration of the pauses (see section 3.2.1). There was no main effect of speaking style on pause duration for all pauses, $F_{(2, 10)} = 0.815$, $p = .470$, $\eta_p^2 = .140$. A repeated measures ANOVA showed that the duration of filled pauses were significantly affected by speaking style, $F_{(2, 10)} = 6.653$, $p = .015$, $\eta_p^2 = .571$, but the duration of silent pauses were not, $F_{(2, 10)} = 0.540$, $p = .599$, $\eta_p^2 = .098$. Pairwise comparisons showed that there were significantly more filled pauses in the SS speaking style than both in the S speaking style ($p = .036$), and in the NS speaking style ($p = .028$). There was no significant difference between the speaking styles S and SS ($p = .124$). For the comparison of silent and filled pauses, a factorial repeated measures ANOVA was performed with speaking style (S, SS and NS) and type of pause (silent and filled) as within-subject factors. The results showed a significant main effect of type of pause on the mean duration, $F_{(1, 5)} = 30.339$, $p = .003$, $\eta_p^2 = .859$, and approached significance for speaking style, $F_{(2, 10)} = 4.057$, $p = .051$, $\eta_p^2 = .448$. The pause durations were shorter for filled pauses ($M = 0.231$, $SD = 0.057$) than for silent pauses ($M = 0.514$, $SD = 0.029$). There was no significant interaction effect between the speaking style and type of pause, however, it approached significance, $F_{(2, 10)} = 3.590$, $p = .067$, $\eta_p^2 = .418$.

Next to the measurement of the mean duration of pauses, the pauses were also compared with the total duration of the fragments. Therefore, a percentage of the pauses compared to the

duration of the speaking in the fragments was created. Thus, another factorial repeated measures ANOVA was performed to analyse the difference between type of pause and speaking style for the comparison of the duration of pauses within the total duration of the fragments. The results revealed a significant main effect of pause on the duration in the whole fragments, $F_{(1, 5)} = 57.364$, $p = .001$, $\eta_p^2 = .920$, but no main effect for speaking style, $F_{(2, 10)} = 1.600$, $p = .249$, $\eta_p^2 = .242$. The percentages for the pause durations compared with the whole fragments were smaller for filled pauses ($M = 4.0\%$, $SD = 1.209$) than for silent pauses ($M = 18.4\%$, $SD = 2.304$). Mauchly's test indicated that the assumption of sphericity had been violated for the interaction effect of speaking style and type of pause, $\chi^2(2) = 9.477$, $p = .009$. Therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .525$). There was no significant interaction effect between the speaking style and type of pause, $F_{(1.049, 5.245)} = 3.530$, $p = .116$, $\eta_p^2 = .414$.

4.2 Intonation

As mentioned above, intonation was measured through the analyses of mean pitch, pitch range and boundary tones. First, consider mean pitch. The repeated measures ANOVA performed on mean pitch showed a significant main effect of speaking style, $F_{(2, 10)} = 9.212$, $p = .005$, $\eta_p^2 = .648$. Pairwise comparisons showed that mean pitch of the NS speaking style was significantly higher than the SS speaking style ($p = .032$), and the difference between NS and S approached significance ($p = .077$). Furthermore, pairwise comparisons between the speaking styles S and SS revealed that the mean pitch are similar ($p = 1$). Next to mean pitch, a repeated measures ANOVA on pitch range was performed, which showed no significant main effect of speaking style, $F_{(2, 10)} = 3.113$, $p = .089$, $\eta_p^2 = .384$. However, pairwise comparisons showed a significant difference between speaking styles S and NS ($p = .020$): pitch range was higher for NS than S. Pairwise comparisons revealed that the pitch range is similar between SS and NS ($p = 1$), and not significant between S and SS ($p = .444$)

Lastly, a repeated measures ANOVA was performed on boundary tones and showed no significant main effect for the total amount of boundary tones on speaking styles, $F_{(2, 10)} = .090$, $p = .915$, $\eta_p^2 = .018$, nor for the rising boundary tones, $F_{(2, 10)} = 1.320$, $p = .310$, $\eta_p^2 = .209$, or falling boundary tones, $F_{(2, 10)} = 1.320$, $p = .310$, $\eta_p^2 = .209$. Pairwise comparisons showed that the total number of boundary tones was similar for all speaking styles ($p = 1$). For the comparison between falling and rising boundary tones, a factorial repeated measures ANOVA was performed with speaking style (S, SS and NS) and type of boundary tone (falling and rising) as within-subjects factors. The results showed no significant main effect for boundary tones, $F_{(1, 5)} = 0.467$, $p = .525$, $\eta_p^2 = .085$, and no interaction effect, $F_{(2, 10)} = 1.320$, $p = .310$, $\eta_p^2 = .209$. In spite of this result, Figure 2 does show that the percentage of rising boundary tones is lower than the falling boundary tones in NS, while the opposite occurred for the S and SS speaking styles.

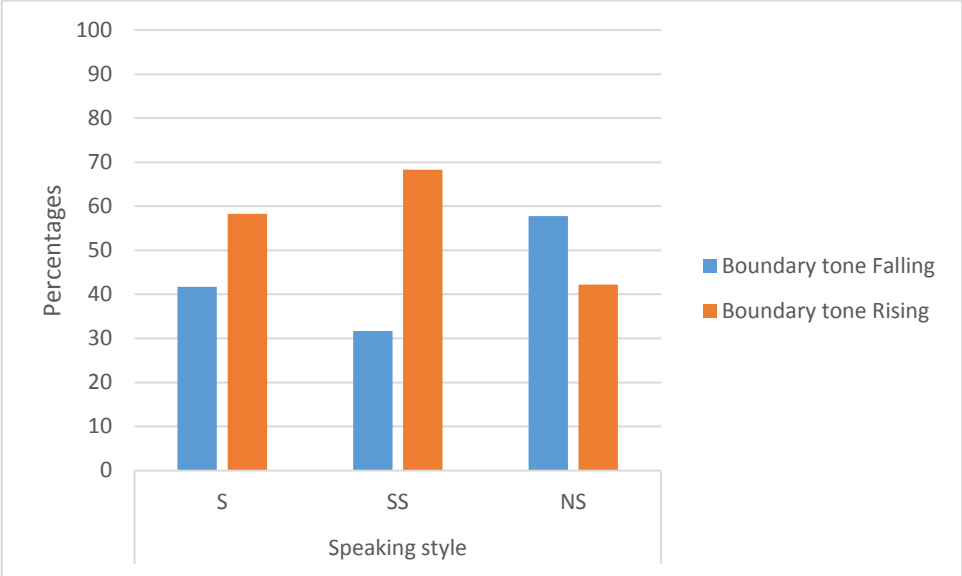

Figure 2

Percentages of number of falling and rising boundary tones per speaking style.

Overall, only pitch mean and filled pauses showed to affect the speaking styles significantly. The next section will discuss the results and give a conclusion.

5. Discussion

In this section, the results will be discussed in comparison with the hypotheses stated in section 2.4. The hypotheses were summarized in Table 1, which is presented again in this section for convenience (see Table 4).

5.1 Influential acoustic variables (RQ1)

5.1.1 Fluency of speech

Articulation rate

Speakers analysed in this study did not speak faster when speech was less prepared, therefore H1 can be rejected. This outcome of the results of the analyses differs from other research (e.g., Fujisaki, 1997; Dellwo et al., 2015; Trouvain et al., 2001). However, previous research focused on the difference between read and spontaneous speech produced in a laboratory setting. This might influence the speaking styles, which is why this study chose for a natural setting of the speakers: they spoke in front of an audience and were motivated to speak naturally, not prompted by the investigator or a confederate. This naturally produced speech showed different results than the so-called lab speech used in former research. Therefore, it can be suggested that the research with the designs of speech produced in a laboratory setting might not be reliable. Nevertheless, it cannot be said that the current

research is for this reason more reliable than previous research. Therefore, the results from the current research should be checked in further research to confirm the suggestion that articulation rate is not a determinant for naturally produced speaking styles. The current research did not investigate the significance on the difference between naturally produced speech and lab speech, thus further research for this suggestion is needed. Furthermore, the non-spontaneous speech produced by the speakers of the current study is not always read out loud. One of the politicians read a lecture out loud from their memory instead of an autocue. This could have led to the difference between the current study and previous studies.

Pause

H2a and H2b were also rejected: overall, the number and the duration of pauses did not differ significantly between speaking styles. Pause analyses did show significant differences between the duration of filled pauses for the different speaking styles, while this did not occur for the total number of pauses and the silent pauses. This is an important result, because former research on pause analyses between speaking styles mostly excluded the analysis of filled pauses (e.g., Howell & Kadi-Hanifi, 1991). Furthermore, the design of previous studies made it impossible to create naturally spoken speech, because the speech was read out loud from a paper. However, non-spontaneous speech in the current study also included speech read out loud or from memory, which might create less chance for filled pauses. Nevertheless, from the current study, it cannot be confirmed that there is a correlation between the fluency of speech and speaking style as a continuum of speech (H2c), because speakers spoke with more filled pauses in the semi-spontaneous speaking style than both the spontaneous and non-spontaneous speaking styles.

Furthermore, there was no interaction effect between pause duration of the different pauses and the speaking styles. This result approached significance, which suggests that there might be a significant interaction effect when the amount of speakers analysed increases. This could lead to the assumption that the mean duration of pauses is longer in non-spontaneous speech than in semi-spontaneous and spontaneous speech, which was stated in H2b. Further research on speaking styles and their influence on pauses is needed. As for the distribution of different types of pauses in the fragments, there was no significant interaction effect: the speaking styles did not differ significantly in the number of filled or silent pauses. However, this might be different when analysing longer fragments, which will probably include more pauses. The current study analysed only 30 seconds of speech per fragment, which were mostly part of a longer conversation. Therefore, it can be expected that analysing the whole conversation might show different results. For example, during non-spontaneous speech a speaker might lose track of their lecture, which might lead to more filled pauses.

5.1.2 Intonation

Pitch

Mean pitch and pitch range indeed showed higher pitch for the non-spontaneous speaking styles than for the spontaneous speaking style, as suggested in H3. This confirms the results from prior studies on pitch contour (e.g., De Ruiter, 2015; Dellwo et al., 2015; Koch, 2008). However, there did not appear to be a continuum: the semi-spontaneous speaking style was similar to the spontaneous speaking style regarding mean pitch, yet similar to the non-spontaneous speaking style with respect to pitch range. This can be explained by the fact that semi-spontaneous speech can be partly prepared, which makes it possible to emphasize certain words by means of creating a higher pitch. This could have led to the higher pitch range, which was similar to the non-spontaneous speaking style. However, because the speech overall was less prepared for in the semi-spontaneous speaking style, the mean pitch could be more compared to the spontaneous speaking style.

Furthermore, non-spontaneous speech mostly occurs at formal speaking events, which might lead to nervous speakers. When people are nervous, they tend to tighten their vocal cords which leads to higher pitch frequencies. However, in the current research, speakers were professionals and are used to giving lectures or read out loud a text, whether from their memory or from an autocue. Therefore, the nervousness of the speakers are probably less compared to non-professional speakers. The current research took this factor of nervous speaking style into account, and chose for audio fragments from professional speakers. This has probably decreased the influence of nervousness. For this factor, the results of the current research cannot be generalized to every speaker – as there is a lot of speaker variability and the nervousness of speakers will also differ.

Boundary tones

The fourth prediction was that boundary tones were influenced by speaking style, which would result in more boundary tones in the spontaneous speaking style than the semi-spontaneous and non-spontaneous speaking style (H4a). It was predicted that there would be more falling boundary tones in the non-spontaneous speaking style, while there would be more rising boundary tones the more spontaneous the speaking style is (H4b). Boundary tones did not seem to be influenced by speaking style. Though, as Figure 2 shows (p. 25), the non-spontaneous speaking style did seem to have a higher number of falling boundary tones than rising boundary tones, while opposite occurred for both the other speaking styles. These results contradict the results of former research of Blaauw (1994), Bauman and Riester (2013) and De Ruiter (2015). This difference might not be significant because of the low number of falling or rising boundary tones in the analysed fragments in the current study. Therefore, this difference should be focus of further research.

5.2 Continuum of speech (RQ2)

Overall, speaking styles seemed to be influential for the pitch contour and pause duration. However, a continuum of speech did not occur. The results showed that the semi-spontaneous speaking style influenced the filled pauses most, which made a continuum of speech from spontaneous to non-spontaneous speaking style impossible. Dellwo et al. (2015) suggested that there might be a hierarchy for the acoustic variables influenced by speaking styles. This could, on the other hand, be partly confirmed from the results of the current study. For the non-spontaneous speaking style, pitch seemed to be most influential, while for the semi-spontaneous speaking style filled pauses were more influenced. Table 4 summarizes the results of the current research in comparison with the hypotheses formulated before analyses.

Table 4

Summary of the hypotheses and the results of the current study, X = hypothesis rejected, and where possible the adjusted hypothesis.

	Variable	Hypothesis	Results
	Fluency of speech		
H1a	Articulation rate	S > SS > NS	X
H1b	Speech rate	S > SS > NS	X
H2a	Number of pauses	S > SS > NS	X
H2b	Duration of pauses	S < SS < NS	X
H2c	Number of filled pauses (in comparison with silent pauses)	S > SS > NS	SS > S & NS
	Intonation		
H3a	Pitch range	S < SS < NS	NS > SS & S
H3b	Pitch mean	S < SS < NS	NS > SS & S
H4a	Number of boundary tones	S > SS > NS	X
H4b	Number of falling boundary tones	S < SS < NS	X
	Number of rising boundary tones	S > SS > NS	X
H5	Continuum of speech	S – SS – NS	Hierarchy of cues

6. Conclusions

6.1 Research questions

In this section, the research questions will be answered, practical implications will be discussed, and further remarks on the current research will be given. The first research question was: What are the differences between spontaneous (S), semi-spontaneous (SS) and non-spontaneous (NS) speaking style regarding the acoustic variables? The current study showed that pitch and filled pauses were indeed influenced by speaking style. Pitch was higher for the non-spontaneous speaking style, and filled pauses occurred more in the semi-spontaneous speaking style than both the other speaking styles. This also leads to the answer on the second research question: Is there a continuum of speech according to the differences in the acoustic variables of the speaking styles? The analysis on pitch showed that it is merely a determinant for the non-spontaneous speaking style, while the analysis on filled pauses showed to be a determinant for the semi-spontaneous speaking style. There seems to be no continuum, but more a hierarchy of acoustic variables that are determinants for different speaking styles.

6.2 Practical implications

Thus, spontaneous, semi-spontaneous and non-spontaneous speaking styles only sometimes differ from each other, but different speaking styles are influenced by different acoustic cues. Pitch was shown to be influenced more by the non-spontaneous speaking style, while filled pauses were influenced more by semi-spontaneous speaking style than by the other speaking styles. This result suggests that there is a hierarchy of the acoustic variables per speaking style. The current research showed the importance of studying naturally produced speech instead of speech produced in a laboratory setting, as the results differ from former research on speaking styles. Therefore, further theoretical research should focus on naturally produced speech, for example using videos or fragments available online.

Practical implications for the development of signal processing schemes can also be influenced by the results of the current study, as the current study showed that pitch and pauses are characteristic for different speaking styles. Thus, to make the speech in those technology application or speech-enhancement algorithms more natural and spontaneous, those acoustic variables should be taken into account. The same is important for actors and spokespersons, who want to appear as natural and spontaneous speakers. However, for the persuasiveness of speaking styles, different acoustic cues might be important. This will be interesting for further research, and will be elaborated on in the next section. Furthermore, for example language learners or teachers of a language learning program can benefit from the current research, because it showed that speaking styles differ. And, to speak spontaneously, one should not learn to speak from written text – as this non-spontaneous speaking

style is shown to be different from spontaneous speech. Moreover, the current study showed that filled pauses do not belong to non-spontaneous speech. Thus, when filled pauses occur in speech, it would probably be seen as more spontaneous. Nonetheless, there are some limitations and other remarks to the current study, and further research is needed, which will be elaborated on in the next section.

6.3 Further remarks

It should be noted that the differences between speaking styles found in the current study on filled pauses and pitch cannot be generalized to other languages or language families (e.g., Xu & Wang, 2009; Dicanio, 2015; Blaauw, 1994: 163; Prieto et al., 2012). For example, in Mandarin Chinese, the middle syllable is always pronounced faster than the other syllables in a word (Xu & Wang, 2009). Furthermore, Smiljanic and Bradlow (2009) suggest that hyper articulation can be used to enhance intelligibility of speech, but that the duration of such cues differ per language. The studies reviewed in the current thesis were all based on the Germanic language family, which, aside from Dutch, also includes the German and English language.

Furthermore, the current research is limited, because the data used in this study only consisted of six speakers. Including more speakers in the study could have created more significant results, just as using longer fragments could have led to this effect. This might be necessary for determining the influence of speaking styles on acoustic cues, especially for the analysis of boundary tones and pauses. Further research should take this into account to create more reliable results with higher effect sizes. For the analyses of pauses, the current research for example showed that the interaction effect between speaking style and pause duration approached significance. Further analyses can consider to use more and longer fragments of speech of different speaking styles, to examine whether this interaction between the speaking style and filled pauses exists or not. When this is the case, it can be combined with the research from Corley et al. (2007), which showed that presentations are better followed and remembered when there are hesitations (i.e., filled pauses) in the speaking style. This combination can lead to the question what the effect is on the appreciation of the speaking styles. A follow up study can be conducted by performing a study for example on the persuasion of different speaking styles. As Corley et al. (2007) showed in their study, presentations are better followed and remembered when there are hesitations. Thus, it might be that semi-spontaneous speech has more effect on the persuasion than other speaking styles, as it is shown in the current research that semi-spontaneous speech included more filled pauses.

Another possibility for further research that followed from the current study is the analysis of the hierarchy of acoustic cues per speaking style. This was suggested by Dellwo et al. (2015) and is further supported in the current research: the semi-spontaneous speaking style seemed to influence

the filled pauses more, while the non-spontaneous speaking style seemed to influence the mean pitch and pitch range more than the other speaking styles. However, it seems important to first consider the difference between lab speech and naturally produced speech. This could be examined through collecting data of non-spontaneous speech in 'real-life', as defined in the current research, and of read speech produced in a laboratory setting. Both data groups can then be compared on several acoustic cues, to investigate the exact difference between the two speaking styles and whether there is such a distinction as is suggested in the current research.

References

Audacity Team (2015). Audacity® (Version 2.1.0). Retrieved from http://audacityteam.org/

Baumann, S., & Riester, A. (2013). Coreference, lexical givenness and prosody in German. *Lingua, 136,* 16-37.

Beckman, M. E. (1997) A typology of spontaneous speech. In Y. Sagisaka, N. Campbell & N. Higuchi (Eds.), *Computing prosody. Computational models for processing spontaneous speech* (pp. 7-26). New York, NY: Springer-Verlag.

Blaauw, E. (1994). The contribution of prosodic boundary markers to the perceptual difference between read and spontaneous speech. *Speech Communication, 14*, 359-375.

Boersma, P., & Weenink, D. (2015). Praat: doing phonetics by computer (Version 5.4.09) (Computer software). Retrieved from http://www.fon.hum.uva.nl/praat/

Burger, S., MacLaren, V., & Yu, H. (2002). The ISL meeting corpus: The impact of meeting type on speech style. Retrieved from http://isl.anthropomatik.kit.edu/cmukit/downloads/icslp02_susi.pdf

Clip Converter (2015). Free Online Media Conversion and Download. Retrieved from: http://www.clipconverter.cc/nl/

Corley, M., MacGregor, L.J., & Donaldson, D.I. (2007). It's the way that you, er, say it: Hesitations in speech affect language comprehension. *Cognition, 105*, 658-668.

Dellwo, V., Leemann, A. & Kolly, M. J. (2015). The recognition of read versus spontaneous speech in local vernacular: The case of Zurich German. *Journal of Phonetics, 48*, 13-28.

De Jong, N.H. & Wempe, T. (2009). Praat script to detect syllable nuclei and measure speech rate automatically. *Behavior research methods, 41* (2), 385 - 390.

De Ruiter, L. E. (2015). Information status marking in spontaneous vs. read speech in story-telling task – Evidence from intonation analysis using GToBI. *Journal of Phonetics, 48*, 29-44.

DiCanio, C., Hosung, N., Amith, J. D., Castillo García, R., & Whalen, D. H. (2015). Vowel variability in elicited versus spontaneous speech: Evidence from Mixtec. *Journal of Phonetics, 48*, 45-59.

Fowler, C. A. (1988). Differential Shortening of Repeated Content Words Produced in Various Communicative Contexts. *Language and speech, 31* (4), 307-319.

Fujisaki, H. (1997). Prosody, models, and spontaneous speech. In Y. Sagisaka, N. Campbell & N. Higuchi (Eds.), *Computing prosody. Computational models for processing spontaneous speech* (pp. 27-42). New York, NY: Springer-Verlag.

Howell, P. & Kadi-Hanifi, K. (1991). Comparison of prosodic properties between read and spontaneous speech material. *Speech Communication, 10*, 163-169.

Koch, K. A. (2008). Spontaneous speech, lab speech, and effects on intonation: some useful findings for fieldworkers (and laboratory phonologists). *Proceedings of the 2008 annual conference of*

the Canadian Linguistic Association. Retrieved from: http://homes.chass.utoronto.ca/~cla-acl/actes2008/CLA2008_Koch.pdf

Krause, J. C., & Braida, L. D. (2004). Acoustic properties of naturally produced clear speech at normal speaking rates. *Acoustical Society of America*, 362-378.

Laan, G. P. M. (1997). The contribution of intonation, segmental durations, and spectral features to the perception of a spontaneous and a read speaking style. *Speech Communication, 22*, 43-65.

Labov, W. (1972). The isolation of contextual styles. In W. Labov (Ed.), *Sociolinguistic patterns* (pp. 70-109). Oxford, England: Blackwell University of Pennsylvania Press.

Lickley, R.J., Schepman, A., & Ladd, D.R. (2005). Alignment of "Phrase Accent" Lows in Dutch Falling Rising Questions: Theoretical and Methodological Implications. *Language and Speech, 48* (2), 157-183.

Pitrelli, J., Fong, C., Wong, S.H., Spitz, J.R. & Leung, H.C. (1995). PhoneBook: a phonetically-rich isolated-word telephone-speech database. *Acoustics, Speech, and Signal Processing, 1*, 101-104.

Prieto, P., del Mar Vanrell, M., Astruc, L., Payne, E., & Post, B. (2012). Phonotactic and phrasal properties of speech rhythm. Evidence from Catalan, English, and Spanish. *Speech Communication, 54*, 681-702.

Smiljanic, R. & Bradlow, A.R. (2009). Speaking and hearing clearly: talker and listener factors in speaking style changes. *Lang. Linguist Compass, 3*(1), 236-264.

Swerts, M., Strangert, E., & Heldner, M. (1996a). F0 declination in read-aloud and spontaneous speech. *Proceedings of the Fourth International Conference on Spoken Language, 3*, 1501-1504. Doi: 10.1109/ICSLP.1996.607901

Swerts, M., & Zerbian, S. (2010). Prosodic transfer in Black South African English. Retrieved from http://speechprosody2010.illinois.edu/papers/100198.pdf

Swerts, M., Wichmann, A., & Beun, R.-J. (1996b). Filled pauses as markers of discourse structure. *Proceedings of the Fourth International Conference on Spoken Language, 2*, 1033-1036. Doi: 10.1109/ICSLP.1996.607780

Trouvain, J., Koreman, J., Erriquez, A. & Braun, B. (2001). Articulation rate measures and their relation to phone classification in spontaneous and read German speech. *Proceedings of the Workshop Adaptation Methods for Speech Recognition*, 155-158.

Wu, C.-H., & Yan, G.-L. (2004). Acoustic feature analysis and discriminative modelling of filled pauses for spontaneous speech recognition. *Real World Speech Processing*, 17-30.

Xu, Y. (2010). In defense of lab speech. *Journal of Phonetics, 38*, 329-336.

Xu, Y., & Wang, M. (2009). Organizing syllables into groups—Evidence fromF0 and duration patterns in Mandarin. *Journal of Phonetics, 37*, 502-520.

Appendix A

Elaborated description of Audio fragments per speaker, including information about the context, date of recording, date of downloading, part of fragment, duration

Speaker	Profession	Condition	Context	Date of recording	Source and downloading date	Part of original fragment (approx.)	Duration (in sec.)
Alexander Pechtold	Politician	Spontaneous	Museum visit with Dieuwertje Blok, watching the painting 'Het puttertje' – in television program 'Landinwaarts'	12-03-2015	NPO 29-04-2015	8.00 – 8.30	28.96
Alexander Pechtold	Politician	Semi-Spontaneous	Ntr Interview programme '5 Jaar later', which is a follow-up interview program to look back at what was said five years ago.	30-12-2011	5 Jaar later 22-04-2015	3.17 – 3.43	24.68
Alexander Pechtold	Politician	Non-Spontaneous	Promotion video political party D66	14-06-2012	Promotion D66 22-04-2015	Start – 0.30	29.95
Philip Freriks	Newsreader	Spontaneous	Interview with child in 'Willem Wever' about the selection of news	2-12-2003	Willem Wever 22-04-2015	4.55 – 5.19	25.04
Philip Freriks	Newsreader	Semi-Spontaneous	Interview in Museum of Army about his ancestors	23-11-2011	Legermuseum 22-04-2015	Start – 0.24	24.65
Philip Freriks	Newsreader	Non-Spontaneous	NOS Journaal, one of the Dutch news publishers on television	17-12-2009	Journaal 22-04-2015	0.28 – 0.52	24.36
Rik van de Westelaken	Newsreader	Spontaneous	'Confession' in an entertainment television program, called 'Wie is de Mol'	3-03-2015	Wie is de Mol 29-04-2015	0.20 – 0.47	26.28
Rik van de Westelaken	Newsreader	Semi-Spontaneous	Interview Radioshow 'De Perstribune'	28-12-2014	De Perstribune 22-04-2015	0.56 – 1.19	23.18

Rik van de Westelaken	Newsreader	Non-Spontaneous	NOS Journaal, one of the Dutch news publishers on television	11-04-2015	NPO 22-04-2015	12.55 – 13.20	25.09
Twan Huys	Newsreader	Spontaneous	At his home in the television program 'Dat is andere taal'	26-09-2012	Dat is andere taal 22-04-2015	15.12 – 15.40	28.65
Twan Huys	Newsreader	Semi- Spontaneous	Interviewing Herman Finkers in 'College Tour'	6-03-2015	College Tour 29-04-2015	13.16 – 13.28 + 15.56 – 16.09	25.69
Twan Huys	Newsreader	Non-Spontaneous	Announcement for television news program 'Nieuwsuur'	20-06-2011	Nieuwsuur 22-04-2015	Whole video	21.05
King Willem Alexander	Politician	Spontaneous	Documentary 'Máxima, portret van een prinses', where he discusses a speech in the presence of his assistants and his wife.	7-02-2012	NPO 22-04-2015	3.07 – 3.19	12.24
King Willem Alexander	Politician	Semi-Spontaneous	Interview NOS and RTL Willem-Alexander and Maxima, when they announced to become king and queen of the Netherlands.	17-04-2013	Interview Monarchs 22-04-2015	0.27 – 0.56	30.33
King Willem Alexander	Politician	Non-Spontaneous	Troonrede Prinsjesdag, a speech the king gives each year on the third Tuesday of September.	16-09-2014	Troonrede 22-04-2015	start – 0.30	29.06
Wouter Bos	Politician	Spontaneous	RTL television program about soccer: Voetbal International	10-09-2010	Voetbal International 22-04-2015	0.41 – 0.46 + 0.48 – 1.03	19.70
Wouter Bos	Politician	Semi-Spontaneous	Interview program by students, called Room for Discussion	8-10-2014	Room for Discussion 22-04-2015	2.14 – 2.48	34.53

Wouter Bos	Politician	Non-Spontaneous	Lecture Isala Wetenschapsavond – a scientific evening	16-12-2014	Isala Wetenschapsavond 22-04-2015	2.41 – 3.12	31.11