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A Speech Test to Assess Mask Efficacy

Kaanchana Parameswaran, Bryant Lin MD, *Member, IEEE*

***Abstract*— Face masks prevent viral spread. Their effectiveness depends on intrinsic material composition and user fit. Our research shows that Word Error Rate (WER) calculations for a custom speech test on two common Automatic Speech Recognition (ASR) platforms correlates with intrinsic mask filtration.**

***Clinical Relevance*— This simple and fast procedure can be used by clinical staff and patients to check the efficacy of face coverings and masks given the current COVID-19 pandemic.**

I. INTRODUCTION

Most non-medical consumer masks do not provide any measure of filtration. Numerous studies have separately profiled filtration efficacy [1], and the audio/speech transmission characteristics through various types of masks and facial coverings [2]. Our research proposes a new custom speech test derived from standard hearing loss tests to compare any face covering with the National Institute for Occupational Safety and Health (NIOSH) certified N95 mask.

II. METHODS

We chose the bestselling masks on Amazon for our experiments. We used a low-cost wind tunnel, equipped with (1) a Sensirion SPS30 Laser Particulate Matter Sensor, (2) a Testo 405i anemometer and (3) a Philips Respironics nebulizer to measure mask filtration efficacy. A standard ducted fan pulled a constant velocity stream of saline aerosol through each mask specimen. Particulate Matter (PM) per unit volume ($\mu g/cm^3$) was recorded for 1μm particles that penetrated the mask samples.

We developed a series of sentences which comprised phonemes with spectral peaks peaks in the 8 - 16 KHz frequency band, where most mask materials show the greatest differential attenuation between low and high frequencies [2]. The sentences are: *(1) Seek the self. (2) Hasten to see puss. (3) The Swiss sift gas. (4) Sip that gus. (5) Sees this seep. (6) Fasten the parcel. (7) Sop plus class.* Two speakers, (male and female) read the sentences with and without each of the 11 masks into both Google and Amazon ASR systems with a pre-set cadence and visual analog volume feedback to maintain consistency. A phoneme-based Word Error Rate (WER) was calculated for each sentence.

Kaanchana Parameswaran is a student intern at Stanford University School of Medicine, Stanford CA 94305 (email: kaanchip@icloud.com)
Bryant Lin MD is Associate Professor, Stanford University School of Medicine, Stanford CA 94305 (e-mail: bylin@stanford.edu)

III. RESULTS

Table 1 shows the correlation between WER and Filtration for the most popular masks on Amazon as of January 2021.

TABLE I. WER AND FILTRATION FOR POPULAR MASKS

Mask Type	*PM 1μm Filtration*	*WER (Avg)*	*WER (GOOG)*	*WER (Amzn)*
NIOSH N95	**99.7%**	**32.6 %**	**26.1%**	**39.1%**
Black Disposable (FLTR)	98%	17.5%	17.4%	17.4%
Purple Surgical (Disposable)	98%	19.6%	21.74%	17.4%
KN94	94%	19.6%	17.4%	21.74%
Double Mask (Athletic + Blue Surgical)	81%	24%	21.7%	26.1%
Blue Surgical (Disposable)	73%	21.7%	21.7%	21.7%
Vida (PM2.5 insert)	33%	15.2%	17.4%	13%
Proper Cloth Black	24%	13%	17.4%	8.7%
Athletic Black	7%	15.2%	13%	17.4%
3M Everyday	5%	13.1%	8.7%	17.4%

The N95 mask shows the highest correlation between WER and filtration, followed by the Double-Mask. Masks with a filtration below 50% exhibit poor correlation to WER.

IV. DISCUSSION & CONCLUSION

Masks with the highest filtration exhibit the largest differences between mid and high frequency attenuation. Consequently, these masks show the best correlation between WER and filtration. Enhancements in ASR platforms can be accounted for by adding custom signal processing code that calibrates the user input stream into the ASR system based on the WER of a reference sentence. Our work provides the basis for a smartphone application that can be widely deployed to rapidly evaluate the efficacy of face coverings.

REFERENCES

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