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Personality in the mix - investigating the contribution of fillers and speaking style to the perception of spontaneous speech synthesis

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Abstract

Studies on human-human interactions have shown that that the fluency of a speaker influences the perception of personality. Adding fillers and discourse markers can make the speaker seem uncertain, more casual and spontaneous. With recent TTS developments it is now possible to investigate if the same holds for artificial speakers. In a previous experiment, it was shown that local insertion of fillers in a regular TTS voice influenced the perceived personality. In the current study we extend that work in two ways: Firstly, we recreate the English experiment adding a voice trained on spontaneous speech, where adding fillers also has a global effect on the synthesized speech. We also add Swedish read and spontaneous voices. Secondly, for the Swedish voices, we investigate the effect of using a multi-speaker model mixing a read speech voice and a spontaneous speech voice when generating disfluent synthetic speech.

Index Terms: spontaneous speech synthesis, personality traits, speaking styles, fillers

1. Introduction

The way people speak in conversation is dependent both on extralinguistic factors like age, gender, dialect and personality, and on situation-dependent factors, like affective state, cognitive load and feedback from the listener. Hence, the actual realization of a spoken utterance influences how listeners perceive the speaker, both in terms of personality and cognitive state. Filler words like filled pauses ("uh") and discourse markers ("you know") play an important role in communicating these in spontaneous speech. Filled pauses have been viewed in three ways [1]: as a floor-holding signal [2], as interjections [3], where .e.g. "um" has been found to announce a longer delay in the upcoming speech than "uh" [4], and as symptoms to a planning problem [5]. Thus, filled pauses appear to be useful for the listener in conversations: as a turn-handling cue [6], to improve comprehension [7, 8] and to understand the speaker's certainty of what they are saying [9]. The usage patterns of filled pauses have been found to vary with nationality, age, gender and socio-economic class [10]. Filled pauses have been found to influence the perception of personality traits like neuroticism, and extensive use of filled pauses have been rated negatively as unprepared, unsophisticated, and insecure [11].

Discourse markers are often used to indicate the speaker's stance. Depending on the speaker, context and prosodic realisation "you know" and "I think" can express both confidence and uncertainty, seeking confirmation of understanding from the listener [12]. "I mean" and "like" have been found to act as fillers, as hedging devices to what is being said [13] and to mark modification of what was previously said [14]. Discourse markers such as "like" are more common for younger speakers and in loose talk, where it is produced in the middle of fast and fluent speech [15]. They have been found to be markers of conscientiousness [16], as well as casualness, solidarity, politeness and spontaneity [17, 15, 18].

Prosodic features like pitch and speaking rate also influence the perception of personality [19]. Extraversion is associated with fast speaking rate and a wide pitch range, while introversion is perceived in slow, soft, deep and monotone voices [20]. Speaking rate influences the perception of several speaker traits, where slower speech is perceived as older in age [21] and more introvert [22], while faster speech is associated with higher knowledge and social attractiveness [23], greater persuasiveness [24], and higher competence and dominance [25]. In the current study, we aim to investigate how fillers and speaking style influence the perception of personality in read and spontaneous speech synthesis.

2. Related work

There have been several investigations in making read speech synthesis more spontaneous and expressive by automatically inserting fillers in its text input [26, 27, 28]. In order to make a diphone unit selection synthesizer more suitable for generating fillers, spontaneous speech utterances have been supplemented to its read speech training corpus [29]. Recently, [30] introduced a spontaneous speech synthesizer trained on a conversational podcast corpus, that could automatically insert and synthesize natural sounding fillers.

There have been some previous efforts in synthesizing voices with personality: a diphone synthesis voice was made more extrovert by providing it with the stereotypical extrovert features: high loudness, increased pitch, a great frequency range and a fast speaking rate [31]. In a project that developed voices for a speech-enabled computer game that features fairy-tale characters with different personalities, both speaking rate modifications and insertions of fillers was used [32].

The current paper builds on a previous study by Wester et al., where filled pauses where added to a read speech unit selection synthesizer in order to alter the perceived personality of the voice [33]. The authors found that adding fillers makes the artificial voice sound more neurotic, less open, less extrovert and less conscientious. In a follow-up study, they also investigated the effect of synthesis method and voice quality on the perceived personality and naturalness [34]. The result showed that increased voice quality enhances the personality the text conveyed, but it does not alter it to another personality. In this study we extend their work by using a state-of-the-art neural sequence-to-sequence speech synthesizer built from a spontaneous speech corpus. The main contributions of this work are that we extend their perceptual experiment on read speech to spontaneous speech synthesis, and that we investigate the perceptual effect of training a multi-speaker model, that allows us to mix between a read speech voice and a spontaneous speech voice when generating disfluent synthetic speech.

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3. Speech synthesizers

In this paper we carry out studies on read and spontaneous speech synthesis in English and Swedish. For the English read speech synthesis we use the female Scottish CereVoice unit selection synthesis voice Heather. The English spontaneous speech voice and both Swedish voices are built using a PyTorch implementation[1] of Tacotron 2 [35]. The voices were trained using transfer learning for 200k iterations on top of a pre-trained model trained on large (ca. 20 hours) read speech corpora in English and Swedish. For vocoding, we fine-tuned the pre-trained universal model of WaveGlow to the English and Swedish conversational corpora [36].

The English spontaneous speech corpus is created from the audio recordings of the Trinity Speech-Gesture Dataset (TSGD) [37], which is comprised of 25 impromptu monologues by a male Irish actor. In each session (ca 10 minutes long) the actor tells a listener in the room about his hobbies, daily activities, and interests. The Swedish spontaneous speech corpus consist of 6 hours of speech extracted from a conversational podcast recorded by a male Swedish comedian. In the podcast, the co-median makes sandwiches and tell stories to his co-host. The data is very spontaneous and includes a lot of laughter and overlapping speech, which had to be removed from the TTS corpus before training the voice. Both spontaneous corpora were transcribed using ASR and subsequently manually corrected, to ensure that all fillers are transcribed accurately. Segmentation was done automatically into breath groups (stretches of speech delineated by breath events) using a deep learning-based breath detector described in [38]. The Swedish read speech corpus is an open source TTS corpus from the Norwegian Språkbanken [2]. The 11-hour speech corpus consists of 5200 sentences read by a professional speaker. In the current study, we make use of a version of the Swedish synthesizer where both voices have been trained at the same time in a multi-speaker version of Tacotron-2 [35], with a speaker embedding concatenated to the encoder outputs at every token as in [39]. For training a multi-speaker model, an 8 dimensional speaker embedding is appended to a pre-trained single speaker Tacotron-2 model built on spontaneous speech, with the weights of the additional nodes initialized at 0. This setup implies that interpolating between speaker vectors changes speaker identity and speaking style simultaneously, since the read speech and the spontaneous speech corpora were recorded by two different people.

The English read speech samples were taken from the study by Wester and colleagues [33]. In order to make disfluent versions of the synthesized prompts, the authors spliced in spontaneous fillers from the voice actor they used to train the TTS voice. The English and Swedish spontaneous voices described above both contain spontaneous fillers in the training corpus and could thus be generated at the same time as the linguistic content of the prompt. The Swedish read speech voice did not contain fillers in the training corpus, but as the multi-speaker model was trained together with the spontaneous voice, it was possible to produce fillers even when the read speaker's identity vector was applied at inference. In order to assess to what extent this affected the quality of speech with fillers, we also investigated the perceived personality trait of disfluent speech at different interpolation points between the two speaker id vectors. The English spontaneous speech and all Swedish samples in the evaluations below are available online [3].

[1] https://github.com/NVIDIA/tacotron2

[2] https://www.nb.no/sprakbanken/en/resource-catalogue/

[3] http://www.speech.kth.se/tts-demos/ssw2021personality

4. Experiments

In these experiments, our aim is to study how the way a speech synthesizer reads a text influences the perceived personality using the Big-Five model: *Extraversion* (Enthusiasm, Assertiveness); *Neuroticism* (Volatility, Withdrawal); *Conscientiousness* (Industriousness, Orderliness); *Agreeableness* (Compassion, Politeness) and *Openness* (Intellect, Openness). [40]. In order to measure the perceived personality traits, we used the ten Newcastle Personality Assessor (NPA) Questions, as in the original study (Appendix). We also used the same texts as the original study [33], which were designed to elicit different personality traits. They include a person's view of their working environment and a speed dating utterances with negative or positive emotions. They were translated to Swedish (Appendix).

4.1. Experiment 1: perceived personality depending on speaking style and fluency

The first study examined to what extent the perception of personality of synthesized speech depends on whether it is trained on read or spontaneous speech and if the input text contains fillers. We investigated this both in English and in Swedish, where all texts were synthesized in 4 versions: *read fluent* (Eng-Read-Flu, Swe-Read-Flu) , *read disfluent* (Eng-Read-Dis, Swe-Read-Dis), *spontaneous fluent* (Eng-Spon-Flu, Swe-Spon-Flu) and *spontaneous disfluent* (Eng-Spon-Dis, Swed-Spon-Dis). For each language we recruited 60 participants via Prolific. During the test, each synthesis file was presented at the top of a web page, with the 10 personality questions/statements below, where the subjects had to score each on a Likert scale from "Very Unlikely" to "Very Likely". For both languages all sound files were assessed by 30 subjects each.

4.2. Experiment 2: perceived personality depending on the mix of read and spontaneous speaking style

The aim of the second evaluation is to study the extent to which the perception of personality of synthesized speech depends on to which degree the voice speaks with a read or spontaneous speaking style. Using the multi-speaker model, 5 variants of the 13 prompts were generated, where the read/spontaneous speech ratios, set by interpolation between the two speaker identity vectors at inference, were 100/0 90/10, 50/50, 10/90 and 0/100. In the perceptual test, we focused on the personality traits where there was a difference in judgment of speaking style in the Swedish part of Experiment 1: Extraversion, Conscientiousness and Openness. Furthermore, since the ratings of these did not depend on fluency we only used the prompts with inserted fillers A total of 40 participants were recruited via Prolific to take part in a MUSHRA-like side by side assessment of how well the 5 variants agreed with the personality questions/statements.

4.3. Experiment 3: perceived spontaneity depending on speaking style and fluency

The third study, we investigated to what extent the perception of spontaneity depends on the insertion of fillers on the input text, and on whether the voice was trained on read speech or conversational podcast data. In Experiment 3 we used 10/90 and 90/10 speaker ratios, since they where less extreme in speaking rates, and we only included the 10 shortest of the 13 prompts. A total of 40 participants were recruited via Prolific to take part in an A/B test where they could listen to two version of the same prompt that differed either in fluency or speaking style, and select which one they thought sounded more spontaneous.

5. Results

5.1. Results 1: perceived personality depending on speaking style and fluency

Mean scores for the personality judgements in English and Swedish can be seen in Figure 1. A one-way ANOVA and a post-hoc Tukey multiple comparison test identified the following significant differences between the voices. For English, the spontaneous voice was perceived as significantly more extrovert than the read one, both for fluent and disfluent styles ($p < 0.001$). A similar pattern was seen for openness, however less strong when comparing the fluent styles ($p = 0.02$). For the read voice, the fluent style was more open than the disfluent style ($p < 0.001$). For neuroticism, the disfluent read voice was more neurotic than the fluent one ($p < 0.001$) but this relation did carry over to the spontaneous voice. The disfluent read voice was also more neurotic than the disfluent spontaneous voice ($p < 0.001$). For conscientiousness, the fluent read voice scored higher than the disfluent read voice.

For Swedish, the spontaneous voice was rated as more extrovert than the read voice ($p < 0.001$), while the read voice was rated as more open and ($p < 0.001$) and conscientious ($p < 0.001$). There were no significant differences in personality between the fluent and disfluent styles of the Swedish voices.

5.2. Results 2: perceived personality depending on the mix of read and spontaneous speaking style

Mean scores of the personality judgement for the Swedish voices on the continuum from 100%spontaneous to read speech (or 0% spontaneous) can be seen in figure 2 (left). A one-way ANOVA and a post-hoc Tukey multiple comparison test identified the following significant differences: For extraversion, there were significant differences ($p < 0.001$) between all voices except the extremes (100% vs 90% and 10% vs 0%), where more spontaneous was rated more extrovert. Regarding both openness and conscientiousness, the less spontaneous styles (50%, 10% and 0%) was rated significantly higher than the spontaneous ones ($p < 0.001$).

5.3. Results 3: perceived spontaneity depending on speaking style and fluency

Results from the pairwise comparisons of Swedish voices with respect to spontaneity can be seen in Figure 2 (right). The spontaneous voices were judged more spontaneous than the read voices, and the disfluent voices were judged more spontaneous than the fluent. All differences were significant ($p < 0.001$).

6. Discussion

The results of Experiment 1 show that there is a larger effect on the personality rating of adding fillers to the read speech samples that in the spontaneous speech. Adding fillers to read speech makes the voice significantly more neurotic and less open and less conscientious. This is consistent with the original study where adding fillers to read speech also made it less extrovert. For the Swedish voices, the inserted fillers had no significant effect on the personality ratings. The reason might be that the fillers inserted in the English unit selection synthesis were prosodically different than the surrounding speech, and thus more prominent. In the spontaneous English voice and both Swedish voices, fillers where treated as any word in the TTS, which meant that the prosodic realization of both the fillers and the surrounding speech where generated cohesively.

For both Swedish and English the spontaneous voices were rated significantly more extrovert than the read speech voices regardless of fluency. This is consistent with previous findings that extroversion is associated with greater pitch range and faster speaking rate. For the English samples with fillers, the spontaneous ones were rated as significantly more open and less neurotic than the read speech versions. For Swedish, the spontaneous samples were rated less open and less conscientious than the read speech versions. According to previous psychological studies, speakers with great prosodic variability are perceived as "competent" and "knowledgable", thus they should rate high on conscientiousness. At the same time, this trait is also described as "organized", "thorough", and "reliable", which matches speaking style of professional radio speakers, which is a slow and low pitched voice [41]. In our case the read speech voice is recorded with a professional low pitched speaker, which might explain the results.

In Experiment 2 we studied the effect of mixing speaking styles through different interpolations between speaker ids in a multi-speaker model. For openness and conscientiousness the difference between read and spontaneous speech was not very large. For extroversion the difference was quite large and the 50/50 mix is rated in the middle of the ratings for read and spontaneous speech. Overall the speaking rate and pitch range increases with more spontaneous speech in the mix, and this is reflected in the personality ratings. What we could find was that adding 10% spontaneous speech into the read speech voice improved the way it realized the fillers, and by adding 10% read speech into the spontaneous voice made it slightly slower and more articulated. At the same time, these small modifications did not have a significant effect on the personality ratings.

In Experiment 3, we decided to investigate how the 10/90 and 90/10 mixes of read and spontaneous speech voices were rated in terms on perceived spontaneity. Regardless of fluency, the voice with the weight mainly towards conversational speech was almost always rated as more spontaneous than the one with weight towards read speech. Regardless of speaking style, adding fillers makes a voice sound significantly more spontaneous.

7. Conclusions

In this paper we investigated the impact of speaking style and the addition of fillers on perceived personality traits and spontaneity. We confirmed the results of Wester et al. [33], that adding spontaneous fillers into read English speech synthesis makes it significantly more neurotic and less open and less conscientious, but in our listening tests, only slightly less extrovert. For English spontaneous speech synthesis adding fillers only had a significant difference for extraversion and openness. For Swedish, fillers did not change the perceived personality, but is changed the perceived spontaneity. These results are promising because it means that we can insert fillers in a voice in cases where it needs to sound more spontaneous, without changing the portrayed personality. We also found that it is beneficial both for a read speech voice and a spontaneous speech voice to co-train it with a voice with another speaking style, even if they differ in voice quality. It gives the possibility to either slightly adjust the speaking style and handling of fillers, or to create a voice style that exhibits characteristics halfway between read speech and spontaneous speech.

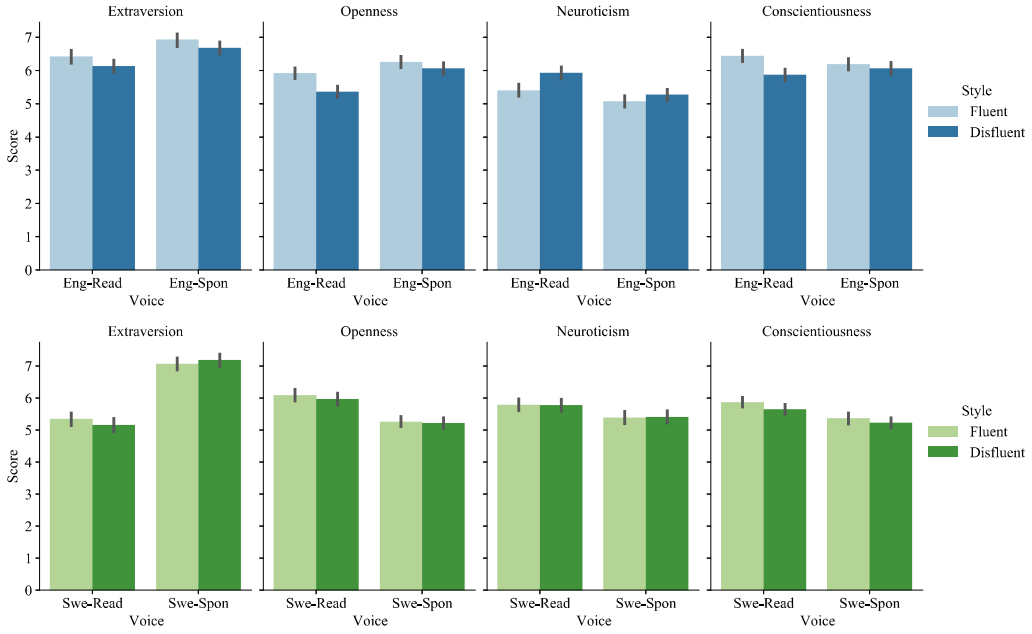

Figure 1: *Results of the personality rating experiments for EN (top) and SW (bottom)*

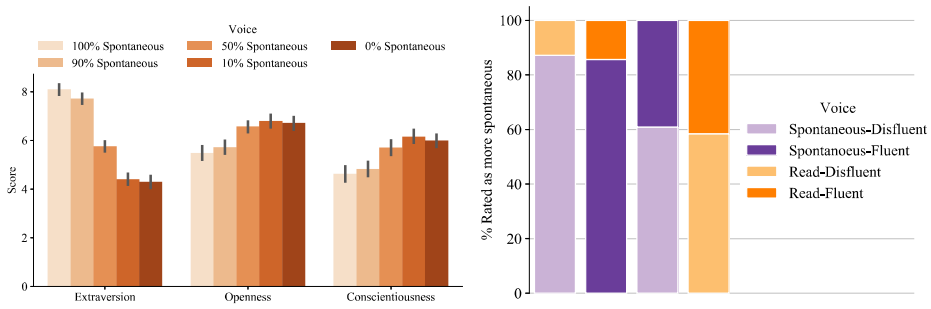

Figure 2: *Extended experiments on the Swedish voices. Left: MUSHRA-like simultaneous scoring of voices on a continuum from read to spontaneous w.r.t. to personality questions. Right: A/B comparison of* read *vs.* spontaneous *voice and* fluent *vs* disfluent *voice w.r.t. the question "Which one sounds more spontaneous?"*

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10. Appendix

Newcastle Personality Assessor Questions/statements: Start a conversation with a stranger? (Ext); Make sure others are comfortable and happy? (Agr); Use difficult words? (Ope); Prepare for things in advance? (Con); Feel blue or depressed? (Neu); Plan parties or social events? (Ext) Insult people? (-Agr) Think about philosophical questions? (Ope); Let things get into a mess? (-Con); Feel stressed or worried? (Neu)

ID	Sentences
A1	I like to bring order to everything I do (YOU KNOW). I think the details and facts are often missed by others and (UM) I like to work based on concrete result. If faced by a problem I like to look at it logically and (LIKE) make a decision based on the specific problems at hand.
A2	(I MEAN) I'm good at encouraging others to work with each other and cooperate effectively. I think that if you look after and help colleagues you (UH) get the best out of them.(I MEAN)If you do good work then the people around you will also become more motivated.
A3	I'm great at getting people to work with each other and (I MEAN) sorting out misunderstandings and conflict. If you concentrate on the common ideas and values you all share (YOU KNOW) you can find real insight and discover new possibilities.
A4	I like to plan provide direction and (UM) make sure everyone knows what their responsibilities are. I think its very important to be a good example to others (LIKE) to be committed and to work hard on doing things the right way to achieve your goals.
A5	I'm good at encouraging others to contribute (UM) effectively. I think its important to enjoy your work and to be enthusiastic about what you do(YOU KNOW)
A6	I'm great at helping others plan and (LIKE) cooperate to get things done. Its important to work out what can be done and (UH) the best way to do it. (I MEAN) I like to work with others and help everyone come together behind a project.
A7	I'm good at developing new strategies and approaches to a problem and I think (UM) being committed to what you do is very important. I love innovation and overcoming challenges (YOU KNOW)
N1	I'm from West London ; which is a part of town I really dislike (YOU KNOW). it was a real pain it the arse to get here (I CAN TELL YOU) ; I used to like film until Hollywood (LIKE) ruined them all.
N2	What a mess this place is (I MEAN) I'm sure the organiser has got it in for me.I've always had problems with people either because they are stupid or (UH) jealous of me.
N3	(UM) you don't seem to have made much effort though given the losers here (LIKE) I'm not surprised you'd probably be happier (UM) um watching TV at home.
P1	I'm from a lovely little suburb with (UM) lots of trees and parks. The train is very quick and it was no (LIKE) trouble to get here. I love going to the beach and (LIKE) spending time with my friends.
P2	They've done a brilliant job at redecorating this bar (YOU KNOW) The people running it have been (UM) really nice to me. I always get on with people (I MEAN) we have so much to share with each other.
P3	(I MEAN) I must say you are looking very nice tonight Everyone is very nicely dressed and (LIKE) seem so successful (UM) I expect you are looking forward to coming again.

Table 1: *The prompts from Wester et al 2015 [33]. About Myself (A) Speed Dating Negative (N) and Speed Dating Positive (P)*

ID	Sentences
A1	Jag gillar och ha ordning på allt jag gör(SKULLE JAG SÄGA) Jag tycker att detaljerna och fakta ofta saknas i det andra gör och (EH) Jag gillar att arbeta baserat på konkreta resultat. Om jag ställs inför ett problem vill jag angripa det logisk och (TYP) fatta ett beslut baserat på det specifika problemet .
A2	(JAG ANSER ATT) jag är bra på att uppmuntra andra att arbeta med varandra och samarbeta effektivt. Jag tycker att om du tar hand om och hjälper kollegor så får du (EH) ut det bästa av dem. (DET ÄR JU SÅ ATT) om du gör bra arbete då kommer folk omkring dig också att bli mer motiverade.
A3	Jag är bra på att få människor att arbeta med varandra (LIKSOM) och reda ut missförstånd och konflikter. Om du koncentrerar dig på de gemensamma idéerna och värderingarna (ALLTSÅ) så kan du komma till verklig insikt och upptäcka nya möjligheter.
A4	Jag gillar att planera ge vägledning och (EH) se till att alla vet vad deras ansvar är. Jag tycker att det är mycket viktigt att man är ett bra exempel för andra (LIKSOM) att man är engagerad och arbetar hårt för att göra saker på rätt sätt för att uppnå sina mål.
A5	Jag är bra på att uppmuntra andra att bidra (EH) effektivt. Jag tycker att det är viktigt att man njuter av sitt arbete och att man är entusiastisk över det man gör (SÅ ATT SÄGA)
A6	Jag är bra på att hjälpa andra att planera och (LIKSOM) samarbeta för att få saker gjorda. Det är viktigt att ta reda på vad som kan göras och (EH) det bästa sättet att göra det. (JAG MENAR) jag gillar att arbeta med andra och hjälpa alla att känna sig delaktiga i ett projekt.
A7	Jag är bra på att utveckla nya strategier och tillvägagångssätt för att lösa problem och jag tycker att det är mycket viktigt (EHM) att man är engagerad i det man gör. Jag älskar innovation och att övervinna utmaningar (SÅ ATT SÄGA)
N1	Jag är från västra London som är en del av staden som jag verkligen ogillar (SKULLE JAG SÄGA). Det var ett jäkla sjå att komma hit (SÅ ATT SÄGA). Jag brukade gilla film tills Hollywood förstörde dem alla.
N2	Vilken röra det är på det här stället (JAG MENAR) jag är säker på att arrangören inte gillar mig Jag har alltid haft problem med folk antingen för att de är dumma eller (EH) avundsjuka på mig.
N3	(EH) du verkar inte ha gjort stora ansträngningar men med tanke på förlorarna här (LIKSOM) är jag inte förvånad du skulle förmodligen vara lyckligare (EHM) om du var hemma och kollade på tv
P1	Jag kommer från en härlig liten förort med (EH) massor av träd och parker. Tågresan var mycket kort och det var (TYP) inga problem att ta sig hit. Jag älskar att åka till stranden och (LIKSOM) spendera tid med mina vänner.
P2	Dom har gjort ett fantastiskt jobb med att renovera den här baren (ALLTSÅ), Dom som driver det har varit riktigt (EH) trevliga mot mig. Jag kommer alltid väl överrens med folk (JAG MENAR) vi har så mycket att dela med oss av till varandra.
P3	(JAG MENAR) jag måste säga att du ser väldigt bra ut ikväll. Alla är väldigt snyggt klädda och verkar (LIKSOM) så framgångsrika. (EH) Jag förväntar mig att du ser fram emot att komma tillbaka.

Table 2: *The Swedish translation of the texts. About Myself (A) Speed Dating Negative (N) and Speed Dating Positive (P)*