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On the change in Speech Quality and Speed with a Tongue Interface for Control of Rehabilitation Robotics – A Case report

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Abstract— **Previous studies have described inductive tongue computer interfaces (ITCI) as a way to manipulate and control assistive robotics, and at least one commercial company is manufacturing ITCI today. This case report investigates the influence of an ITCI on the speed and quality of speech. An individual with tetraplegia read aloud a short part of "The Ugly Duckling", a well-known story by Hans Christian Andersen, in her native language Danish. The reading was done twice, first with her own Removable Full Upper Denture (RFUD) and secondly with a copy of this RFUD with an integrated ITCI in the palatal area. A word count assesses the speed of 5 minutes of reading aloud, and the confidence of an automated transcription into text measures the quality. This study found no difference in the speed or quality of speech between two settings with or without an ITCI.**

I. INTRODUCTION

The ITCI has demonstrated the potential to empower individuals with severe disabilities to control various personal assistive systems including rehabilitation robotics, wheelchairs, text editing and exoskeletons [1-5]. The ITCI was developed at Aalborg University, Denmark and later commercialized by TKS [6] under the name Itongue®, and consists of an electronic package placed in the palatal area, and a pointing unit attached to the tongue. The user can activate sensors at the palate with the pointing unit that sends a specific control signal to the assistive system or robot depending on the activated sensors. The ITCI can provide an individual with tetraplegia with a broad array of potentially invaluable rehabilitation strategies. A person with tetraplegia that controlled a robotic arm with an ITCI proceeded to control the robot to perform a handshake with the experimenter. This was her first handshake since her spinal cord injury 19 years ago. She was also able to grasp a bottle of water and pour into a cup [4]. An advantage that ITCI has over many other control systems is the invisibility of the intraoral system, which makes it less stigmatizing for the user. The potential disadvantages for the user have drawn less attention. The intraoral ITCI will inevitably take up space from the tongue and thus potentially affect speech, which is a well-known problem for denture wearers [7]. Subjective assessment of speech [1] has indicated that a subject with an RFDU with built-in ITCI did not feel any speech impairment, whereas three subjects who had the ITCI attached to their own teeth felt the speech affected but found it was improving throughout the experiment. On the other hand, some researchers speculate that an ITCI in fact makes it impossible to talk and use such a device simultaneously [8]. These potential problems could limit the users' acceptance of such a system. This case report therefore focuses on the possible changes in speech when the user wears an ITCI. The speech's speed and quality are compared between two settings, one with the subjects own everyday RFUD and secondly with a copy of this RFUD with an integrated ITCI in the palatal area. Speech quality for persons with RFUD was assessed previously in a study with computer-assisted automatic speech recognition [9].

II. METHODS

A 48-year-old female with tetraplegia due to a spinal cord injury at level C5 enrolled as a volunteer in the experiment. The subject had used an RFUD for many years without problems and was excellent at reading aloud. This RFUD was copied one to one and had an ITCI from the company TKS [6] built in (Fig 1).The subject had previously had a tongue piercing [10] that held the pointing device, and the subject was comfortable with this. Therefore, the tongue piercing was in place during the whole experiment.
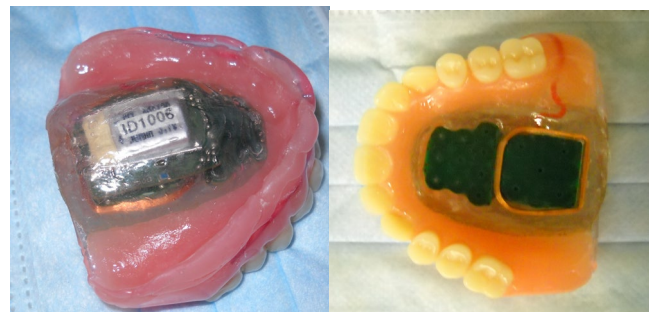
Fig. 1 removable full upper denture with integrated tongue control system, upper and lower aspect.

In a laboratory shielded from external noise, the subject read aloud a part of "The ugly Duckling" a well-known story by Hans Christian Andersen in two settings. In the first setting with her everyday RFUD and in the second setting with a copy of this RFUD with an integrated ITCI in the palatal area. The reading aloud in both sessions was recorded once and on the same laptop in WMA -format (Microsoft). The subject had the chance to rehearse the reading aloud the day before the experiment once with both types of RFUD.

An online and automated transcription service [11] transcribed the two WMA files to text in Danish. The transcription program gave an assessment of the accuracy of the transcribed words with the ratings "very confident", "fairly confident" and "slightly confident" and these ratings were used as an objective measure for the quality of the reading aloud. The speed of reading aloud was based on a simple word count in Word (Microsoft) based on a stamped timeline in the transcribed document. Three persons with Danish as their native language listened carefully to the recordings from the two sessions to try to identify general speech differences between the two sessions.

The local ethical committee approved this study: Den Videnskabsetiske Komité for Region Nordjylland.

III. RESULTS

The subject carried out the reading without interruptions, and the only flaw was that the subject started a sentence over again in the second setting at the very end of the reading. None of the three persons that listened to the recordings was able to identify any significant differences that could distinguish the two sessions. The duration of the reading was 5.19 minutes in the first setting and 5.03 minutes in the second setting. The reading speed was measured in 1-minute intervals and showed a rate of 113, 117, 114, 117 and 117 words per minute in the first 5 minutes of reading in the first setting with the usual RFUD and 114, 113, 122, 116, 142 words per minute in the second setting with integrated ITCS in the RFUD (Fig 2). The accuracy of transcription to text in
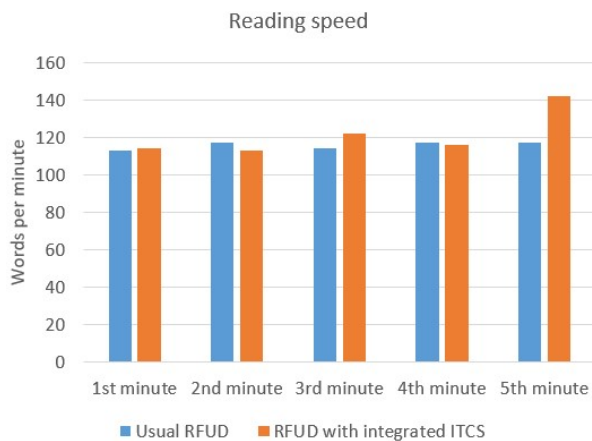
TABLE 1 - THE QUALITY OF READING ALOUD, MEASURED WITH THE SONIX TRANSCRIPTION SOFTWARE FEEDBACK

Transcription quality	very confident	fairly confident	slightly confident
Subject's usual RFUD	89,79%	8,10%	2,11%
RFUD with integrated ITCI	88,67%	9,85%	1,48%

the first session was "very confident" in 89.79%, "fairly confident" in 8.10%, and "slightly confident" in 2.11% of the words. In the second setting the accuracy of transcription to text was "very confident" in 88.67%, "fairly confident" in 9.85%, and "slightly confident" in 1.48% of the transcribed words (Table 1).

IV. DISCUSSION

We tested the difference in the speech quality and speed between the two settings due alone to the size of the ITCI and the fact that other researchers have speculated that it is impossible to talk and use an ITCI at the same time, which showed not to be the case in this study. Together with a previous study [12] indicating that speech also do not elicit unwanted sensor activations and, further, can take place simultaneously with tongue controlling a powered wheelchair, these results support that speech effectively can take place using the ITCI. The transcription software turned out to be useful as an easy and fast means to obtain a quality assessment of the speech. This, however, requires a confident reader with good pronunciation, which may not be always the case in part of the target group for the ITCI. Furthermore, potential quality issues with the transcription software may interfere with the result, as inconsistencies in the transcriptions could render the two settings incomparable. We have attempted to alleviate concerns in this regard by personally listening to the recordings and trying to find differences between the two settings. It may be unwise to generalize from this case study, but it could show an easy way to collect valid data on speech quality and speed.

V. CONCLUSION

This study found no difference in the speed or quality of speech between two settings, namely with and without an ITCI. Further studies on this topic that include the subject's satisfaction with the overall speech ability with such systems would be beneficial. Artificial intelligence transcription systems could provide a fast and affordable means to assess changes in speed and quality of speech in cases where intraoral tongue control systems are needed.

Fig.2 The speed of reading aloud during the two sessions measured as a simple word-count in intervals of 1 minute.

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