# Understanding the Spread of COVID-19 Through the Analysis of Speech Droplets

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## Abstract

In the midst of the COVID-19 pandemic, many studies analyzing the transmission of the deadly virus have surfaced, but an in-depth examination of the variance in speech droplet density over a predetermined distance has not been reproduced and studied sufficiently. Many scientists have shown the effectiveness of different masks in blocking the dispersion of potentially infectious speech droplets; however, the question of determining the range of speech droplets with and without masks still stands. In this research, we made use of a small particle analyzer in order to determine the relative size of speech and breath droplets. Given the relative size of droplets, we captured a series of images detailing the spread of particles over a distance of six feet using a green laser curtain. Images captured with the subject wearing a mask revealed a substantial decrease in droplet density across the six foot range. In public settings involving a crowd of people, the usage of masks greatly reduce the transmission of COVID-19 and many other airborne viruses. Specifically in a public speaking setting, it would be safer for the speaker to wear a mask and the audience not have any masks than for the speaker to remove his mask whilst having the audience wear masks. The safest option would have both the speaker and the audience wearing masks.

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## Introduction

Due to the the COVID-19 pandemic, scientists and and doctors have come together in an effort to stop the spread of the virus and they decided that wearing face-masks would greatly decrease the number of cases arising; however, how effective are face-masks in stopping potentially infectious speech or breath droplets from spreading and what is the range, in distance, for which face-masks retain their efficiency? Despite the general rule of remaining six feet apart whilst wearing masks, reports have conflicted on the distances people had to remain apart from each other and on whether masks and gloves were even necessary for preventing the spread of the virus. In the words of Nina Bai, a scientific writer for the University of California San Francisco, "Both the Centers for Disease Control and Prevention (CDC) and the World Health Organization now recommend cloth masks for the general public, but earlier in the pandemic, both organizations recommended just the opposite" (Bai, 2020). As the worldwide death toll increases, a consensus generated by an easily reproducible experiment regarding the effectiveness of masks should undergo further testing and should be shared globally in an effort of raising the awareness of uninformed or misinformed communities who suffer the most from the pandemic. Aside from answering the two research questions above, the purpose of this research is to reaffirm the understanding of the effectiveness of masks in preventing the spread of airborne viruses as well as providing an easily reproducible experimental design so that any person could reproduce the experiment with relative ease.

## Materials and Methods

### Small Particle Analyzer

For measuring droplet size, an old model of the SympaTEC HELOS workbench which uses a 638 nm red laser was used. For the purposes of taking measurements for the research project, we modified the workbench to allow for manual calibration. In addition, an optical aperture was used in order to control the amount of light passing through the lens. In order to make measurements easier, the lens with the shortest focal length was chosen. For the measuring process, the test subject would either breathe or speak onto a microscope slide which would be placed in front of the lens. Measuring particle sizes presented quite the challenge due to the evaporation of the droplets and the difficulty in finding the Fraunhofer Diffraction patterns. Nevertheless, once solid measurements were taken, the distances between the dark and light fringes led directly to a value for the average particle size of droplets.

### Droplet Density Enumerator

A test subject was used to breathe and talk in an enclosed environment. This environment was as dark as possible to prevent light pollution, with a black photographer's canvas covering the back of the field of vision. A sufficiently strong laser was swept across an area of interest, where the subject would be talking or breathing. A SONY camera was used to capture the particles illuminated by the laser and emitted from the mouth of the person. To be fully sure all particles were picked up, several settings were changed in manual mode. The aperture was changed to 2.8, the ISO was changed to an automatic setting near 6400 to maximize pickup of light noise, and the shutter speed was changed to 0.5 seconds to allow for a full panning of the laser over the field of vision. To focus the lens, a 2-meter stick was placed across the bottom of the field of vision. This also allowed for scaling by distance during data analysis. Different mouth coverings were used and the pictures were taken of particles emitting from the subject's mouth. A Python program was written to input a picture and output the number of particles and a graph showing the particle density per unit of horizontal distance.

## Results

### Average Speech Droplet Size

In Progress.

### Speech Droplet Density over Distance (no mask)

In Progress.

### Speech Droplet Density over Distance (with mask)

In Progress.

## Discussion

Although masks greatly reduce the probability of either spreading or getting infected by COVID-19, certain cases have shown that even the most vigilant and careful subjects who wore their masks contracted the virus. The contradiction found in these cases lie beyond the scope of this experiment; however, from a scientific standpoint, the most probable cause would present the hypothesis that the virus could have entered the system through a pathway other than the respiratory tract. Other contradictions regarding the experiment have explanations based on the limitations of the measuring equipment available to our research team.

### Limitations

On average, the smallest speech droplets range in size from $4\mu m$ to $21\mu m$ and even the small particle analyzer struggles to identify the droplets due to the Fraunhoffer diffraction limitations. Furthermore, the smallest droplets tend to evaporate between $\tau = 8$ minutes to $\tau = 14$ minutes. Such short time intervals between emission and evaporation lead to great difficulties in measuring the number of droplets per unit volume. Lastly, without an insulated space with which to conduct the experiment, convection currents may affect the positioning of the droplets in unnatural ways.

## Conclusion

The study of droplets and the effectiveness of masks in preventing the transmission of deadly diseases continues past its application to COVID-19. An effective perception of how the virus works and how to prevent it from spreading requires knowledge in both physics and medicine. Understanding how disease spreads and how to contain the dispersion of highly contagious diseases may prove incredibly useful in the future. As new and dangerous viruses come into existence, recognizing the importance of masks and their effectiveness in preventing diseases based on how they spread should continue to receive support in order to provide the public with competent preventive measurements as soon as possible.

## References

Bai, N. (2020). Still confused about masks? here's the science behind how face masks prevent coronavirus. *University of California San Francisco.*