A Pilot Study on Conversational Speech Differences Between Transmen with and Without Hormone Replacement Therapy

Chris F., Department of Physiology, University of Wyoming, 2019

Abstract

Transgender individuals have offered researchers important and otherwise unattainable opportunities to study the behavioral effects and functions of sex hormones in human adults. Furthermore, testosterone's role has been heavily implicated in language processing in a variety of studies (Lombardo et al, 2012; Wolf et al, 2000). In conjunction with this, a recent study on transmen analyzed before and after undergoing four months of high-dosage testosterone hormone replacement therapy (HRT) observed considerable changes in both the gray and white matter brain regions associated with speech production, a trait which has been found to be distinguishable between the sexes (Hahn et al, 2015; Signh et al, 2001).

Presently, it is uncertain if sexual differentiation of speech is rooted predominantly in social and cultural factors or biological influences, and this study hopes to open the door to answering this question. The goal of this study is to determine if there is a statistically significant difference between the speech patterns between transmen who have not undergone HRT and transmen who have. We have transcribed the speech of a group of transmen that have never been exposed to HRT and a group that has undergone HRT for more than six months. We then used lexical richness measures as described in Singh, 2001 to compare the two groups due to its success in differentiating male and female speech patterns.

Introduction

Broadly, testosterone has been heavily implicated in both the process of differentiating sexually dimorphic brain regions as well as for modulating language function (Lombardo, 2012; Wolf, 2000). More particularly, a recent study that compared MRI scans of female-to-male (FtM) individuals before taking hormone replacement therapy (HRT) and four months after consistent HRT were found to have statistically significant reduction in the Broca's Area and Wernicke's area, gray matter regions of the brain associated with language production and processing, along with significant strengthening of a white matter pathway that bridges the two regions (Hahn, 2015). Importantly, this study strongly suggests neuronal plasticity in the effects of circulating sex hormones even in late life.

In this study, we evaluated the speech patterns of a group of transmen that has never undergone HRT and compared it to a group of transmen that has consistently taken HRT medications for longer than six months. This speech was compared using lexical richness measures found to be different between cisgender men and women to attempt to discern if these gendered differences can be attributed to testosterone's role in language production.

Methods

There were 13 participants in this study, 6 of which that had not undergone HRT and 7 of which that had. For the purpose of this study, we define HRT as a female-to-male hormone therapy drug consisting of high dosage testosterone such as Testosterone cypionate, testosterone enanthate, dissolved testosterone crystals, DepoTestosterone®, Delatestryl®, AndroGel®, Androderm®, or other approved forms of high dosage testosterone medication. As a prerequisite to participate in this study, we required that individuals could have no history of speech issues, stroke, or any form of brain injury that may impact speech production. The demographic form used to verify these qualifications has been attached in Appendix A. Previous studies using lexical richness measures did not find significant differences between individuals based on age or educational background, and therefore this information was not gathered (Singh, 2001).

Each participant was recorded on a one-to-one basis in a quiet room with a handheld recording device. All subjects had approximately 30 minutes of speech recorded, and between 900-1100 words of speech transcribed. Stereotyped speech and set phrases such as “to be honest” or “you know” were omitted from analysis. “Yes” and “no” in direct response to questions were also omitted.
The slight variance in transcribed speech length was allotted to allow for the conversation to come to a natural close due to the belief that ending the transcription prematurely would influence word frequency variables. However, the transcription was kept to as close to 1000 words as possible since text length is also believed to be an influencing factor. Subjects were asked about a list of standard conversation starters, such as hobbies, music interests, and past experiences. This organic and conversational speech was transcribed and measured for seven distinct speech units, as in accordance with the lexical richness measures utilized by Singh (2001):

1. Noun rate per 100 words

2. Pronoun rate per 100 words

3. Adjective rate per 100 words

4. Verb rate per 100 words

5. Clause-Like Semantic Units (CSU) per 100 words. This is defined as "the minimum number of words in a grammatically cohesive string with semantic meaning,” (Singh 2001).

6. W value, calculated using $N^{V-.165}$. This is defined as a measure of “how varied the vocabulary is,”(Singh 2001). Lower values indicate lexical richness.Typical values are 10-20.

7. R value, calculated using 100*log (N)/ (1 - V_1/ V). This is defined as “the propensity of a speaker to to choose between the alternatives of employing a word used previously or employing a new word,” (Singh 2001). Higher values indicate greater lexical richness. Typical values are 1000-2000.

In these equations, N is the length of the entire text, V is the total number of distinct vocabulary used, and V_1 is the number of words used only one time. The first four measures are based on lexical items. Clause-like semantic units (CSUs) is a measure of how well participants can combine words into phrases, and a series of rules delineated in in Singh and Bookless (1997) was followed to calculate CSUs. CSUs often end at conjunctions. For instance, “I saw a cat,| but I didn’t pet it” contains two CSUs. For this study, we calculated CSUs per 100 words. A higher rate indicates shorter CSUs while a low rate indicates high CSUs, and a low rate is believed to denote better sentence making abilities. W is a measure that relates how varied the vocabulary is within a text, and the finally, R has been explained by Holmes (1992) as: “ It directly tests the propensity of a [speaker] to choose between the alternatives of employing a word used previously or employing a new word ... When comparing texts, therefore, the higher the R-value is, the richer the vocabulary in the sense that a greater number of words appear infrequently”, (Holmes, 1992). Roughly, W and R are expected to be inversely related.

To calculate the first four variables, transcriptions were ran through Stanford University’s Maximum Entropy Part-of-Speech tagger program, and results were then manually verified. CSUs were determined manually and tagged. Tags were then counted using a tag finder. W and R were both calculated by running the transcripts through a free and open source word frequency counter to determine N, V, and V_1, and these variables were plugged into the aforementioned equations to determine values.

Analysis

Descriptive Analysis

If testosterone does play a role in speech production, we expect the relationship between participants that have undergone HRT for more than 6 months and to those naive to HRT to mimic the relationship between cisgender men and cisgender women respectively. Therefore, we have analyzed the results in comparison to these findings between cisgender men and women in Singh (2001) while also analyzing the associations between certain variables independently.

The descriptive statistics for the group naive to HRT and the group exposed to HRT is shown in Figure 1. The purpose of this first analysis is to identify significant relationships between different variables and observe key differences between the two demographics informally. Upon first inspection, participants having undergone HRT have a higher noun-rate measure and a lower pronoun-rate measure than their pre-HRT counterparts. Variability amongst participants without HRT is much higher in regards to pronoun-rate while there is little difference in variability between the two groups on noun-rate.

Participants that have undergone HRT also have a marginally higher adjective-rate with a much larger variance between participants. These observations follow the trends denoted in Singh (2001) between cisgender men and women. While there are no relationships found to strongly oppose the trends found in Singh's study, many variables did not show any significant difference in variability or mean value, including CSUs, W, and R.

Correlational Analysis

The correlational analysis between variables is denoted in Figure 2, and all figures above 0.70 have been highlighted. Pearson's correlation coefficient differs between demographics on a number of variables, but show more similarities than cisgender male and female statistics. For example, while cisgender male and female statistics show a large variation in magnitude between P-value and N-value (R= -0.80 in cisgender men and R= -0.31 in cisgender women) our data maintains the inverse relationship between P-value and N-value but loses much of the change in magnitude between groups (R= -0.76 in transmen with HRT and R= -0.92 in transmen without HRT.) Interestingly, both demographics of transmen show a correlational value closer to that of cisgender men than cisgender women. While cisgender women have been noted to use nouns and pronouns interchangeably, this pattern does not hold true for transmen regardless of HRT usage. Beyond this, pronoun and adjective-rate are significantly correlated in the group of transmen naive to HRT, but are inversely correlated to a lesser extend to the group exposed to HRT. While this follows the trend observed by Singh (2001), the difference observed is considerably greater than that between cisgender men and women. This same phenomenon occurred between adjective-rate and verb-rate.

The adjective-rate and the R measure were found to be inversely correlated in both groups, but the group naive to HRT was found to have a stronger correlation. Notably, the R measure and verb-rate was found to be positively correlated in transmen using HRT but strongly inversely correlated in those naive to HRT. These findings deviate from the results observed by Singh (2001).

Many of the variables do not show a substantial difference between the two demographics analyzed in either Singh's study or ours, such as adjective-rate and noun-rate, pronoun-rate and verb-rate, or CSU-rate and any of the other lexical richness measures.

Conclusion

In short, some of the gender differences observed by Singh (2001) between cisgender men and women appear to persist between transmen that have undergone HRT and those that have not, while some lexical richness measures more closely associate with either cisgender female or cisgender male data regardless of HRT usage. Due to the small sample size, no definitive conclusions can be confirmed from this study, but current data suggests that testosterone may play a role in language production, but other social, cultural and biological factors are also present.

Figure 1 **Descriptive Analysis**

	Min	Max	Mean	StDev
Noun-rate HRT no HRT	16.7 14.1	20.7 19.1	18 16.3	1.39 2.47
Pronoun-rate HRT no HRT	11.8 15.0	16.2 18.8	14.3 16.5	1.43 1.52
Adj-rate HRT no HRT	5.04 4.46	11 7.11	6.44 5.78	2.09 .844
Verb-rate HRT no HRT	19.8 19.9	22 23.7	20.8 22.4	0.848 1.41
CSU HRT no HRT	10.5 12.0	14.3 14.7	12.4 13.1	1.55 1.03
W HRT no HRT	13.4 13.3	14.5 14.1	13.8 13.7	.372 .335
R HRT no HRT	692 730	808 794	745 753	43.3 23.4

Figure 2 **Correlational Analysis**

	N-rate	P-rate	A-rate	V-rate	CSU	W
P-rate						
HRT	**-0.76**					
no HRT	**-0.92**					
A-rate						
HRT	-0.18	-0.49				
no HRT	-0.64	**0.76**				
V-rate						
HRT	0.064	0.18	-0.57			
no HRT	-0.39	0.42	**0.88**			
CSU-rate						
HRT	-0.42	0.49	0.38	0.13		
no HRT	-0.39	0.40	0.68	0.57		
W						
HRT	-0.01	-0.06	0.00	-0.52	-0.51	
no HRT	-0.51	0.57	0.61	0.58	0.40	
R						
HRT	0.44	-0.10	-0.45	0.53	0.07	-0.42
no HRT	0.26	-0.27	**-0.75**	**-0.96**	-0.37	-0.55

Appendix A

Have you ever undergone female-to-male hormone replacement therapy? This would include but is not limited to injecting, ingesting, or topically applying any of the following: Testosterone cypionate, testosterone enanthate, dissolved testosterone crystals, DepoTestosterone®, Delatestryl®, AndroGel®, Androderm®.

Yes _____ No _____ Unsure _____

If you answered yes to the previous question, have you been using this product in accordance with its recommended dosage or longer than 6 months?

Yes _____ No _____ Unsure _____

If yes, have you stopped using this product at any time (including currently not using the medication?)

Yes _____ No _____ Unsure _____

Have you ever had a stroke, brain aneurysm, encephalopathy, or other disease or ailment known to influence speech?

Yes _____ No _____ Unsure _____

References

Holmes, D. I. (1992). A stylometric analysis of mormon scripture and related texts. Journal of the Royal Statistical Society (A), vol. 155, Part 1, 91-120.

Lombardo, M.V., et al., 2012. Fetal testosterone influences sexually-dimorphic gray matter in the human brain. J Neurosci 32(2): 674–680.

Singh S. A pilot study on gender differences in conversational speech on lexical richness measures. Literary and Linguistic Computing, Vol 16, Issue 3, 2001 Sep, pp. 251–264,doi.org/10.1093/llc/16.3.251

Singh S., Bookless T., Analyzing spontaneous speech in dysphasic adults, The International Journal of Applied Linguistics, vol. 7.2, no. 2, pp. 165-182, 1997.

Wolf, O.T., et al., 2000. Testosterone and cognition in elderly men: a-single testosterone injection blocks the practice effect in verbal fluency,-but has no effect on spatial or verbal memory. Biol Psychiatry 47(7):-650–654.