Y Ddraig Goch:

An Interdisciplinary Honors Journal

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Letter from Faculty Advisor

The latest issue of *Y Ddraig Goch: An Interdisciplinary Honors Journal*, under the excellent editorial leadership of Amanda Noell Astillero, with support from Lloyd International Honors College alumna and former *YDG* editor Jenny Lois Francisco, brings together a dynamic set of articles from across the sciences and humanities. As with past issues of *YDG*, the editorial team worked diligently with contributors and faculty members to present another compelling example of rigorous and creative academic research that is being carried out by undergraduate students. Bravo to our editors and student contributors! And much gratitude to our faulty members.

Readers, we warmly welcome your comments, questions, and suggestions as we continue building our ever-expanding community of artists, scientist, and humanists (or, perhaps, more accurately, artists-scientists-humanists) dedicated to learning and development with Lloyd International Honors College's guiding motto: *Ludite, Explorate, Perficite*! (Play, Experiment, Perform!)

My e-mail is ohali@uncg.edu and those of the editorial team are on the next page.

Congratulations all!

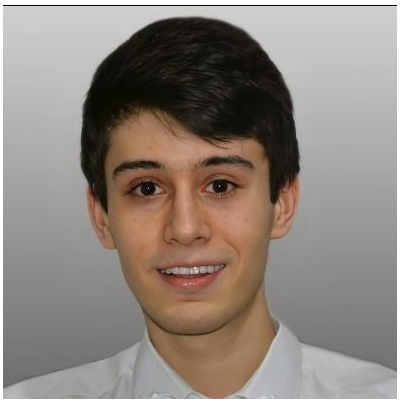
Omar H. Ali, Ph.D.
Dean and Professor, Lloyd International Honors College

Letter from the Editor

From the intricacies of computer science to the effects of group membership to plants in altered gravity conditions, this edition encapsulates the broad scope of interests that students hold. This edition is a reminder of the mission of Y Ddraig Goch as a platform for undergraduate students to publish their pieces on academic research and creative writing. In addition to class courses and extracurricular activities, students dedicate time to dive further into the wonders of science, the profundity of humanities, and the beauty in the fine arts. We hope this work continues to inspire and encourage everyone to share their passion and ideas, as it is an opportunity for bigger discoveries and deeper conversations.

We would like to express our gratitude to the authors contributing to this edition. The editorial team is grateful for their patience, collaboration, and hard work throughout this process. It is our pleasure to present the long awaited fifth issue of Y Ddraig Goch: An Interdisciplinary Honors Journal!

For comments and suggestions, please email them to Amanda at a_astillero@uncg.edu or Dr. Omar Ali at ohali@uncg.edu


Amanda Astillero (left), Editor-in-Chief
Amir Reza Hashemi (middle), Associate Editor
Jasmine Madjd-Sadjadi (right), Associate Editor
Rebecca McEvoy, Associate Editor

SCIENTIFIC PROGRAMMING TO ENHANCE LEARNING PHYSICS: LISSAJOUS CURVE

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Abstract

In this work, we present scientific programming to plot Lissajous Curves with different parameters and analyze how it changes the Lissajous Curves diagram. To do this, we need to prepare the complicated problems in the form of algorithms for programming then we use Python programming language to implement our algorithms. The main reasons for utilizing Python are its simplicity of it as well as having a lot of useful packages which are called libraries. As a result, we see the high sensitivity of the Lissajous Curve to the ratio $\frac{a}{b}$, where a and b are the angular frequencies. As an application, it can help students to understand better the parameters of the Lissajous Curve to design their algorithms for drawing these curves.

Introduction

Nowadays, programming plays an important role in various aspects of human societies, particularly in the science and technology fields. A variety of problems in engineering, physics, mathematics, economics, and etc. should be programmed scientifically to get desired results. Also, to have more accuracy and enhance the speed of the procedure we need to use scientific programming. For example, some numerical calculations in mathematics and plotting diagrams like a Lissajous curve with a large angular frequency ratio are required to use such programs because of their complicating and saving time. Research on why learning programming is essential for everyone

indicated that it can be entered into almost any science and the industry or even expanded.[1] In 1974, Donald E. Knuth stated that computer programming is "an art".[2] Emma Lehmer 1956 expressed that she had found coding to be "an exacting science as well as an intriguing art".[3] Learning computer programming improves cognitive skills including creativity, reasoning, and mathematical skills.[4]

In this article, we illustrate the Lissajous curve through Python programming using libraries such as Matplotlib, NumPy, etc., and present a summary of the codes that generates the Lissajous curve. Based on what we worked on a presentation of the Lissajous curve by coding, we will first analyze the Lissajous curve with different data from variables a and b, i.e. different angular frequencies, then show the implementation of Lissajous curves by programming.

Parametric Forms

In this section, we are going to express the basic concept of parametric equation. It is a type of equation that employs an independent variable called a parameter (often denoted by t) in which dependent variables are defined as continuous functions of the parameter and are not dependent on another existing variable. One reason to introduce an idea is to explain some curves in an easy way which is called a parametric curve, However, curves described by parametric equations can range from graphs of the most basic equations to those of the most complex. While parametric equations can be used to describe all types of curves that can be represented on a plane, they are mostly used in situations where curves on a Cartesian plane cannot be described by functions (e.g., when a curve crosses itself). When illustrating graphs of curves on the Cartesian plane, equations in parametric form can provide a clearer representation than equations in Cartesian form. For instance, consider the equation of a circle with radius r and its center at the origin that is $x^2 +$

[1] Yasmin B. Kafai and Quinn Burke, *Connected code: why children need to learn programming*, (The MIT Press, 2014).
[2] Donald E Knuth, "Computer programming as an art," In *ACM Turing award lectures*, (2007), 1974.
[3] Emma Lehmer, "Number theory on the SWAC," in *Proc. Syrup. Applied Math*, vol. 6, (1956), pp. 103–108.
[4] Ronny Scherer, Fazilat Siddiq, and Bárbara Sánchez Viveros, "The cognitive benefits of learning computer programming: a meta-analysis of transfer effects," *Journal of Educational Psychology* 111, no. 5 (2019): 764.

$y^2 = r^2$, so we can write this equation according to one of the variables x or y:[5]

$$x^2 = r^2 - y^2$$

$$y^2 = r^2 - x^2$$

Hence, the equation of the circle is expressed as two different equations. As we see each of these equations consists of two equations with opposite signs that would plot the graph of only one-half of the circle on Cartesian plane. When converted to parametric form, the x, and y coordinates are defined as functions of t which represent angles in this form:[6]

$$x = r\cos t$$

$$y = r\sin t$$

For an ellipse, the parametric equations are:

$$x = a\cos t$$

$$y = b\sin t$$

Here, in the ellipse, we are free to choose two different numbers a and b which is usually said the degree of freedom increases. Therefore, the figure of this type of curve would be varied in shape. For example, one of the famous figures is The **Butterfly curve** and the parametric equation of this beautiful curve is:[7]

$$x = \sin(t)\,(e^{\cos t} - 2\cos(4t) - \sin^5(\frac{t}{12}))$$

$$y = \cos(t)\,(e^{\cos t} - 2\cos(4t) - \sin^5(\frac{t}{12}))$$

Where $0 \le t \le 12\pi$.

Now we go through the plotting curve using Python. At first, we need to import the libraries that exist in this area. Matplotlib and NumPy are two useful libraries that former is a comprehensive library for creating static,

[5] Enrique Ucal, "parametric equation," Encyclopedia Britannica, June 1, 2021, https://www.britannica.com/science/parametric-equation.
[6] Ucal, "parametric equation."
[7] Paul Bourke, "Butterfly Curve," PaulBourke, 2003, http://paulbourke.net/geometry/butterfly/.

animated, and interactive visualizations in Python and the latter is used for working with arrays and lists. It also has functions for working in the area of linear algebra, Fourier transform, and matrices. These two libraries are very popular among Python programmers and it would be very helpful to be familiar with the functions of these two libraries.

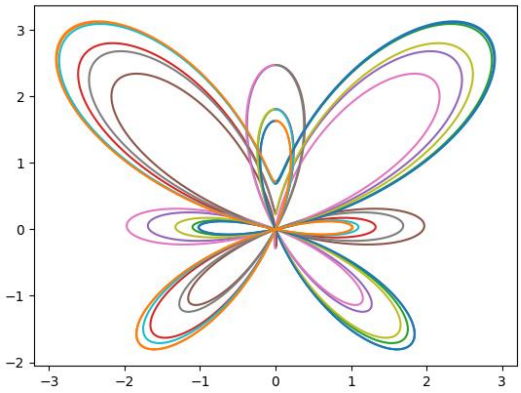


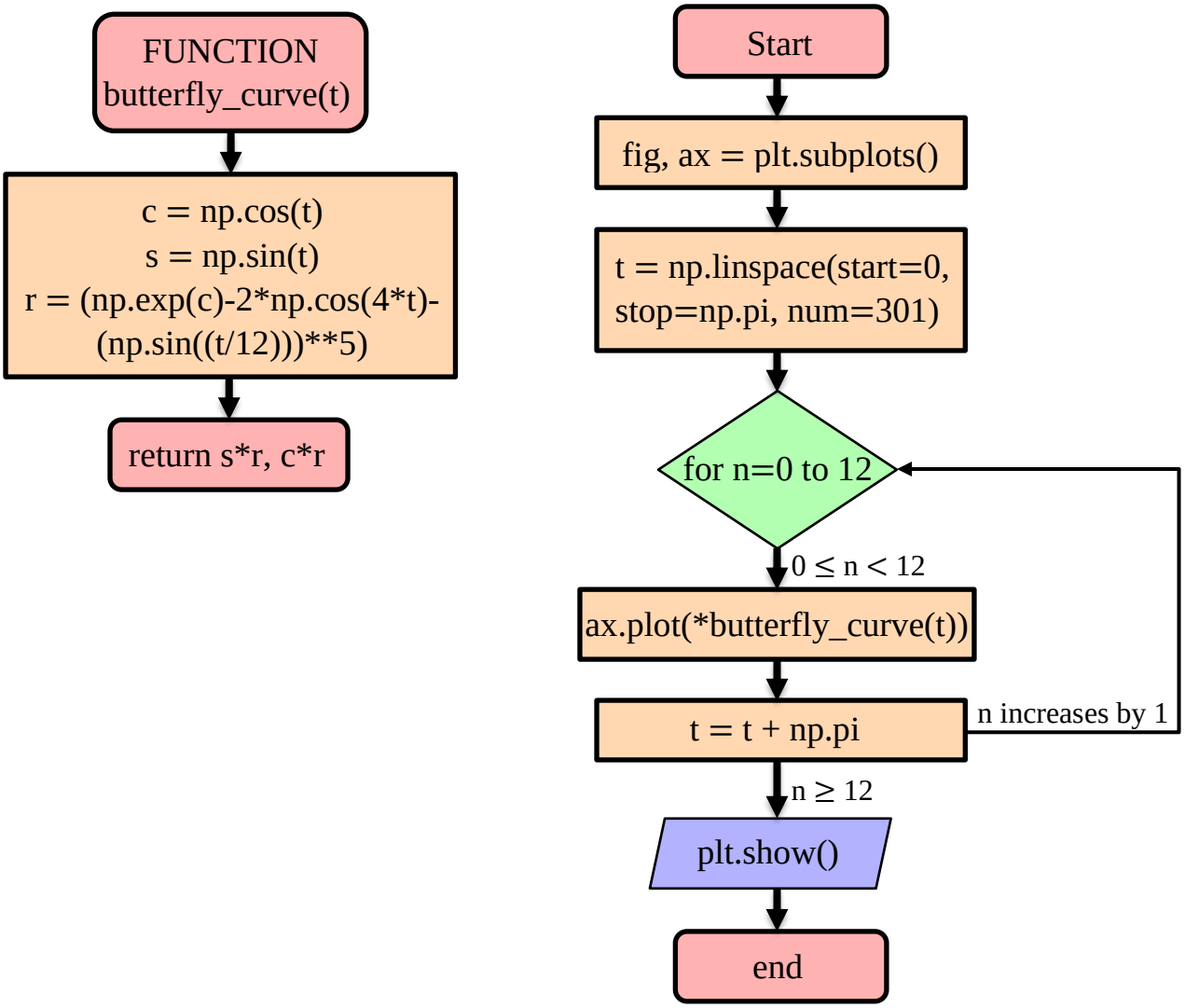
Figure 1. Butterfly Curve.

A flowchart is a type of diagram that represents a workflow or process. In other words, it can be defined as a diagrammatic representation of an algorithm to solve a task step-by-step in which the steps are shown by boxes of various kinds, and their order by connecting the boxes with arrows. For this reason, they are popular among programmers, decision-makers, and problem solvers. It is not necessary to construct a flowchart of the program; however, it helps students to understand how the program is processed and it allows students to discuss more in terms of algorithmic thinking. Therefore, teachers must explain the algorithm of the program before coding it. As an application, we plot easily the Butterfly curve discovered by Temple H. Fay of the University of Southern Mississippi in 1989,[8] see the Figure 1.

In programming detail, the flowchart and code of the plotting Butterfly curve are given. As you can see in the flowchart, we first create a function called butterfly_curve(t) including a parameter t that returns the numeric value of the parametric equation by giving the numerical value to t. Then, we import the Python packages to use the subplots() function from the Matplotlib library to draw multiple plots.

[8] Temple H Fay, "The butterfly curve," *The American Mathematical Monthly* 96, no. 5 (1989): 442–443.

Furthermore, from the NumPy library, we utilize the linspace() function to create numeric sequences. Indeed, we use three parameters in this function which include **start**, **stop** and **num** which are the start of the interval, the end of the interval, and the number of items to generate within the range, respectively. Flowchart of the Butterfly curve:



Also, the full code is:

```
#butterfly curve
import matplotlib.pyplot as plt
import numpy as np
def butterfly_curve(t):
      c, s = np.cos(t), np.sin(t)
      r = (np.exp(c) - 2 * np.cos(4 * t) - (np.sin((t / 12))) ** 5)
      return s*r, c*r
fig, ax = plt.subplots()
t = np.linspace(start = 0, stop = np.pi, num = 301)
for n in range(12):
      ax.plot(*butterfly_curve(t))
      t += np.pi
plt.show()
```

Lissajous Curves, or Lissajous Figures, are beautiful patterns formed when two harmonic vibrations (In physics, harmonic vibration is a type of periodic motion where the restoring force is proportional to the displacement)[9] along perpendicular lines are superimposed. The parametric form of the Lissajous figure is:[10]

$$x = A\sin(at + \delta)$$

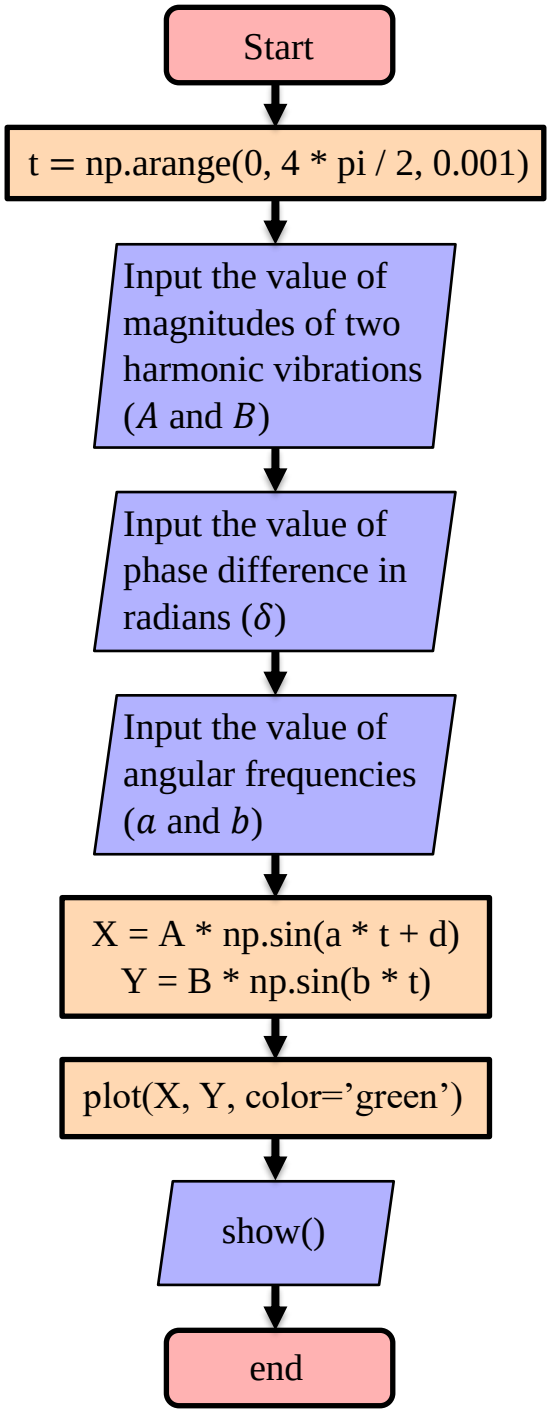
$$y = B\sin(bt)$$

Where A and B are magnitudes of two harmonic vibrations, a and b are their angular frequencies and δ is their phase difference, expressed in degrees or more often in radians.

Lissajous Diagrams

[9] Peng Zhao, "Lissajous curve," Math Images, July 16, 2012, https://mathimages.swarthmore.edu/index.php/Lissajous_Curve.
[10] Eric W Weisstein, "Lissajous curve," MathWorld—A Wolfram Web Resource, 2006, http://mathworld.wolfram.com/LissajousCurve.html.

A Lissajous diagram is defined by a set of parametric equations. These equations define the positions plotted on the X (horizontal) and Y (vertical) axes. To plot the Lissajous curve, like the Butterfly curve, we use the same libraries for the value of π. To clarify, let us create its flowchart first:



And the full code is:

```
import numpy as np
from matplotlib.pyplot import plot, show
from math import pi
t=np.arange(0, 4 * pi / 2, 0.001)
A, B = float(input("input the value of A: ")), float(input("input the value of B: "))
delta = pi/2
#first set of parameters
a, b = float(input("input the value of a: ")), float(input("input the value of b: "))
X = A * np.sin(a * t + delta)
Y = B * np.sin(b * t)
plot(X, Y, color="green")
show()
```

In order not to prolong the codes, this is quite common in the programming area, we have manually added a value to the radian in the delta variable. Now, in this section, we plot and analyze some sorts of Lissajous curves with different data using the above code and discuss the result that is based on them. In the simplest case, if $A = B = 1$, $a = b = 1$, and $\delta = 0$, meaning the two frequencies are the same and there is no phase shift, then the parametric equations are as the following:

$$x = \sin(t)$$

$$y = \sin(t)$$

This implies that $x = y$. Moreover, since the range of $\sin(x)$ is from -1 to 1, we have $-1 \leq x \leq 1$, and together, they give us the line segment shown in Figure 2 which is the output of our code, when the variables $\text{delta} = 0$, $a = b$, and $A = B = 1$:

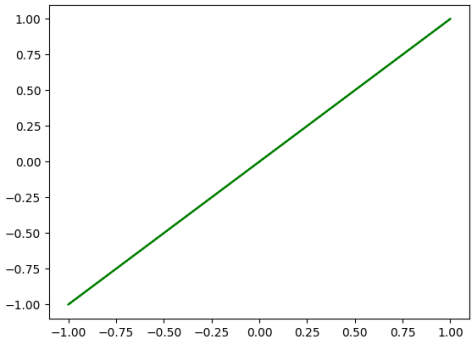


Figure 2. Line Segment.

$$\delta = 0, \quad a = b$$

Remarkably, the resulting figure is the $45°$ line (Figure 2). If we still have $a = b = 1$ and the corresponding phase shift is $90°$ ($\frac{\pi}{2}$ radians), then the resulting figure will be a simple pure circle (Figure 3):

$$x = \cos(t)$$

$$y = \sin(t)$$

Since $\sin^2(\theta) + \cos^2(\theta) = 1$, we can eliminate t and get the following equation:

$$x^2 + y^2 = 1$$

This gives us the circle shown in Figure 3. The figure is again the output of our code, once the variables $\text{delta} = \text{pi}/2$, $a = b$, and $A = B = 1$:

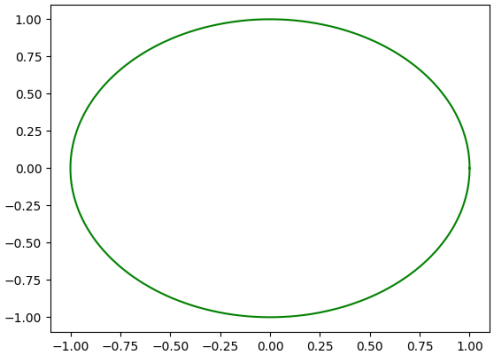


Figure 3. Circle.

$$\delta = \frac{\pi}{2}, \quad a = b, \quad A = B$$

If there is a phase difference other than 90°, then another example will be obtained. Figure 4 is an ellipse where we implement our code with the variables delta = pi/4, $a = b$, and $A = B = 1$:

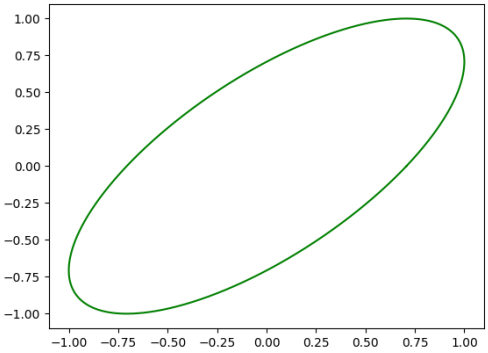


Figure 4. Ellipse.

$$\delta = \frac{\pi}{4}, \quad a = b$$

Also, when the ratio of angular frequencies is equal to two ($\frac{a}{b} = 2$), the figure will be a part of a parabola (Figure 5). In this case, consider the parameters $a = 1$, $b = 2$, and $\delta = \frac{\pi}{4}$, hence the parametric equations are as follows:

$$x = \sin(t + \tfrac{\pi}{4}) \quad (1)$$

$$y = \sin(2t) \quad (2)$$

From Eq. (1), we can get:

$$2x^2 - 1 = 2\sin^2\left(t + \frac{\pi}{4}\right) - 1$$

By using the trigonometric identity $\cos(2\theta) = 1 - 2\sin^2(\theta)$, we obtain:

$$2x^2 - 1 = -\cos(2t + \frac{\pi}{2})$$

Applying the formula $\cos(\theta + \frac{\pi}{2}) = -\sin(\theta)$:

$$2x^2 - 1 = \sin(2t)$$

Now, combining the above equation with Eq. (2) and eliminating t yield:

$$y = 2x^2 - 1$$

where x belongs to the interval $[-1, 1]$. This gives us the parabola in Figure 5 with variables delta $=$ pi$/4$, $a = 1$, $b = 2$, and $A = B = 1$.

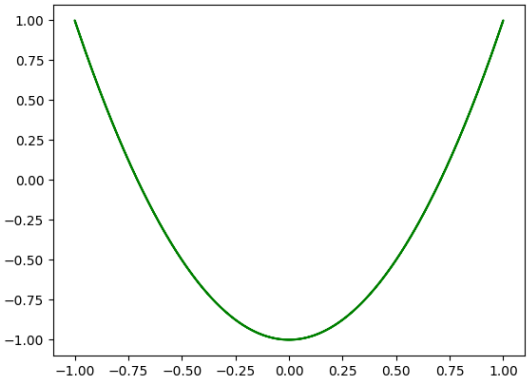


Figure 5. Parabola.

$$\delta = \frac{\pi}{4}, \quad \frac{a}{b} = 2$$

Other ratios produce more complicated curves, which are completed only $\frac{a}{b}$ to be rational.[11] The visual form of these curves is often suggesting a three-dimensional knot and more, including those known as Lissajous knots,[12] and projected to the plane as Lissajous figures.[13] Special cases are summarized in the following table and contain the line, circle, ellipse, and part of a parabola.[14]

Special cases	
Parameters	Curve
$a = b, \quad \delta = 0$	Line
$a = b, \quad A = B, \quad \delta = \frac{\pi}{2}$	Circle
$a = b, \quad A \neq B, \quad \delta = \frac{\pi}{2}$	Ellipse
$a = b, \quad \delta = \frac{\pi}{2}$	Section of parabola

[11] J. Dennis Lawrence, *A catalog of special plane curves*, (Courier Corporation, 2013).
[12] M. G. V. Bogle et al., "Lissajous knots," *Journal of Knot Theory and its Ramification* 3, no. 2 (1994): 121–140.
[13] Hisham AH Al-Khazali, and Mohamad R. Askari, "Geometrical and graphical representations analysis of lissajous figures in rotor dynamic system," *IOSR Journal of Engineering* 2, no. 5 (2012): 971–978.
[14] Weisstein, "Lissajous curve."

Visually, the ratio $\frac{a}{b}$ determines the number of "lobes" of the figure.[15] For instance, a ratio of $\frac{4}{1}$ or $\frac{1}{4}$ produces a figure with four major lobes. Similarly, a ratio of $\frac{7}{3}$ produces a figure with seven horizontal and three vertical lobes. Rational ratios produce close or "still" figures, meanwhile, irrational ratios produce one that appears to rotate. Furthermore, the ratio $\frac{A}{B}$ determines the relative width-to-height ratio of the curve,[16] e.g. a ratio of $\frac{2}{1}$ produces a figure that the height of it is twice long as its width. Eventually, the value of δ determines the apparent "rotation" angle of the figure, viewed as if it was a three-dimensional curve.[17] Consider a trial example, $\delta = 0$, it leads x and y components exactly to the inside phase, so the resulting figure seems to be a three-dimensional figure viewed from straight on (0°). In contrast, any non-zero δ produces a figure that appears to be rotated, either as a left-right or an up-down rotation (depending on the ratio $\frac{a}{b}$). Some more figures would be helpful to visualize the underlying complex symmetry represented in Figure 6.

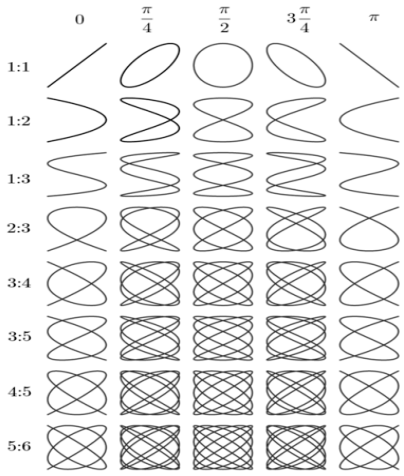


Figure 6. Figure with varying ratio and phase difference.[18]

[15] Bill Schweber, "Lissajous figures: From math to measurement to art, Part 1," EEWorldOnline, May 18, 2021, https://www.eeworldonline.com/lissajous-figures-from-math-to-measurement-to-art-part-1/; Kenneth Palmer et al., "Lissajous figures: an engineering tool for root cause analysis of individual cases—a preliminary concept," *The Journal of extra-corporeal technology* 43, no. 3 (2011): 153.
[16] Schweber, "Lissajous figures."; Palmer et al., "Lissajous figures," 153.
[17] Ibid.
[18] Vhastorga, "Lissajous figures: various frequency relations and phase differences," Wikipedia, January 8, 2020, https://en.wikipedia.org/wiki/Lissajous_curve.

Towards the end of this section, it is important to highlight a special instance of the Lissajous curve. which occurs when $a = 1,\ \ b = N$ (where N is a natural number), and $\delta = \frac{N-1}{N}\frac{\pi}{2}$. This particular curve is known as the **Chebyshev polynomials** of the first kind of degree N.[19] This property is leveraged to generate a set of points called **Padua points**.[20] These points enable the computation of bivariate interpolation or quadrature of a given function over the domain $[-1, 1] \times [-1, 1]$ by sampling the function at these specific locations.[21] The relation of some Lissajous curves to Chebyshev polynomials will be transparent to understand if the Lissajous curve generating each of them is represented by using cosine functions rather than sine functions.

$$x = \cos(t)$$

$$y = \cos(Nt)$$

Benefits of Scientific Programming

As we have mentioned, scientific programming, scientific computing in broad terms, deals with solving scientific problems with the help of computers to obtain results more quickly and accurately, as said **Programs must be accurate!** A program is a collection of statements stored in a text file. The statements can be executed interactively in a Python shell and any error in each statement may lead to termination of the execution or wrong results. The computer does exactly what the programmer tells the computer to do![22] Humans are certainly better to do some tasks than a computer does, but storing data, analyzing results, and doing massive calculations are exactly what computers were designed to do. For example, consider the following parametric equations of a Lissajous Curve:

$$x = \sin(9t)$$

$$y = \sin(8t)$$

[19] John C Mason, and David C Handscomb, *Chebyshev polynomials*, (CRC press, 2002); Al-Khazali, and Askari, "Geometrical representation analysis of lissajous figures," 971–978.
[20] Wolfgang Erb, "Bivariate Lagrange interpolation at the node points of Lissajous curves–the degenerate case," *Applied Mathematics and Computation* 289 (2016): 409–425.
[21] Len Bos et al., "Bivariate Lagrange interpolation at the Padua points: the generating curve approach," *Journal of Approximation Theory* 143, no. 1 (2006): 15–25.
[22] Hans Petter Langtangen, *A primer on scientific programming with Python*, Vol. 6. (Springer, 2014).

In general, this could be solved by expanding the x– and y– functions into powers of $\sin(t)$ and $\cos(t)$:

$$x = \sin(9t) = \sin^9 t - \frac{9.8}{2!}\sin^7 t \cos^2 t + \frac{9.8.7.6}{4!}\sin^5 t \cos^4 t - \frac{9.8.7.6.5.4}{6!}\sin^3 t \cos^6 t + \frac{9!}{8!}\sin t \cos^8 t$$

$$y = \sin(8t) = \sin^8 t - \frac{8.7}{2!}\sin^6 t \cos^2 t + \frac{8.7.6.5}{4!}\sin^4 t \cos^4 t - \frac{8.7.6.5.4.3}{6!}\sin^2 t \cos^6 t + \frac{8!}{8!}\cos^8 t$$

These equations come from a general formula given in the 16th century by French mathematician Vieta.[23]

Notice that in these equations, if we consider $\sin(t)$ and $\cos(t)$ as unknown variables, then we will have a set of two polynomial equations with two variables and in principle we can solve $\sin(t)$ and $\cos(t)$ in terms of x and y. Thus, the identity $\sin^2 t + \cos^2 t = 1$ will give us a direct relationship between x and y. In practice few people are willing to carry on with this kind of algebra, because the calculations involved are cumbersome and annoying. There is no guarantee that our effort will lead us to the answer. Moreover, the relationship between x and y is going to be very complex and it results in realizing useful information about the shape of the curve would be difficult. Therefore, the method of elimination fails here, and we would like to study these curves in a new way.[24] One way is to go through experiments and observation, that is, we can use computer software to plot some Lissajous Curves with different parameters then we see how they change the form of Lissajous Curves. When we work on a subject with multiple variable parameters, it is much easier to study these parameters separately rather than together. As we discuss in the previous sections, there are three variable parameters, a, b and δ, in Lissajous Curves that we briefly argue about writing a program to plot curves with different values of them. In the next section, by providing a table we go into more details about the program.

Lissajous Curves Table

In this section, we will illustrate an animation of the Lissajous Curves table by Python. Until now, we learned and make use of the Matplotlib library

[23] Samuel G. Moreno, and Esther M. García-Caballero, "On Viète-like formulas," *Journal of Approximation Theory* 174 (2013): 90–112; Milton Abramowitz, Irene A. Stegun, and Robert H. Romer, "Handbook of mathematical functions with formulas, graphs, and mathematical tables," *American Journal of Physics* 56, 958 (1988): 958–958.
[24] Zhao, "Lissajous curve."

whereas here we want to utilize other libraries, especially the Pygame library which is a useful tool for displaying graphical animated shapes. Pygame is a cross-platform set of Python modules designed for writing video games that includes computer graphics and sound libraries planned to be used with the Python programming language. Therefore, it would be helpful to be aware of the more advanced concepts of programming as well as the concept of object-oriented in the Python programming language. We provided the full code of the Lissajous curves table in the following:

```
import pygame
import os
import math
import colorsys
import numpy as np
class Curve:
    def __init__(self, color):
        self.points = []
        self.color = color
        self.current = [0, 0]
    def set_point_x(self, x):
        self.current[0] = x
    def set_point_y (self, y):
        self.current[1] = y
    def update_points(self):
        point = (int(self.current[0]), self.current[1])
        if point not in self.points:
            self.points.append(point)
    def draw(self, screen):
        for i in range(len(self.points)):
            if i > 0:
                        pygame.draw.line(screen, self.color,
                self.points[i-1], self.points[i], 2)
```

```
            pygame.draw.circle(screen, (20, 120, 200),
            (int(self.current[0]), int(self.current[1])), 5)
            self.current = [0, 0]
os.environ["SDL_VIDEO_CENTERED"] = '1'
width, height = 1020, 1000
size = (width, height)
h = 0
def hsv_to_rgb(h, s, v):
        return tuple(round(i * 255) for i in colorsys.hsv_to_rgb(h,
    s, v))
pygame.init()
pygame.display.set_caption("Lissajous Curves")
screen = pygame.display.set_mode(size)
clock = pygame.time.Clock()
fps = 60
white, black, gray = (15, 15, 15), (245, 245, 245), (15, 15, 15)
angle = 0
w = 130
restart = False
columns = width//w-1
rows = height//w-1
speed = 0.01
radius = int((w//2) - 0.1 * w)
curves = [[i for i in range(columns)] for j in range(rows)]
for x in range(rows):
    for y in range(columns):
        curves[x][y] = Curve(hsv_to_rgb (h, 1, 1))
        h += 0.001
run = True
while run:
    clock.tick(fps)
    screen.fill(black)
    for event in pygame.event.get():
```

```
        if event.type == pygame.QUIT:
            run = False
        if event.type == pygame.KEYDOWN:
            if event.key == pygame.K_ESCAPE:
                run = False
            if event.key == pygame.K_r:
                restart = True
    for i in range(columns):
        a = w+10 + i * w + w//2
        b = w//2 + 15
        pygame.draw.circle(screen, white, (a, b), int(radius), 1)
        x = radius * math.cos(angle*(i+1) - math.pi/2)
        y = radius * math.sin(angle*(i+1) - math.pi/2)
        pygame.draw.line(screen, gray, (int(a+x), 0), (int(a+x),
        height), 1)
        pygame.draw.circle(screen, white, (int(a+x), int(b+y)), 8)
        for j in range(rows):
            curves[j][i].set_point_x(a+x)
    for j in range(rows):
        a = w//2 + 15
        b = w+10 + j * w + w//2
        pygame.draw.circle(screen, white, (a, b), radius, 1)
        x = radius * math.cos(angle*(j+1) - math.pi/2)
        y = radius * math.sin(angle*(j+1) - math.pi/2)
        pygame.draw.line(screen, gray, (0, int(b+y)), (width,
        int(b+y)), 1)
        pygame.draw.circle(screen, white, (int(a+x), int(b+y)), 8)
        for i in range(columns):
            curves[j][i].set_point_y(b+y)
    for x in range(rows):
        for y in range(columns):
            curves[x][y].update_points()
```

```
                curves[x][y].draw(screen)
        angle -= speed
        if angle < - 2 * math.pi or restart == True:
            for x in range(rows):
                for y in range(columns):
                    curves[x][y].points = []
            angle = 0
            restart = False
        pygame.display.update()
pygame.quit()
```

Also, the execution of the above code, if $\delta = \frac{\pi}{2}$, is:

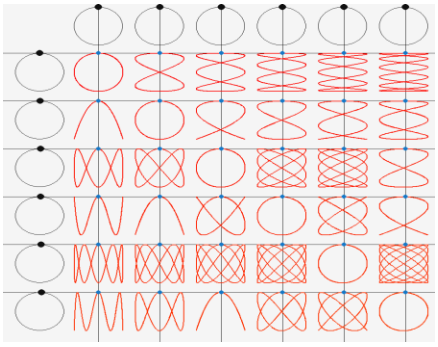


Figure 7. Lissajous Curve table.

Note that in this kind of Lissajous curves table we have an explicit phase difference and variable angular frequencies. Having this in mind, creating a table of Lissajous curves helps us to study the parameters and to understand Lissajous figures more accurately. In the next section, we will investigate the parameters of the Lissajous curve.

Result and Discussion

To begin with, we fix the phase difference δ to examine the angular frequencies a and b and vice versa.

To do this, the following table shows the Lissajous Curves where:

$$x = \sin(at + \delta)$$

$$y = \sin(bt)$$

with angular frequencies a and b varying from 1 to 6, and phase difference δ fixed at 0:

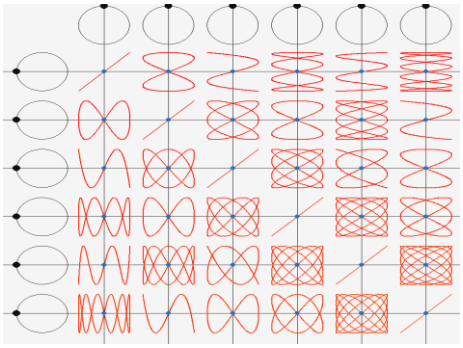


Figure 8. The table of Lissajous Curves with different angular frequency ratios.

There are many interesting properties associated with this table (Figure 8):

1. All Lissajous Curves in the table are limited to a 2×2 square box. The curves can touch, but cannot go beyond, the lines $x = 1$, $x = -1$, $y = 1$, and $y = -1$.[25] The reason why it cannot go beyond is because the amplitudes of both horizontal and vertical vibrations are set to 1.
2. The Lissajous Curve with $a = b = 1$ is identical to the curves with $a = b = 2$, $a = b = 3$, etc. Likewise, the Lissajous Curve with $a = 1$, $b = 2$ is the same as the curve with $a = 2$, $b = 4$ as shown in Figures 9 and 10.[26]

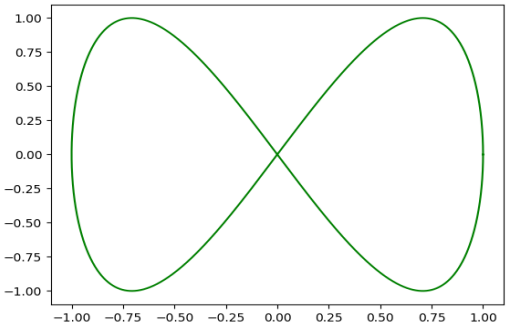


Figure 9. $a = 1$, $b = 2$

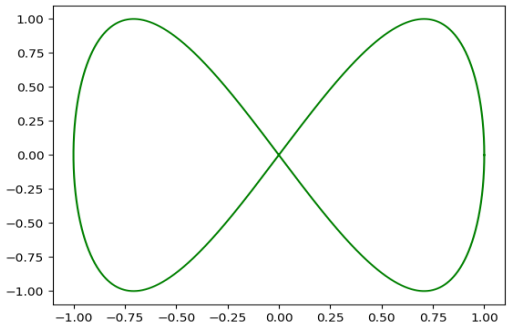


Figure 10. $a = 2$, $b = 4$

[25] Thomas B Greenslade Jr, *Adventures with Lissajous Figures*, (Morgan & Claypool Publishers, 2018).
[26] Zhao, "Lissajous curve."; Chiu-king Ng, "Lissajous Figures," phy.hk, March 20, 2019, http://phy.hk/wiki/englishhtm/Lissajous.htm.

In other words, the ratio between a and b is what matters. Indeed, it can be shown that Lissajous Curves with the same angular frequency ratio must have the same appearance. For instance, if we substitute $t = 2u$ in the Lissajous Curve $x = \sin(t)$ and $y = \sin(2t)$ where $a = 1$ and $b = 2$, then we will have:

$$x = \sin(2u)$$

$$y = \sin(4u)$$

Hence, whether we use the symbol t or u does not matter here because it is nothing different from the Lissajous Curve with $a = 2$ and $b = 4$. Also, this analysis can be generalized to all Lissajous Curves with rational frequency ratios.

3. The Lissajous Curve with $a = 1$ and $b = 2$ is the reflection of the Lissajous Curve with $a = 2$ and $b = 1$ of line $y = x$. If we change the values of a and b in any Lissajous Curve, the result will be the original curve "flipped" of line $y = x$. To prove this, let us consider the following Lissajous Curve:

$$x = \sin(at)$$

$$y = \sin(bt)$$

If we replace a with b and conversely, then we will obtain the following Lissajous Curve:

$$x = \sin(bt)$$

$$y = \sin(at)$$

However, the same resulting curve could be achieved by replacing x with y, and vice versa in the original curve. In other words, the switch of a and b is equivalent to the change of x and y. Furthermore, in Cartesian coordinates, replacing x with y in the equation of the curve is the same as flipping the curve of line $y = x$. Therefore, changing a and b equals the flipping of line $y = x$.

From these properties, we can see that many Lissajous Curves with different angular frequencies are the same in general and we need not study all of them. Thus, we would use the following family to represent all Lissajous Curves:

$$x = \sin(rt)$$

$$y = \sin(t)$$

Where r stands for the angular frequency ratio of two-component vibrations that could be either rational or irrational. Here we are only studying the rational case due to simplicity.

The argument for a simple one goes as the following steps:

- First, for any Lissajous Curve like $x = \sin(at)$ and $y = \sin(bt)$ where a and b are integers, we can assume that $a \leq b$, since if $a > b$ then we can switch their values and from property 3 the curve will only be flipped of line $y = x$. This does not affect the curve's structure which is what we are focusing on.
- The next step is to divide both angular frequencies by b. From property 2, the curve will not change and we will get:

$$x = \sin(\frac{a}{b}t)$$

$$y = \sin(t)$$

The last set of parametric equations belongs to the aforementioned family. We only need to study this family of Lissajous Curves because others can all be converted into this one. Now, to show that the appearance of the figure is highly sensitive to the ratio $\frac{a}{b}$, in the form of an animation, we should write a program which is provided in the following table.

```
import numpy as np
import matplotlib.pyplot as plt
from matplotlib import animation
fig = plt.figure()
ax = plt.subplot()
ax.set_facecolor("white")
plt.plot(0, 0)
t = np.linspace(-2*np.pi, 2*np.pi, 500)
```

```
b = 1
def animate (i):
    if i < 500:
        a = b*(0.01*i)
    else :
        a = b*(0.01*(1000-i))
    x=np.sin(a*t)
    y=np.sin(b*t)
    ax.clear()
    plt.plot(x, y, c="#E02050", lw = "5")
    return fig,
ani = animation.FuncAnimation(fig, animate, frames=1000, interval=
20, blit=False)
plt.show()
```

Although most of these Lissajous Curves are rather convoluted, there are some simple ones scattered in them. In other words, if we reduce the frequency ratio $\frac{a}{b}$ to simplest fraction (that is, a and b have the greatest common divisor of 1), then the larger a and b are, the more complicated our Lissajous Curve is going to be. Let us work on the curve in a way of considering variable t.

Suppose the two-component vibrations start at $t = t_0$. The moving point will eventually return to its starting place and make a closed Lissajous Curve as long as the frequency ratio is rational. Now assume this happens at $t = t_1$,[27] so the time period between t_0 and t_1 is a complete cycle of this Lissajous Curve. Moreover, since the starting point and ending point overlap, we must have:

$$x(t_0) = x(t_1) \quad (3)$$
$$y(t_0) = y(t_1) \quad (4)$$

[27] Zhao, "Lissajous curve."

Substitute this in the parametric equations of the Lissajous Curve with rational frequency ratio, we can get:

$$\sin(\frac{a}{b}t_0) = \sin(\frac{a}{b}t_1)$$

$$\sin(t_0) = \sin(t_1)$$

which leads us to:

$$\frac{a}{b}(t_1 - t_0) = 2k_1\pi$$

$$(t_1 - t_0) = 2k_2\pi$$

Where k_1 and k_2 are integers. The other possibility $t_1 + t_0 = (2k + 1)\pi$ is omitted because they represent the intersections inside one cycle. At these intersections, the positions overlap, though, the velocities do not. Hence, the Lissajous Curve is not closed at these points. Now, Substituting Eq. (4) in Eq. (3), we obtain:

$$\frac{a}{b} = \frac{k_1}{k_2}$$

Since $\frac{a}{b}$ is assumed to be an irreducible fraction (if were not, we could divide them by their common factor without changing the Lissajous Curve), the smallest k_1 and k_2 that satisfy this equation are $k_1 = a$ and $k_2 = b$. Thus from Eq. (4), we can get:

$$(t_1 - t_0) = 2b\pi$$

As we see, whenever b gets large, the Lissajous Curve goes longer before it closes and repeats itself, also it is going to be more convoluted. For a simple angular frequency ratio like $\frac{1}{2}$, the vibrations start early to repeat and the Lissajous Curve is simple, as shown in the previous table. While a ratio $\frac{37}{335}$ makes the curve much more complicated. In the irrational case, meaning the ratio is irrational, both a and b will be "infinitely large" and the Curve is no longer closed. Thus, it can be conducted that the angular frequency ratio $\frac{a}{b}$, which is reduced to the simplest fraction, and determines the complexity of Lissajous Curves. When a and b are large, the Lissajous Curves would be complicated, whereas small a and b give us simple ones. That is why

Lissajous Tuning Forks are so suitable for tuning notes and in music theory, most of the important intervals are simple fractions. For example, the interval of a perfect octave is $1:2$, the perfect fifth is $2:3$, the perfect fourth is $3:4$, and so forth.[28] Mathematically speaking our acoustical perception works with the logarithmic law.[29] This phenomenon has been investigated in the field of psychoacoustics. For the perfect fourth and fifth this is seen in the following little calculation:

$$\text{Perfect fourth} + \text{Perfect fifth} = \text{Octave}$$

$$\log(\frac{3}{4}) + \log(\frac{2}{3}) = \log(\frac{3}{4} \times \frac{2}{3}) = \log(\frac{1}{2})$$

These intervals all correspond to simple Lissajous Curves with distinctive features.

Now we are going to fix the angular frequencies to study the third, and last, variable parameter: the phase difference δ. As the programming is the aim of this work, we execute the following code which is an animation illustrating the Lissajous Curve

$$x = \sin(t + \delta)$$

$$y = \sin(3t)$$

with δ varying continuously from 0 to 2π:

```
import numpy as np
import matplotlib.pyplot as plt
from math import pi
from matplotlib import animation
fig = plt.figure()
ax = plt.subplot()
ax.set_facecolor("white")
plt.plot(0, 0)
a, b = 1, 3
```

[28] William A Sethares, *Tuning, timbre, spectrum, scale*, (Springer Science & Business Media, 2005); Benward Bruce, and M. Nadina Saker, *Music in Theory and Practice*, Vol. 1, (2003).
[29] Peter Lucas Hulen, "A composition procedure for digitally synthesized music on logarithmic scales of the harmonic series," (2015).

```
t = np.linspace(-2*np.pi, 2*np.pi, 500)
delta = 0
def animate (i):
    if i<500:
        delta = b*(0.01*i)
    else:
        delta = b*(0.01*(1000-i))
    x=np.sin(t+delta)
    y=np.sin(b*t)
    ax.clear()
    plt.plot(x, y, c="#E02050", lw = "5")
    return fig,
ani = animation.FuncAnimation(fig, animate, frames = 1000, interval
= 20, blit = False)
plt.show()
```

An interesting fact to remark is that the output of the above code looks more like a rotating 3-D curve rather than a changing 2-D one. The reason for this illusion is related to another way of defining Lissajous Curves. As we said, a Lissajous Curve is the superposition of two harmonic vibrations in perpendicular directions. However, this is not the only available definition for Lissajous Curves. These curves can also be viewed as the projection of a 3-D harmonic height function over a circular base.

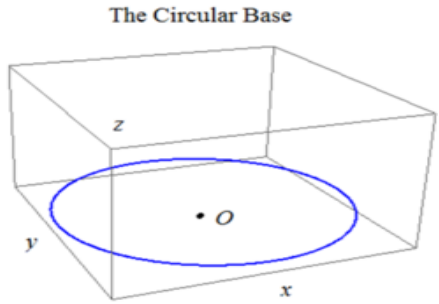


Figure 11. Circular base of harmonic height function.[30]

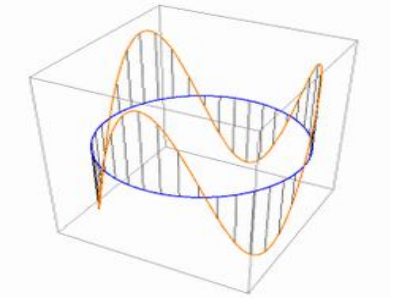


Figure 12. Raising process.[31]

[30] Zhao, "Lissajous curve."
[31] Ibid.

The following steps were taken in order to generate this harmonic height function:

- The first step is to plot a circular base in the x-y plane, as shown in Figure 11. The parametric equation of it is:

$$x = \cos(t + \delta)$$

$$y = \sin(t + \delta)$$

  The variable parameter δ here does not change the shape of the circle, as we still have the relationship $x^2 + y^2 = 1$. However, if we change the value of δ, then the circle will rotate about the origin O. Of course, we cannot see the motion here because O is also the center of the circle, however, this rotation is going to make a difference later.

- The next step to generate the harmonic height function is to heighten each point in this circular base to a certain point. This height is determined by the function:

$$z = \sin(3t)$$

  The raising process is shown in Figure 12. Note that if we change δ here, then the rotation would be visible because of the curve's rotational symmetry is broken in the process.

- Finally, if we project that rotating height curve onto the y-z plane, as shown in Figure 13, we can see that it is the same as the output of the above code.

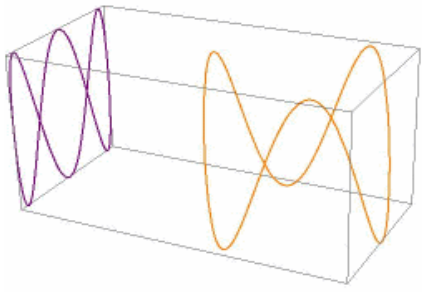


Figure 13. Projection onto y-z plane.[32]

[32] Zhao, "Lissajous curve."

In other words, this Lissajous Curve can be viewed as the projection of this 3-D height function. Changing the value of δ makes the 3-D curve rotate and in turn, changes the 2-D curve. This is why we had the 3-D illusion in the execution of the last code. It is worth mentioning that algebraic analysis confirms this result. As we have seen, the parametric equations of this harmonic height function are:

$$x = \cos(t + \delta)$$

$$y = \sin(t + \delta)$$

$$z = \sin(3t)$$

Now, to project it onto the y-z plane, we can fix its x component to be 0:

$$x = 0$$

$$y = \sin(t + \delta)$$

$$z = \sin(3t)$$

Compare this projection to the Lissajous Curve we investigated on:

$$x = \sin(t + \delta)$$

$$y = \sin(3t)$$

We see they are the same. Although we used a special case $a = 1$, $b = 3$ in our discussion, the result can apply to all Lissajous Curves with rational frequency ratios. In the end, the following image shows the 3-D height function of a Lissajous Curve:

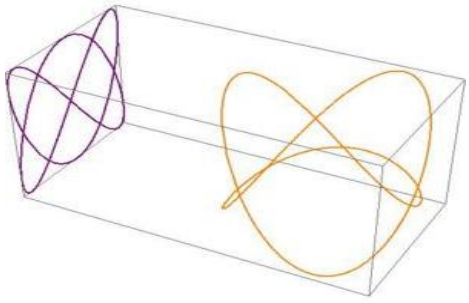


Figure 14. $a = 2$, $b = 3$, $\delta = 0$.[33]

[33] Zhao, "Lissajous curve."

Conclusion

The coding and algorithm of the programs we designed during this work, guide us to learn more deeply and the output of these programs helps us to understand effectively as well as to conduct more logical conclusions. Based on what we discussed, it is expressed that we can plot Lissajous Curves by programming and explain it. Through the illustration of The Lissajous curve which is demonstrated by using Python programming language is expected to facilitate students in realizing the material of the Lissajous curve. They are also supposed to have sufficient skill in plotting equations by programming. After all, in the area of creating scientific programs, they can design algorithms for complicated problems.

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Examining Interactive Effects of Group Membership and Trustworthiness on Recognition Memory

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Abstract

Faces provide certain cues, such as trustworthiness, that are shown to be more memorable than others. To better understand the untrustworthiness advantage in recognition memory, it is important to study faces that vary in trustworthiness and also provide other cues. This research measured recognition memory of faces that varied in group membership and trustworthiness. Participants took a bogus personality test to establish an ingroup and outgroup. Then, they completed a learning phase in which they viewed ingroup and outgroup faces that were either trustworthy or untrustworthy. The untrustworthy advantage was expected to disappear for ingroup trustworthy faces. In addition, untrustworthy outgroup faces were expected to be remembered more than outgroup trustworthy and ingroup untrustworthy faces. The current research builds on previous findings by investigating how two facial cues, trustworthiness and group membership, interact together to affect recognition memory.

Examining Interacting Effects of Group Membership and Trustworthiness on Recognition Memory

People are exposed to an incredible number of faces throughout their lifetimes and can recognize as many as 5000 of them.[34] Recognizing faces is

[34] Jenkins, R., A. J. Dowsett, and A. M. Burton. "How Many Faces Do People Know?" Proceedings of the Royal Society B: Biological Sciences 285, no. 1888 (2018): 20181319. https://doi.org/10.1098/rspb.2018.1319.

important because it is key to facilitating social interactions and communication, as well as information about people's facial features. Some faces contain distinctive cues that have been empirically shown to stand out more than others.[35] One such cue is trustworthiness; a growing body of work shows that people remember untrustworthy faces more than trustworthy ones because they indicate potential danger.[36] Prior work examining facial untrustworthiness advantages in recognition memory has identified these advantages in the absence of other contextual cues. People do not always perceive faces in isolation from other cues potentially affecting recognition memory. People remember ingroup members' faces more than outgroup members' faces when they share group membership.[37]

To better understand untrustworthiness advantages in recognition memory, it is therefore important to investigate how people recognize faces varying in their trustworthiness when other contextual cues are available. The current work examined recognition advantages for untrustworthy faces identified as ingroup or outgroup members relative to perceivers. To this end, I first summarize literature on recognition advantages for untrustworthy faces. Then, I discuss literature on recognition advantages for ingroup faces. I then discuss the current research that examined how facial trustworthiness and group membership cues could interact to affect recognition memory.

Recognition Memory Advantages for Untrustworthy Faces

Recognizing untrustworthiness in others has important implications for survival because this informs people about whether it is dangerous to approach others.[38] Furthermore, perception of untrustworthiness is believed

[35] Oosterhof, Nikolaas N., and Alexander Todorov. "The Functional Basis of Face Evaluation." Proceedings of the National Academy of Sciences 105, no. 32 (2008): 11087–92. https://doi.org/10.1073/pnas.0805664105.

[36] Rule, Nicholas O., Michael L. Slepian, and Nalini Ambady. "A Memory Advantage for Untrustworthy Faces." Cognition 125, no. 2 (2012): 207–18. https://doi.org/10.1016/j.cognition.2012.06.017.

[37] Bernstein, Michael J., Steven G. Young, and Kurt Hugenberg. "The Cross-Category Effect." Psychological Science 18, no. 8 (2007): 706–12. https://doi.org/10.1111/j.1467-9280.2007.01964.x.

[38] Hou, Chunna, and Zhijun Liu. "The Survival Processing Advantage of Face: The Memorization of the (Un)Trustworthy Face Contributes More to Survival Adaptation." Evolutionary Psychology 17, no. 2 (2019): 147470491983972. https://doi.org/10.1177/1474704919839726.

to be so crucial for survival that according to evolutionary theory, people should remember survival related information better than other types of information.[39] Past recognition memory work supports this possibility. [40] This prior work has sought to replicate the experience of quickly and passively viewing faces. The research consisted of three studies where people passively viewed faces rated as being highly trustworthy or highly untrustworthy. In Rule's first study, undergraduate participants completed an encoding task in which they were shown either male or female faces that had previously been evaluated as trustworthy or untrustworthy.[41] Next, participants completed a distraction task. After a retention interval, participants completed a recognition task by identifying whether the previously seen trustworthy or untrustworthy faces were new.

Evidencing a recognition memory advantage for untrustworthy faces, participants had better recognition memory for untrustworthy versus trustworthy faces. These findings are consistent with other work that suggests that people are motivated to remember faces that give cues of danger to be avoided.[42] The finding of a recognition advantage for untrustworthy faces provides a functional perspective within the ecological theory of perception; the ecological theory of perception posits that faces contain information that is crucial for communication about character traits.[43] A functional perspective within this theory suggests that untrustworthy faces would be recognized more because this trait is considered more valuable for memory.

Recognition Memory Advantages for Ingroup Members

People remember more ingroup than outgroup faces. This finding has been found for racial ingroup and outgroup faces, and this is the basis of the

[39] McBride, Dawn M., Brandon J. Thomas, and Corinne Zimmerman. "A Test of the Survival Processing Advantage in Implicit and Explicit Memory Tests." Memory & Cognition 41, no. 6 (2013): 862–71. https://doi.org/10.3758/s13421-013-0304-y.

[40] Rule, "A Memory Advantage for Untrustworthy Faces," 207-18.

[41] Rule, 207-18.

[42] Rule, 207-18.

[43] Rule, 207-18.

cross-race effect.[44] The cross-race effect refers to the tendency for people to remember own-race faces better than other-race faces.[45] One influential theoretical explanation of the cross-race effect is the perceptual expertise model. This model suggests that people better recognize ingroup versus outgroup race faces because they process ingroup race faces more often.[46] Social cognitive models elaborate on the perceptual expertise model by suggesting that perceptual expertise, social cognition, and motivation combine to explain own-race advantages in recognition memory. Social cognition theory explains that people think about outgroups in terms of their category, while they think about ingroup members as being more individual.[47] In addition, motivation is thought to influence the amount of effort that people put into recognizing faces.[48] Hybrid theories that combine elements of perceptual expertise, social cognition, and motivation are posited to be the best models to explain the cross-race effect.[49] Hybrid theories provide a bigger framework for understanding the cross-race effect than the perceptual expertise or social cognitive theories alone.

As previously mentioned, the perceptual-expertise model has been the dominant explanation for the cross-race effect.[50] However, other work has drawn on evidence of social categorization as a mechanism for causing own-group bias.[51] This work suggests that own-group bias is largely caused by thinking about the outgroup categorically, which is explained in the social cognitive model. In Bernstein, Young, and Hugenberg's study, participants saw faces belonging to their own university or a rival university.[52] Simply

[44] Young, Steven G., Kurt Hugenberg, Michael J. Bernstein, and Donald F. Sacco. "Perception and Motivation in Face Recognition." Personality and Social Psychology Review 16, no. 2 (2011): 116–42. https://doi.org/10.1177/1088868311418987.

[45] Young, Hugenberg, Bernstein, and Sacco, 116-42.

[46] Young, Hugenberg, Bernstein, and Sacco, 116-42.

[47] Young, Hugenberg, Bernstein, and Sacco, 116-42.

[48] Young, Hugenberg, Bernstein, and Sacco, 116-42.

[49] Young, Hugenberg, Bernstein, and Sacco, 116-42.

[50] Young, Hugenberg, Bernstein, and Sacco, 116-42.

[51] Bernstein, Young, and Hugenberg, "The Cross-Category Effect," 706–12.

[52] Bernstein, Young, and Hugenberg, 706-12.

assigning faces to a category elicited own-group bias. Unlike cross-race effect studies, this categorization study held faces constant across the ingroup and outgroup. This study showed that categorization itself elicited own-group bias rather than a characteristic of the face. In the second study, they wanted to investigate whether non-pre-existing groups elicited better recognition memory, which was interpreted as own-group bias. Participants completed a bogus personality test before the learning phase of the experiment. The test gave the participants either a red or green personality, and they were also asked to wear a wristband that corresponded with their personality type. They found that group categorization brings about ingroup bias, and therefore found support for the social-categorization model of the cross-race effect. This finding is significant because it shows that non-pre-existing groups also bring about own-group bias.

Young, Bernstein, and Hugenberg examined the question of whether own-group biases occur during encoding and recognition.[53] The Encoding Hypothesis motivated their predictions; this hypothesis suggests that own-group biases emerge when information is first processed in memory, which is called encoding. In the first study, they tested the Encoding Hypothesis by asking participants to complete a face recognition experiment in which they received either pre-encoding or post-encoding instructions asking them to pay special attention to the features of the faces.[54] They found that participants given instructions prior to encoding did not show own-group bias, but those given instructions after this phase did show it. In the second study, they wanted to control when the in-groups and out-groups were created. The researchers found that an own-group bias only occurred when participants were given the personality type prior to encoding. Their findings support the hypothesis that own-group biases occur during encoding as opposed to post-encoding. Therefore, they found support for the Encoding Hypothesis by eliminating own-group bias in the first study and causing it in the second.

Current Research

[53] Bernstein, Young, and Hugenberg, 706-12.

[54] Bernstein, Young, and Hugenberg, 706-12.

Research has found that people remember untrustworthy faces more than trustworthy ones.[55] In addition, researchers have found that when participants are assigned to made-up groups, there is an ingroup bias in recognition memory; they remember ingroup faces more than outgroup faces.[56] To date, there is little research on how group membership and facial trustworthiness may interact to affect recognition memory. The current research investigated how well people remember trustworthy and untrustworthy faces that are arbitrarily categorized as belonging to an ingroup or outgroup. Consistent with prior work, this research used White male faces as stimuli in order to control for race and gender, which could otherwise have affected the results.[57]

Prior work suggests that group membership affects how emotions are interpreted.[58] Research on the positivity bias has shown that people rate the emotional expressions of ingroup members more positively than they do for outgroup members.[59] This study explored how assigning groups to people affects their perceptions of ingroup and outgroup members' emotional expressions. In the first study, participants were assigned to teams to specifically test how groups affect judgments of emotions.[60] Simply labeling an emotional face with ingroup membership resulted in a more positive perception. Thus, it seems plausible that an untrustworthy ingroup face could be perceived as less untrustworthy than an untrustworthy outgroup. This differential perception could affect the untrustworthy advantage in recognition memory.

Hypotheses

[55] Rule, "A Memory Advantage for Untrustworthy Faces," 207-18.

[56] Bernstein, Young, and Hugenberg, "The Cross-Category Effect," 706-12.

[57] Rule, "A Memory Advantage for Untrustworthy Faces," 207-18.

[58] Lazerus, Talya, Zachary A. Ingbretsen, Ryan M. Stolier, Jonathan B. Freeman, and Mina Cikara. "Positivity Bias in Judging Ingroup Members' Emotional Expressions." Emotion 16, no. 8 (2016): 1117–25. https://doi.org/10.1037/emo0000227.

[59] Lazerus, Talya, Ingbretsen, Stolier, Freeman, and Cikara, 1117-25.

[60] Lazerus, Talya, Ingbretsen, Stolier, Freeman, and Cikara, 1117-25.

Consistent with identified recognition memory advantages for untrustworthy faces, I hypothesized that people would better recognize untrustworthy versus trustworthy faces.[61] Consistent with identified recognition memory advantages for same-category faces, I hypothesized that people would better remember faces categorized as ingroup versus outgroup members.[62] Critically, I also hypothesized that facial trustworthiness and group membership would interact to affect recognition memory. Specifically, I hypothesized that because ingroup untrustworthy faces are likely to be more positively perceived, that untrustworthiness advantages in recognition memory would be stronger for outgroup versus ingroup faces.[63]

An alternative hypothesis was that untrustworthy faces would be so salient to perceivers that ingroup membership would not reduce the untrustworthy advantage in recognition memory.[64] Rather, outgroup membership could exacerbate this recognition advantage. This alternative pattern was motivated by work showing that people recognize the faces of those who cheat more than trustworthy faces because the former could signal danger or harm.[65] An additional possibility was that the ingroup untrustworthy faces and the outgroup trustworthy faces would violate the expectations of participants. This was motivated by past work showing that people's memory is enhanced when they encounter trustworthy-looking cheaters.[66] However, the current research measured recognition memory, while Suzuki and Saga measured a different form of memory in their research.[67]

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[61] Rule, "A Memory Advantage for Untrustworthy Faces," 207-18.

[62] Bernstein, Young, and Hugenberg, "The Cross-Category Effect," 706-12.

[63] Lazerus, Talya, Zachary A. Ingbretsen, Ryan M. Stolier, Jonathan B. Freeman, and Mina Cikara. "Positivity Bias in Judging Ingroup Members' Emotional Expressions." Emotion 16, no. 8 (2016): 1117–25. https://doi.org/10.1037/emo0000227.

[64] Mealey, Linda, Christopher Daood, and Michael Krage. "Enhanced Memory for Faces of Cheaters." Ethology and Sociobiology 17, no. 2 (1996): 119–28. https://doi.org/10.1016/0162-3095(95)00131-x.

[65] Mealey, Linda, Daood, and Krage, 119-28.

[66] Suzuki, Atsunobu, and Sayaka Suga. "Enhanced Memory for the Wolf in Sheep's Clothing:" Cognition 117, no. 2 (2010): 224–29. https://doi.org/10.1016/j.cognition.2010.08.004.

[67] Suzuki, Atsunobu, and Sayaka Suga. "Enhanced Memory for the Wolf in Sheep's Clothing:" Cognition 117, no. 2 (2010): 224–29. https://doi.org/10.1016/j.cognition.2010.08.004.

Method

Participants

One hundred and forty-nine adult participants were recruited from the Amazon Mechanical Turk and given $1 for their participation. When taking exclusion criteria into account, the participant number decreased significantly. Participant number decreased to 143 when accounting for the manipulation checks, which consisted of asking participants their personality type before the encoding task as well as before the demographics section. In addition, participants who answered less than 7 distractor task questions were removed because of concerns that the stimuli would not transfer to long-term memory for the retrieval task. This brought the participant number down to 135. Participants whose accuracy on the distractor task was less than 75% were also removed for concerns about memory storage, and this brought the total number down to 129. When participants who did not respond to at least 85% of encoding task questions were removed, participant number dropped to 125. Participants who were less than 75% accurate on the learning task were also removed, bringing the total number to 91. These two exclusion criteria were implemented because sufficient encoding is necessary for information to be stored in memory. If participants did not see most of the stimuli and accurately identify their personality type, neither trustworthiness nor group membership would be manipulated. Finally, participants who had less than a 50% hit rate (i.e., chance level memory performance) on the recognition task were removed, yielding a final analyzed sample of 58 participants (Mage=38.93 years, SD=10.79; Myears of education = 14.97 years, SD = 2.14). Fifty-five out participants identified as White, two participants identified as Asian, and one identified as Black. Of the 58 participants, 55 also identified as non-Hispanic.

Materials

Faces. Eighty-eight neutrally expressive White male faces were selected from the Chicago Face Database.[68] Trustworthiness norms from the database were used to classify faces as trustworthy or untrustworthy. A t-test confirmed that the faces classified as trustworthy or untrustworthy significantly differed in their facial trustworthiness. Selected faces were grey-scaled and cropped to the face area (e.g., hair and clothing cues were removed).

Personality Test. Participants rated their agreement (1 = strongly disagree, 7 = strongly agree) with questions from the Ten-Item Personality Inventory.[69]

Design

Participants were randomly assigned to having a red or blue personality type. Untrustworthy and trustworthy faces were also randomly assigned as being labeled as having a red or blue personality type. By randomly assigning participants to one of two personality types, this created their ingroup and outgroup. Participants were exposed to trustworthy and untrustworthy ingroup and outgroup faces, and the proposed research was concerned with the group membership of the faces rather than the personality type assigned to participants. Participants saw faces across the four combinations of facial trustworthiness and group membership (trustworthy/ingroup, trustworthy/outgroup, untrustworthy/ingroup, untrustworthy outgroup). Thus, the primary analyses examining recognition memory advantages employed a 2 (Target Group Membership: ingroup, outgroup) x 2 (Target Facial Trustworthiness: trustworthy, untrustworthy) within-subjects design.

Procedure

After providing informed consent, participants began the experiment. The experiment was conducted remotely on participants' computers.

[68] Ma, Debbie S., Joshua Correll, and Bernd Wittenbrink. "The Chicago Face Database: A Free Stimulus Set of Faces and Norming Data." Behavior Research Methods 47, no. 4 (2015): 1122–35. https://doi.org/10.3758/s13428-014-0532-5.

[69] S.D. Gosling, P.J. Rentfrow, and W.B. Swann. "A very brief measure of the big-five personality domains." Journal of Research in Personality, 37 no 6 (2003): 504- 528, 10.1016/S0092-6566(03)00046-1.

Participants took the above-described personality test. After taking the test, participants were randomly told that their results indicated that they had a red or blue personality type. Participants were not informed that their personality type was randomly determined. After receiving their results, participants answered a manipulation check for personality type. Participants then completed the learning phase of the experiment. Participants saw 44 faces one at a time in a random order. Faces were presented for 2 seconds each, with 1 second between each face. Participants responded with a button press to indicate the group type of the faces on each trial. Participants pressed 1 if the face was a red personality and 2 if it was a blue personality. The personality type was listed above each face, and each personality type was also listed below each face in the corresponding color with the appropriate number press (i.e., red personality (1), blue personality (2)). Of the 44 randomly selected faces, there were 11 faces across the four combinations of facial trustworthiness and group membership (trustworthy/ingroup, trustworthy/outgroup, untrustworthy/ingroup, untrustworthy outgroup).

After completing the learning phase, participants completed a distractor task in which they solved 8 simple math problems with 8 seconds allotted for each question. After the distractor task, participants completed the recognition phase of the experiment. In the recognition phase, participants saw 88 faces. Forty-four of the faces were seen during the learning phase. The other 44 faces were new faces that participants did not see during the learning phase. The new 44 faces were evenly distributed across trustworthiness/untrustworthiness and red/blue personality type. The recognition phase was self-paced. Participants pressed 1 to indicate that they have seen the face before (i.e., it was an "old" face) and pressed 2 to indicate that they had not seen the face before (i.e., it was a new face). There were eight task versions counterbalancing whether trustworthy and untrustworthy faces were assigned to red or blue personality types and whether they were used in the learning phase. After completing the recognition phase, participants answered another manipulation check for personality type as well as a brief demographics section asking for age, education level, race, and ethnicity. After finishing the experiment, participants were thanked and debriefed.

Results

D'

Like prior work, recognition memory was measured using d'. D' is a measure of sensitivity, or the distance between the means of the hit and false alarm rate. Previously seen ("old") faces identified as "old" are hits. New faces incorrectly identified as "old" are false alarms. To find d', the standardized difference between the hit rate and false alarm rate was calculated.[70] Larger values for d' indicate greater sensitivity, or a greater difference between the hit and false alarm rate. A d' value close to zero indicates that participants performed at chance. D' values were calculated separately for untrustworthy and trustworthy ingroup and outgroup faces. "Old" untrustworthy ingroup faces identified as such were considered hits, while new untrustworthy ingroup faces identified as "old" were considered false alarms. D' was used to analyze the results rather than relying only on hit rate because it corrects for response bias, or the tendency for participants to randomly answer questions.[71]

A two-way repeated measures ANOVA for D' found a marginal Facial Trustworthiness effect, $F(1,57)=2.696$, $p=0.106$, $\eta_p^2 = 0.007$. Consistent with past research (Rule et al., 2012), people had more sensitivity in recognizing untrustworthy relative to trustworthy faces. There was no Group Membership effect, $F(1,57)=0.178$, $p=0.675$, $\eta_p^2 = 0.0004$, or Facial Trustworthiness x Group Membership interaction, $F(1,57)=0.522$, $p=0.473$, $\eta_p^2 = 0.001$. See Table 1 for descriptive statistics on Group Membership and Trustworthy categories for D'.

[70] Stanislaw, Harold, and Natasha Todorov. "Calculation of Signal Detection Theory Measures." Behavior Research Methods, Instruments, & Computers 31, no. 1 (1999): 137–49. https://doi.org/10.3758/bf03207704.

[71] Stanislaw, Harold, and Todorov, 137-49.

Table 1: Means and Standard Deviations of D' ANOVAs for Trustworthiness and Group Membership Categories

Facial Trustworthiness	Group Membership	Mean	Standard Deviation
Trustworthy	Ingroup	0.790	0.710
Trustworthy	Outgroup	0.767	0.712
Untrustworthy	Ingroup	0.857	0.789
Untrustworthy	Outgroup	0.942	0.798

Hits

As described above, hits refer to previously seen ("old") faces that are correctly identified as "old." A two-way repeated measures ANOVA for Hit Rate found no significant effect for Facial Trustworthiness, *F(1,57)=0.138*, *p=0.712*, $\eta_p^2 = 2.967 \times 10^{-4}$, no effect for Group Membership, *F(1,57)=0.776*, *p=0.382*, $\eta_p^2 = 3.972 \times 10^{-3}$, and no Trustworthiness x Group Membership interaction, *F(1,57)=0.0005*, *p=0.983*, $\eta_p^2 = 1.299 \times 10^{-6}$. See Table 2 for descriptive statistics for Trustworthiness and Group Membership categories for Hit Rate.

Table 2: Means and Standard Deviations of Hit ANOVAs for Trustworthiness and Group Membership Categories

Facial Trustworthiness	Group Membership	Mean	Standard Deviation
Trustworthy	Ingroup	0.639	0.171
Trustworthy	Outgroup	0.661	0.052
Untrustworthy	Ingroup	0.645	0.052
Untrustworthy	Outgroup	0.667	0.052

False Alarms

As described above, false alarms refer to "new" faces that are incorrectly identified as "old" faces. A two-way repeated measures ANOVA

for False Alarm Rate found a marginal effect for Facial Trustworthiness, where trustworthiness was remembered more than untrustworthiness, *F(1,57)=2.376, p=0.129,* $\eta_p^2 = 0.007$. There was no Group Membership effect, *F(1,57)=0.288, p=0.594,* $\eta_p^2 = 0.001$, or Facial Trustworthiness x Group Membership interaction, *F(1,57)=0.327, p=0.590,* $\eta_p^2 = 0.0008$. See Table 3 for descriptive statistics for Trustworthiness and Group Membership categories for False Alarm Rate.

Table 3: Means and Standard Deviations of False Alarm ANOVAs for Trustworthiness and Group Membership Categories

Facial Trustworthiness	Group Membership	Mean	Standard Deviation
Trustworthy	Ingroup	0.374	0.184
Trustworthy	Outgroup	0.397	0.192
Untrustworthy	Ingroup	0.352	0.188
Untrustworthy	Outgroup	0.354	0.206

Discussion

It was predicted that untrustworthy faces would be remembered more than trustworthy faces and that ingroup faces would be remembered more than outgroup faces. Additionally, I hypothesized that facial trustworthiness and group membership would interact to affect group membership, and that the untrustworthiness advantage would be reduced for ingroup faces. Overall, the results are not in line with the hypotheses. The results show that the untrustworthiness effect was maintained across group contexts; this effect is marginal, but it is in line with my prediction as well as past research.[72] The results did not find a general group membership effect, which is not in line with the hypotheses or past research findings that ingroups are remembered more than outgroups.[73] This may be because trustworthiness is a more powerful cue than group membership. Another possibility is that the group

[72] Rule, "A Memory Advantage for Untrustworthy Faces," 207-18.

[73] Bernstein, Young, and Hugenberg, "The Cross-Category Effect," 706-12.

membership cue used in the current research, the Ten-Item Personality Inventory did not elicit sufficient group manipulation.[74]

It was predicted that because ingroups are rated more positively than outgroups, this would cause a diminished untrustworthy advantage among ingroup faces. However, no interaction was found for a reduced untrustworthy advantage in the ingroup, indicating that group membership does not have a significant influence on trustworthiness. Untrustworthiness cues may be more salient than group category cues when they are presented together, and this possibility counters the hypotheses of the current research. A potential explanation for the lack of interaction between facial trustworthiness and group membership could be explained by evolutionary theory, which posits that trustworthiness perception is crucial to survival.[75] It could be that when presented with trustworthy and group membership cues, people give more sway to the trustworthy cues because they are deemed more relevant for survival, and therefore convey more important information than group membership cues.

A significant limitation to the current research was the participant exclusion, which limited the statistical power of the study. The participant exclusion removed participants who did not pass the manipulation check, did not answer at least 85% of encoding questions, and did not have at least 75% accuracy on the retrieval task. This exclusion brought the participant number down from 149 to 58. This study was conducted online rather than in a lab, and the online format could be a contributor to the high number of participants who were excluded. The format of this online study could have resulted in a greater likelihood for distraction than would be expected in a study conducted in a lab. Replicating the current research in a lab rather than online would be useful in order to investigate differences in the distraction of participants. In other words, it seems likely that participants would be less distracted if they completed the study in the lab, and thus accuracy in the retrieval task would increase. A potential mitigation for the lack of group membership salience is to ask participants to write down their personality type as well as verbally communicate it to the researcher. These steps would presumably increase the salience of the bogus personality test. In addition, if replicating this study

[74] Gosling, Rentfrow, and Swann, "A very brief measure," 504-28.

[75] McBride, Thomas, and Zimmerman, "A Test of the Survival," 862-79.

online, it would be useful to use a group membership cue that is known to elicit strong ingroup and outgroup bias, rather than an arbitrary personality test.

Another limitation to the current research is that the stimuli were White male faces. This was necessary in order to control for other variables such as race and gender that might otherwise impact the findings. The current research sought to measure how recognition memory is affected only by group membership and trustworthiness, not race or gender. Thus, it is unclear how the findings generalize across female faces and to minority faces. Investigating how these cues affect minority faces is also important because racial stereotypes could be linked to untrustworthiness, which could in turn lead to a greater untrustworthy advantage for the outgroup. The current research used arbitrary group membership; however, using group membership cues such as race or political affiliation could lead to more salient group membership bias. Real-life group memberships like race and political affiliation are associated with stereotypes, while the arbitrary group membership used in the current research is not associated with existing stereotypes. Also, future research should investigate how group membership and facial characteristics affect recognition memory of women's faces because women are perceived differently in terms of their social traits.[76]

Additionally, future research could investigate how other facial characteristics such as likeability and dominance as well as group membership affect recognition memory. This is an important avenue for research because recognizing these characteristics is important during social interactions.[77] Another direction for future research is to test the recognition memory of participants without color context at recognition. This is an important next step to take because it is valuable to know whether participants remember the faces because of the color context or because of specific facial features. Overall, the current research takes an important step in investigating how more than one characteristic affects recognition memory.

[76] Vianello, Michelangelo, Konrad Schnabel, N. Sriram, and Brian Nosek. "Gender Differences in Implicit and Explicit Personality Traits." Personality and Individual Differences 55, no. 8 (2013): 994–99. https://doi.org/10.1016/j.paid.2013.08.008.

[77] Oosterhof and Todorov, "The Functional Basis of Face Evaluation," 11087-92.

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Stanislaw, Harold, and Natasha Todorov. "Calculation of Signal Detection Theory Measures." *Behavior Research Methods, Instruments, & Computers* 31, no. 1 (1999): 137–49. https://doi.org/10.3758/bf03207704.

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Fujoshi and the Obsession with Homoerotica in Japanese Media Culture

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Abstract

In modern Japan, a subcultural group called *fujoshi* have been expanding their community internationally through the internet. *Fujoshi*, meaning "rotten girls," refers to young women who enjoy reading homoerotic manga called *yaoi*. Attempts by governments worldwide to curb the distribution of *yaoi* and controversy over the morality of *yaoi* and the ethics of the *fujoshi* community has led the community to remain hidden online. Through journal articles and written works by professors studying *fujoshi*, Japanese fan culture, and sexuality, this paper analyzes perspectives on the inner workings of the *fujoshi* community and its impacts on homosexual men, Japanese society, and the global view of homosexuality.

In Japan, there is a subcultural group called *fujoshi*. In Japanese, *fujoshi* translates to "rotten women." These women are considered "rotten" because they enjoy a genre of fan-made media called *yaoi* that involves male

characters in homoerotic relationships[78]. The main aspect of *yaoi* is that it typically is consumed through manga (Japanese comics) in which these male characters have sex. The more interesting part is the target audience of *yaoi*: not homosexual men, but instead heterosexual women[79]. There are theories as to why women enjoy male homoerotic manga, most notably saying the *fujoshi* phenomenon derives from women's "sexual play" and desire to escape traditional Japanese gender and sexuality norms[80]. The strength of this community and how it has grown in numbers in the face of scrutiny and criticism prove how controversial this *fujoshi* phenomenon is. Exploring the complexities of the *fujoshi* community and the genre itself will help contextualize its effects on Japanese society, the audience who consume *yaoi*, and the worldwide LGBTQ+ community.

The word *fujoshi* comes from a Japanese play on words. The original word *fujoshi* is written in these kanji, "婦女子," meaning respectable women. To create a homonym, the first kanji is replaced with a symbol of the same pronunciation but different meaning, changing the word to "腐女子," meaning rotten women[81]. This "rottenness" may refer to the media *fujoshi* consume: BL and *yaoi*. BL stands for Boys' Love, a literary genre depicting homosexual relationships. This term is typically an umbrella term for all homosexual literature[82]. *Yaoi* is a subgenre of BL, however dealing

[78] Patrick W. Galbraith, "*Fujoshi* : Fantasy Play and Transgressive Intimacy among 'Rotten Girls' in Contemporary Japan," *Signs: Journal of Women in Culture and Society* 37, no. 1, (Autumn 2011): 211–32, https://doi.org/10.1086/660182.

[79] Mizuko Itō, Daisuke Okabe, and Izumi Tsuji, *Fandom Unbound : Otaku Culture in a Connected World* (New Haven: Yale University Press, 2012), https://ebookcentral.proquest.com/lib/uncg/detail.action?docID=3420822.

[80] Kristine Michelle L. Santos, "Queer Affective Literacies: Examining 'Rotten' Women's Literacies in Japan," *Critical Arts* 34, no. 5, (October 2020): 72–86, https://doi.org/10.1080/02560046.2020.1825506.

[81] Kayo Takeuchi, "The Genealogy of Japanese 'Shōjo Manga' (Girls' Comics) Studies," *U.S.-Japan Women's Journal*, no. 38 (2010): 81–112, http://www.jstor.org/stable/42772011.

[82] Rebecca Snyder, "Feminism or Homophobia: An Analysis of Discourse on Female Yaoi Readers" (Undergraduate Honors Thesis, State University of New York at New Paltz, 2019).

more with depicting sexual relations between the couple. *Yaoi* is written in hiragana, "やおい," because it is an acronym. The word stands for *yamanashi, ochinashi, iminashi*, and its literal translation is "no peak, no fall, no meaning"[83]. The Japanese made this word to further degrade *fujoshi* as it implies that *yaoi* is not a respectable form of literature as it focuses entirely on sex without any plot or character development.

Yaoi tends to depict specific characterizations of Japanese gay men. They are drawn to look androgynous, beautiful, and slender. These men will probably have *seme* and *uke* roles. *Seme* refers to the man who is masculine, typically with a muscular body, and is the giver of love. *Uke* refers to the man who is feminine, typically with a skinny body, androgynous features, big, sparkling eyes, and receives the *seme*'s love. *Yaoi* is often created by young heterosexual women for other heterosexual women to consume[84]. This type of literature allows straight women "to alternate between being a subject who loves man and an object who is loved by men, while at the same time satisfying the desire to voyeuristically watch sexual love between two men"[85]. *Yaoi* is consumed through manga, anime (Japanese animation), and more recently, *doujinshi*. With the introduction of digital artwork, fans are able to produce *doujinshi*, which are fan-made publications or magazines depicting popular male characters from mainstream Japanese media and putting them into different plots[86]. These publications are often distributed illegally on the internet for global consumption, creating an international following of *yaoi* works[87].

In Japanese society, *fujoshi* are severely looked down upon. Japanese society is very conservative and ingrained with heteronormative social norms

[83] Galbraith, "*Fujoshi* : Fantasy Play," 211-32.

[84] Santos, "Queer Affective Literacies," 72-86.

[85] Takeuchi, "The Genealogy," 92.

[86] Santos, "Queer Affective Literacies," 72-86.

[87] Andrea Wood, "Boys' Love Anime and Queer Desires in Convergence Culture: Transnational Fandom, Censorship and Resistance," *Journal of Graphic Novels & Comics* 4, no. 1, (May 2013): 44–63, https://doi.org/10.1080/21504857.2013.784201.

and binary gender norms[88]. Japanese society views *fujoshi* as undersocialized, immature, and dangerous[89]. *Fujoshi* are a subculture within the cultural group of *otaku*, people who are obsessed with manga and anime. *Otaku* are viewed as losers and pedophiles by the majority of Japanese society. Some people fear *otaku* because there have been incidents of pedophilia with male *otaku*, some of which who assault or murder young women. Female *otaku* are not often called into question because they are able to hide fairly easily within society, whereas male *otaku* are not[90]. *Fujoshi* specifically are feared for their encouragement of homosexual relationships and their potential corruption of children and teenagers who may gain access to this pornographic homosexual literature[91].

A central aspect of *fujoshi* is the community they have created. The *fujoshi* community is global through its distribution of fan-made *yaoi* via the internet. *Fujoshi* have also taken over at Comic Market, a semiannual *doujinshi* selling event that takes place in Japan. Women and men used to equally make up the population of *doujinshi* sellers, but now women have risen to 70% of the sellers[92]. Many of these female sellers are selling *yaoi*[93]. Not only appearing at Comic Market, *yaoi* has found its way into large bookstores across Japan. Any large bookstore will most likely have a BL section where these works can be found[94]. Explicit works may contain an R18 warning, implying a high sexual nature within the work. The sale and

[88] Genaro Castro-Vázquez and Izumi Kishi, "Masculinities and Sexuality: The Case of a Japanese Top Ranking Senior High School," *Journal of Gender Studies* 12, no. 1, (August 2003): 21–34, https://doi.org/10.1080/0958923032000067790.

[89] Christopher Smith, "Becoming Illegible: The Repatriation of Japanese Fan Culture in Genshiken," *Journal of Graphic Novels and Comics* 12, no. 3, (July 2021): 254–65, https://doi.org/10.1080/21504857.2019.1641530.

[90] Morikawa Kaichiro and Dennis Washburn, "おたく Otaku/Geek," *Review of Japanese Culture and Society* 25, (December 2013): 56–66, http://www.jstor.org/stable/43945382.

[91] Wood, "Boys' Love Anime," 44-63.

[92] Kaichiro and Washburn, "おたく Otaku/Geek," 44–63.

[93] Santos, "Queer Affective Literacies," 72-86.

[94] Wood, "Boys' Love Anime," 44-63.

consumption of *yaoi* brings the community even closer together; since the community is cast out from society, *fujoshi* rarely ever admit to being a part of the community for fear of backlash from friends and family[95]. This makes it hard for *fujoshi* to find other *fujoshi* in everyday life. *Fujoshi* turn to the internet to find their community, and artists and readers alike largely connect through the works they share. The *fujoshi* community is exclusive and secret. *Fujoshi* say they put on a *kyara*, meaning a metaphorical mask, when they interact with non-*fujoshi*[96]. *Fujoshi* feel stigmatized and rejected from society, often harboring shame and self-humiliation in enjoying an act that is socially deviant[97]. Therefore, they will only drop their *kyara* among fellow *fujoshi* as they may find solace in their community as it creates a sense of belonging and unity among the women.

On one side of the *fujoshi* controversy, there are people who sympathize with *fujoshi*. Some people think that *fujoshi* are just women who are discontent with Japanese social and gender norms where women are submissive and men are dominant. In *yaoi*, there is no woman at all in the relationship. It is completely free from the male and societal gaze, making the experience more pleasurable for the female reader[98]. Some may argue that *fujoshi* are taking part in intertextualization, where they change the meaning of a text by imposing a relationship onto homosocial friendships. Where non-*fujoshi* may see friendship, *fujoshi* would see love. Where non-*fujoshi* see rivalry, *fujoshi* see jealousy[99]. These queer readings allow the reader to perceive the original narrative in a new way because they are using their

[95] Dolores P. Martinez, "Reviewed Work: Fandom Unbound: Otaku Culture in a Connected World by Mizuko Ito, Daisuke Okabe, Izumi Tsuji," *The Journal of Japanese Studies* 40, no. 2, (Summer 2014): 469–73, http://www.jstor.org/stable/24242737.

[96] Santos, "Queer Affective Literacies," 72-86.

[97] Hiromi Tanaka and Saori Ishida, "Enjoying Manga as Fujoshi: Exploring Its Innovation and Potential for Social Change from a Gender Perspective," *International Journal of Behavioral Science* 10, no. 1, (2015): 77–85, https://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=117718851&site=ehost-live.

[98] Takeuchi, "The Genealogy," 92.

[99] Santos, "Queer Affective Literacies," 72-86.

creativity and imagination to create fantasies[100]. By seeking out queer potential in heteronormative anime, they are innovating new interpretations of stories and creating a new perception of mainstream media. This has also led to mainstream anime featuring more gay love stories[101]. Most famously, Sayo Yamamoto and Mitsurou Kubo co-created a popular anime called Yuri!!! On ICE (2016). This anime is famous for having a strong underlying homosexual plot between the figure skating coach, Victor, and the figure skater, Yuri. They even go so far as to exchange gold rings towards the end of the show, although never explicitly admitting to being gay.

On the other side, there are people who do not condone *yaoi*. The opposition of *yaoi* is made up of groups who dislike its content for different reasons. Japanese society resents *yaoi* due to its homosexuality and pornographic nature. Some dislike *yaoi* because it is largely pedophilic; many *yaoi* stories take place in middle school and high school settings. However, pornographic art depicting underage characters is legal in Japan. In other Western countries, this is not the case. The United States has the PROTECT Act which outlaws any images of minors engaging in sexual acts[102]. This is why BL may be found in bookstores in Japan but not in America. Many other countries have also outlawed the sale of *yaoi*. Some argue this is not because of underage sex, rather a reflection of a country's conservatism. Rather than the underage sex causing a problem, it is the homosexuality that makes the works obscene.

Opposition to *yaoi* comes largely from Western countries and their LGBTQ+ communities. Instead of giving homosexual men true representation, *yaoi* writers focus exclusively on gay sex but never touch on any topics of homophobia or oppression that gay men face. Western gay activists argue that by *fujoshi* exclusively focusing on gay sex and using it for masturbation material, they are stereotyping and fetishizing gay men[103]. This

[100] Tanaka and Ishida, "Enjoying Manga as Fujoshi," 77-85.

[101] Santos, "Queer Affective Literacies," 72-86.

[102] Wood, "Boys' Love Anime," 44-63.

[103] Snyder, "Feminism or Homophobia."

oversexualization also comes from the appropriation of the male body. Most *yaoi* artists are female and do not have general access to a male body, therefore focusing on aesthetic aspects of the male body and setting an unrealistic expectation for Japanese gay men[104]. The most harmful part is that these interpretations become consumed globally by cultures that differ from Japan's. One study shows that *yaoi* is more likely to influence Western readers' view of gay men than Japanese readers[105]. With these stories being taken out of cultural context, it may influence how other cultures view homosexuality, Japan, and the Japanese gay community.

The view of Japanese gay men has shifted with the introduction of *yaoi* and BL into Japanese and global society[106]. Gay men are often stereotyped as being sexually charged and promiscuous. The oversexualization of gay men in *yaoi* perpetuates a narrative that homosexuality is all about sex. By lacking representation of real homosexual experiences, they are reenforcing this negative stereotype while exploiting gay men for their own pleasure. *Fujoshi* themselves may internalize and employ these harmful stereotypes from *yaoi* on real homosexual men[107].

Globally, there are a number of issues being caused by the rise of *yaoi.* Japanese gay men are being subjected to an unrealistic expectation of who they are supposed to be, a situation which affects the entire LGBTQ+ community. Japanese homosexual men are dealing with the backlash from those who do not approve of the homosexuality within *yaoi* and those who misconstrue homosexuality based on the *yaoi* they read[108]. Chinese and Korean men are reading these stories as well. In one article, Chinese and

[104] MJ Isola, "Yaoi and Slash Fiction: Women Writing, Reading, and Getting Off?" in *Boy's Love Manga: Essays on the Sexual Ambiguity and Cross-Cultural Fandom of the Genre,* (McFarland & Company, 2010), 84-98.

[105] Simon Turner, "Exploring yaoi fans' online practices in an online community," In *Manga Vision: Cultural and Communicative Perspectives*, (Melbourne: Monash University Publishing, 2016), 87-106.

[106] Thomas Baudinette, "Ethnosexual Frontiers in Queer Tokyo: The Production of Racialised Desire in Japan," *Japan Forum* 28, no. 4, (2016): 465–85, https://doi.org/10.1080/09555803.2016.1165723.

[107] Snyder, "Feminism or Homophobia."

[108] Snyder, "Feminism or Homophobia."

Korean men were described as excited to go to Japan. From the *yaoi* they read, they expected Japan to be a "gay paradise," but they were sorely disappointed when met with xenophobia from Japanese gay men and were not especially welcome in Ni-Chōme, the gay community in Shinjuku, Japan[109]. They had an unrealistic expectation of Japanese gay men due to the *yaoi* they read, and they eventually went home with a different perspective on the realities of Japan's gay community.

Fujoshi describes a group of heterosexual women who enjoy reading "rotten" homoerotica. While being entirely rejected by society, they find ways to interact and maintain a global community via the internet. Due to the global distribution of *yaoi* online, yaoi can be read by anyone from any culture if they search hard enough to find the illegal websites that publish it. Some researchers argue that *fujoshi* are the result of Japan's conservative society and that the opposition to *yaoi* comes from an opposition to homosexuality instead of the work itself. Others argue that *fujoshi* fetishize and oversexualize gay men, destroying their reputation and image worldwide. Although there is a lot of speculation and discourse, the *fujoshi* phenomenon is only a recent development, meaning that academia does not yet have an answer for this issue. As the community grows and continually impacts Japanese society, the future of *fujoshi* is unknown. The *fujoshi* phenomenon may be a passing trend or the beginning of a long-term fandom. Each side of the *fujoshi* debate will most likely continue fighting for their side as they have for the past decade, firmly believing they are correct based on their own self-interest[110].

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[109] Baudinette, "Ethnosexual Frontiers," 465-85.

[110] Snyder, "Feminism or Homophobia."

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The Effects of Threat Perception on Motivation in Racial Minorities

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Abstract

The COVID-19 pandemic and the Black Lives Matter (BLM) movement of the year 2020 had multiple effects on the overall population's depression, anxiety and motivation levels. Using a two-part longitudinal survey looking at young Black residents of Quebec, we hypothesized that threat perception might play a motivational role in getting people involved in social movements like the BLM movement. Threat perception, collective basic psychological needs satisfaction, involvement in BLM and depression levels were assessed in October 2020 (T1) and December 2020 (T2). The results indicate that collective basic need thwarting is a predictor of high symbolic threat (a threat to one's sense of self, identity, or culture) and realistic threat perception (a threat to one's health, well-being, or safety). We found that high symbolic threat was associated with greater general involvement in the BLM movement, thus showing that perceiving symbolic threat to one's group works as a motivating factor for activism. Furthermore, results indicated that realistic threat perception for systemic racism was a significant predictor of increases in depression levels and had no significant relationship with activism levels, indicating that perceiving realistic threat is a positive predictor of depression and has no motivational implications for activism. Implications for threat perception (social identity theory) and collective basic need satisfaction in the Black population will be discussed.

Introduction

Over the course of the year 2020, the worldwide COVID-19 pandemic and its related lockdowns had detrimental effects on the population's mental and physical health, quality of relationships, quality of education and more. This was associated with an increase in depression and anxiety levels by up to three times the normal Canadian average. More precisely, 19.6% of the population reported suffering from generalized anxiety disorder and 22.2% from depression, with young people from racial minorities being disproportionately affected.[111] In addition, in the summer of 2020, the Black Lives Matter underwent a revival in the middle of this pandemic after the tragic death of George Floyd to police brutality. The Black Lives Matter movement, which roots back to the 1950-60s civil rights movement to fight structural violence and discrimination towards the Black population, connected thousands of people together for the rights of the Black community through protests and internet posts.[112] This raises multiple questions regarding the negative impacts that this pandemic has had on the mental health and motivation levels of Black Quebecers and whether social activism such as the Black Lives Matter movement could counteract these negative effects. Historically, the Black population has often been most vulnerable to pandemics, such as the Spanish flu, and the COVID-19 pandemic is no exception.[113] Not only are members of the Black population statistically more prone to being exposed to the virus through their jobs, they also tend to work in domains that are more physically demanding and in the public sphere (higher contact levels with the virus). Additionally, they are more likely to receive inadequate or lower quality care in hospitals and are more likely to contract the virus given their average lower socioeconomic status and higher

[111] Czeisler, M. É., Lane, R. I., Petrosky, E., Wiley, J. F., Christensen, A., Njai,R., ... & Rajaratnam, S. M. (2020). Mental health, substance use, and suicidal ideation during the COVID-19 pandemic—United States, June 24–30, 2020. Morbidity and Mortality Weekly Report, 69(32), 1049; University of Sherbrooke. (2020). COVID-19: Des troubles de stress et d'anxiété bien présents au Québec et au Canada, aggravés par la désinformation.

[112] McCoy, H. (2020). Black lives matter, and yes, you are racist: the parallelism of the twentieth and twenty-first centuries. Child and Adolescent Social Work Journal, 37(5), 463-475.

[113] McCoy," Black lives matter, and yes, you are racist: the parallelism of the twentieth and twenty-first centuries", 469.

levels of stress, which puts their immune systems at higher risk.[114] This highlights the importance for members of the Black community to engage in coping mechanisms or activities during sanitary crises to experience healthy levels of well-being. Identifying involvement in the Black Lives Matter movement and some type of threat perception as a predictor of healthy coping mechanisms that might lead to positive outcomes then becomes a very interesting subject that could inform motivation or well-being programs implemented in Black communities during sanitary or social crises.

Self-determination theory (SDT) may be a helpful motivational theory in assessing the impact of the pandemic and of involvement in social movements in the Black population. SDT is a meta-theory that subsumes six smaller theories of motivation, of which the most relevant for this study is that the preferable type of motivation is an intrinsic one, fueled by a natural desire to take part in activities to enhance one's relationships, personal growth and community contributions. This is opposed to extrinsic motivation, generated by a desire to gain something from an action outside of personal gratification such as fame, wealth or image.[115] SDT also stresses the importance of autonomously engaging in goals and doing things with a sense of volition, rather than with a sense of control by possible external incentives or individuals. Multiple studies have found that pursuing autonomous goals is related to increases in goal effort, goal progress and well-being compared to controlled ones.[116]

The importance of the sense of personal autonomy is also integrated in the concept of basic psychological needs satisfaction. In SDT, autonomy is thought to represent one's capacity to perform actions with volition; competence represents one's capacity or ability to succeed in various activities or goals; and relatedness refers to one's feeling of membership or

[114] McCoy, "Black lives matter, and yes, you are racist: the parallelism of the twentieth and twenty-first centuries", 472.

[115] Ryan, R., Deci, E., Vansteenkiste, M., Soenens, B. (2020). Building a Science of Motivated Persons: Self-determination Theory's Empirical Approach to Human Experience and Regulation of Behavior. Aries System Corporation, 4-6.

[116] Ryan, W. S. (2017). The Impact of Autonomy Support on Identity Disclosure and Well-being among Sexual Minority Individuals (Doctoral dissertation, UC Santa Barbara), 7-10.

connection to groups or people.[117] The idea is that goal-oriented activities that are directly satisfying the three basic psychological needs for autonomy, relatedness and competence at the personal level will result in increases in intrinsic motivation and well-being levels.[118] These three components are viewed as essential nutrients humans require to function in a healthy way. A deficiency or thwarting of one or more of these needs would lead to an imbalance in one's life, whether it be on the social or personal sphere of well-being.[119] A distinction is made between low need satisfaction, which is a mere deprivation of one need in a particular context or instant, and need frustration, which is a profound feeling of being excluded/lonely, controlled or a failure.[120] An individual can experience need frustration and feel excluded in general and have his need for relatedness satisfied in the moment.[121] Using self-determination theory as a theoretical model for motivation, involvement in social movements like the Black Lives Matter protests could be considered as an important factor related to possible increases in personal basic needs satisfaction. Participation in the Black Lives Matter movement might even act as a counteracting variable for the negative effects of the pandemic.

Another relevant theory for the current study, social identity theory, helps to explain the relationship between an individual's affiliations or group identification and its impact on personal well-being and motivation.[122] The theory posits that someone's own sense of well-being will be influenced by the overall perceived well-being of their group. Hence, being part of a marginalized group that is discriminated against could personally affect

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[117] Ryan, R. M., & Deci, E. L. (2017). Basic psychological needs theory: Satisfaction and frustration of autonomy, competence, and relatedness in relation to psychological wellness and full functioning. Self-determination theory, EL Deci & RM Ryan, 2-3.

[118] Ryan & Deci, Basic psychological needs theory: Satisfaction and frustration of autonomy, competence, and relatedness in relation to psychological wellness and full functioning, 2.

[119] Parker, P., Ryan, R., Duineveld, J., & Bradshaw, E. (2019). Validation of the social identity group need satisfaction and frustration scale, 2; Ryan & Deci, Basic psychological needs theory: Satisfaction and frustration of autonomy, competence, and relatedness in relation to psychological wellness and full functioning, 2-4.

[120] Ryan & Deci, Basic psychological needs theory: Satisfaction and frustration of autonomy, competence, and relatedness in relation to psychological wellness and full functioning, 3.

[121] Ryan & Deci, Basic psychological needs theory: Satisfaction and frustration of autonomy, competence, and relatedness in relation to psychological wellness and full functioning, 2-3.

[122] Parker, Ryan, Duineveld, & Bradshaw, validation of the social identity group need satisfaction and frustration scale, 1-5.

someone's own perception of being treated differently or unfairly without having experienced it firsthand. An individual's belief or perception of his group's well-being impacts his personal well-being. Social identity theory becomes very relevant to this study when merged with self-determination theory by the medium of basic psychological needs satisfaction. If an individual's well-being is tied to his group's well-being, then his personal basic need-satisfaction levels for autonomy, relatedness and competence may be influenced by his group's sense of autonomy, relatedness and competence. This gives rise to the concept of collective basic psychological needs, claiming that the perceived volition, capability, and connection of a whole group is also relevant to each of its member's personal well-being and motivation.[123] Social identity theory researchers have evaluated the impact and importance of collective feelings of autonomy, relatedness and competence in political group affiliations to liberalism and communitarianism. They have found that the general satisfaction of autonomy, relatedness and competence that individuals felt concerning their political group was as relevant as their personal need satisfaction for their well-being and intrinsic motivation.[124] Therefore, collective basic need satisfaction could be a meaningful assessment of an individual's mental health and motivation levels when faced with challenges at the group or cultural levels, such as systemic racism targeting the Black community as evidenced by the events of police brutality of the summer 2020.

Social identity theory also looks at the motivational value of threat perception and makes the distinction between symbolic threat, related to one's sense of self or identity, and realistic threat, related to tangible threats to one's safety or health.[125] A study demonstrated that perceiving higher levels of symbolic threat related to the COVID-19 virus, such as threats to one's social interactions or activities, as opposed to realistic threats, such as possible health repercussions caused by the virus, led to less adherence to public health

[123] Kachanoff, F. J., Bigman, Y. E., Kapsaskis, K., & Gray, K. (2020). Measuring realistic and symbolic threats of COVID-19 and their unique impacts on well-being and adherence to public health behaviors. Social Psychological and Personality Science,604-607; Parker, Ryan, Duineveld, & Bradshaw, validation of the social identity group need satisfaction and frustration scale,1-3.

[124] Parker, Ryan, Duineveld, & Bradshaw, validation of the social identity group need satisfaction and frustration scale, 2.

[125] Kachanoff, Bigman, Kapsaskis, & Gray, Measuring realistic and symbolic threats of COVID-19 and their unique impacts on well-being and adherence to public health behaviors, 605-606.

measures.[126] In the same study, Kachanoff and colleagues established that higher levels of perceived realistic threat for COVID-19 were associated with lower life satisfaction, higher anxiety and higher negative affect.[127] Threat perception can also be experienced at the group level when the group is constantly targeted by others or said to be inferior in the social hierarchy. A symbolic threat at the collective level could be the feeling that your culture is dismissed or that your group is given no power, and a realistic threat could be police brutality towards a group. Hence, there is a link to be made between how threat perception may impact the motivation to take part in certain actions or movements and how these actions can have repercussions on mental health through the satisfaction of the needs for competence, relatedness, and autonomy in the Black population.

In this study, an emphasis is put on the importance and impact of the fulfillment of collective basic psychological needs; as the feelings of volition, capability and connectedness as a group or cultural entity is particularly relevant to the issue of systemic racism that is at the heart of the Black Lives Matter movement.[128] Although research shows that the COVID-19 virus has an effect on the general population's mental health and behaviors, racial minorities, who have been historically most affected by pandemics, have not been targeted by studies.[129] Experiments looking at sexual minority groups such as the LGBTQ+ community saw a correlation between collective autonomy restriction and lower personal autonomy basic need satisfaction, lower attitudes of gender and sexuality openness in all contexts, lower autonomy support from their peers and higher perceived discrimination. The opposite was found for the collective autonomy support condition in which participants were led to think their peers were accepting and supportive of their sexuality and of the members of their marginalized group. It was also reported that higher collective autonomy support predicted higher well-

[126] Kachanoff, Bigman, Kapsaskis, & Gray, Measuring realistic and symbolic threats of COVID-19 and their unique impacts on well-being and adherence to public health behaviors, 608-610.

[127] Kachanoff, Bigman, Kapsaskis, Gray, Measuring realistic and symbolic threats of COVID-19 and their unique impacts on well-being and adherence to public health behaviors, 609-610.

[128] McCoy," Black lives matter, and yes, you are racist: the parallelism of the twentieth and twenty-first centuries", 470.

[129] McCoy," Black lives matter, and yes, you are racist: the parallelism of the twentieth and twenty-first centuries", 467.

being.[130] These findings stress the importance of satisfying the needs for autonomy, competence and relatedness at the collective level (cultural or group identification level) for the overall well-being of members of marginalized groups.

Overall, the main objectives of this study were to establish whether threat perception (social identity theory), symbolic or realistic, can be a predictor or motivational factor of involvement in social activism like the Black Lives Matter protests, or of any effects on mental health. We hypothesized that higher levels of symbolic threat will be linked to higher collective basic need thwarting and greater involvement in the BLM movement. Furthermore, we expected to find a larger negative impact on well-being in participants facing higher amounts of realistic threat than symbolic threat.[131] This would tie threat perception (social identity theory) to the self-determination theory of motivation in a meaningful way for minority groups.

Methodology

Participants and Procedures

The current study is a two-part longitudinal survey that assessed the effects of the COVID-19 outbreak and the BLM movement of summer 2020 on the Black population. Through online surveys, we measured well-being, threat perception, motivation, involvement in the Black Lives Matter movement, as well as personal and collective basic need satisfaction and frustration. The procedures performed were approved by the McGill University Research ethics board. Participants were asked to provide informed consent, were given a 10$ compensation for their participation in each section of the survey (once in October and once in December) and could decide to leave any question that made them uncomfortable blank. The survey first assessed 87 participants in October 2020 (T1) and 73 of those participants followed up in December 2020 (T2). Participants were recruited

[130] Kachanoff, F. J., Cooligan, F., Caouette, J., & Wohl, M. J. (2020). Free to fly the rainbow flag: the relation between collective autonomy and psychological well-being amongst LGBTQ+ individuals. Self and Identity, 6-8.

[131] Kachanoff, Bigman, Kapsaskis, Gray, Measuring realistic and symbolic threats of COVID-19 and their unique impacts on well-being and adherence to public health behaviors, 608-611.

through Facebook and Instagram posts as well as advertisements in community organizations for the Black communities in Quebec such as the Black Community Resource Centre. About 60% of the sample were women and 38.1% were men. Given that the goal was to study the effects of systemic racism and involvement in the BLM protests, individuals who were not Black-identifying Quebecers were excluded from participation. Hence, our sample is made up of 100% either African American or mixed African Americans. Participants in our sample are between the ages of 17 and 30 years old.

This study was conducted through online surveys created in Qualtrics, so no stimuli or experimental manipulation were performed in the process. Multiple self-determination theory and well-being validated scales were included in 30-minute surveys to measure the variables of interest. The scales described below have been presented to the participants both at T1 in October and in T2 in December.

Measures

Social Identity Group Need Satisfaction and Frustration Scale

Participant's collective basic need satisfaction and frustration was measured with a 12-item scale with items related to group autonomy such as "my group can express its own values", group competence with items like "my group is successful at pursuing what is important for us", and group relatedness with items such as "my group is positively recognized by other groups and organizations."[132] Group need thwarting was then measured with items like "my group's opinions or concerns are often ignored" (competence), "my group remains oppressed in many ways" (autonomy) or "my group faces ongoing prejudice and stigma" (relatedness).[133] Each item was rated on a 7-point scale in which 1 represented "strongly disagreeing" and 7 represented "strongly agreeing". We computed two subscales, one for need satisfaction

[132] Parker, Ryan, Duineveld, & Bradshaw, validation of the social identity group need satisfaction and frustration scale, 2-3.

[133] Parker, Ryan, Duineveld, & Bradshaw, validation of the social identity group need satisfaction and frustration scale, 2-4.

and one for need frustration, by averaging the scores on the group of relevant items.

Balanced Measure of Psychological Needs (BMPN)

Participants were given an 18-item scale to assess the satisfaction of their need for autonomy, relatedness and competence at the personal level. Some items were related to personal autonomy (I was free to do things my own way), to personal competence (I was successful at completing difficult tasks and projects), and to personal relatedness (I felt a sense of contact with people who care for me).[134] The frustration of these personal needs was also assessed for autonomy (I had a lot of pressures), competence (I experienced some kind of failure) and relatedness (I was lonelier than I'd like to be).[135] All of the items were rated on a 7-point scale where 1 was "strongly disagree" and 7 was "strongly agree". We computed two subscales, one for need satisfaction and one for need frustration, by averaging the scores on the group of relevant items.

Integrated COVID-19 Threat

Participants were asked to identify levels of symbolic and realistic threat perception relating to COVID-19 based on a 9-item scale.[136] The scale, which originally made references to the "US population" was modified to be adapted to the "community or group". The scale includes 5 items measuring symbolic threats such as "the rights and freedom of my group", "what it means to be part of my community," "my community's values and tradition," and "democracy." Four other items were included to evaluate realistic threat perception such as "my personal health," "my community's health as a whole," "my financial safety," "my community's financial health" and "day-to-day life in your local community." The participants were asked to assess

[134] Sheldon, K. M., & Hilpert, J. C. (2012). The balanced measure of psychological needs (BMPN) scale: An alternative domain general measure of need satisfaction. Motivation and Emotion, 36(4), 442-444.

[135] Sheldon, & Hilpert, The balanced measure of psychological needs (BMPN) scale: An alternative domain general measure of need satisfaction, 446-447.

[136] Kachanoff, Bigman, Kapsaskis, & Gray, Measuring realistic and symbolic threats of COVID-19 and their unique impacts on well-being and adherence to public health behaviors, 607.

the level of realistic or symbolic threat perception COVID-19 represented for each item presented ranging from 1 "not a threat" to 4 "major threat." The threat perception was determined by the mean for each subscale (realistic or symbolic threat for COVID-19).

Integrated Systemic Racism Threat Scale

A 9-item scale adapted from Kachanoff's integrated COVID-19 threat scale, in which the items relating to the "US population" were modified to address one's "community or group," was used to assess threat levels related to systemic racism.[137] The scale includes five items assessing realistic threat, such as a threat to the health of your community or to your financial security, and four items assessing symbolic threat such as a threat to the values and traditions of the community or the rights and freedom of your group. The participants were asked to assess the level of realistic or symbolic threat perception for systemic racism represented for each item presented ranging from 1 "not a threat" to 4 "major threat". The threat perception was determined by the mean for each subscale (symbolic and realistic threat for systemic racism).

Involvement in the BLM Movement

An 8-item scale was created to determine to what extent the participants were involved in the BLM movement of summer 2020. Our items assessed whether participants attended the real-life protests, shared content in support of the BLM this year, encouraged black-owned businesses or consumed products manufactured by Black businesses, voiced their opinion and had difficult talks about systemic racism. Each item was assessed from 1 "not at all" to 7 "very frequently." For the current study and its hypotheses, we looked at the mean of all items combined as well as scores on the item pertaining to real-life attendance in protests.

Center for Epidemiological Studies-Depression (CES-D-10)

[137] Kachanoff, Bigman, Kapsaskis, & Gray, Measuring realistic and symbolic threats of COVID-19 and their unique impacts on well-being and adherence to public health behavior, 606.

Depression levels were assessed with a shortened version of the original CES D scale.[138] We assessed participants with 10 items that asked members of the Black community how often over the past two weeks they experienced symptoms associated with depression, like restless sleep and feeling lonely. In addition, rather than treating scores as 0-3, where 0 is "rarely or none of the time" and 3 is "most of the time," our scale ranges from 1 to 4. Furthermore, instead of adding scores together from a range of 0 to 30, as the CES-D 10 suggests, we computed the mean scores of participants on this scale to determine their level of depressive symptoms.[139]

Results

Preliminary Results

We conducted paired-sample t-tests to compare the levels of threat perception related to systemic racism and to the COVID-19 pandemic as experienced by Black young adults (refer to Figure 1). We found that symbolic threat perception at T2 related to systemic racism ($M = 3.17$, $SD = 0.96$) was significantly greater than COVID-19 symbolic threat perception ($M = 2.40$, $SD = 0.85$), $t(72) = 7.571$, $p < .001$. Furthermore, realistic threat perception as it pertains to systemic racism ($M = 3.12$, $SD = 0.86$) was also greater than COVID-19 realistic threat perception ($M = 2.79$, $SD = 0.75$), $t(72) = 5.590$, $p < .001$. Overall, these results suggest that Black young adults in our sample saw systemic racism as a bigger threat to their well-being and communities than the COVID-19 pandemic.

Similarly, we conducted paired-sample t-tests to evaluate whether participants experienced more need satisfaction or need frustration at both the personal and group levels (refer to Figure 2). At the personal level, at T1 participants experienced greater need satisfaction ($M = 4.56$, $SD = 1.11$) than need frustration ($M = 3.86$, $SD = 1.14$), $t(86) = 3.579$, $p = .001$. However, at the group level at T1, there was no significant difference between need

[138] Andresen, Malmgren, Carter, & Patrick, Screening for depression in well older adults: Evaluation of a short form of the CES-D, 80.

[139] Andresen, E. M., Malmgren, J. A., Carter, W. B., & Patrick, D. L. (1994).Screening for depression in well older adults: Evaluation of a short form of the CES-D. American journal of preventive medicine, 10(2), 79-80.

satisfaction (M = 4.48, SD = 1.20) and need frustration (M = 4.61, SD = 1.10), t (86) = -0.619, p = .537.

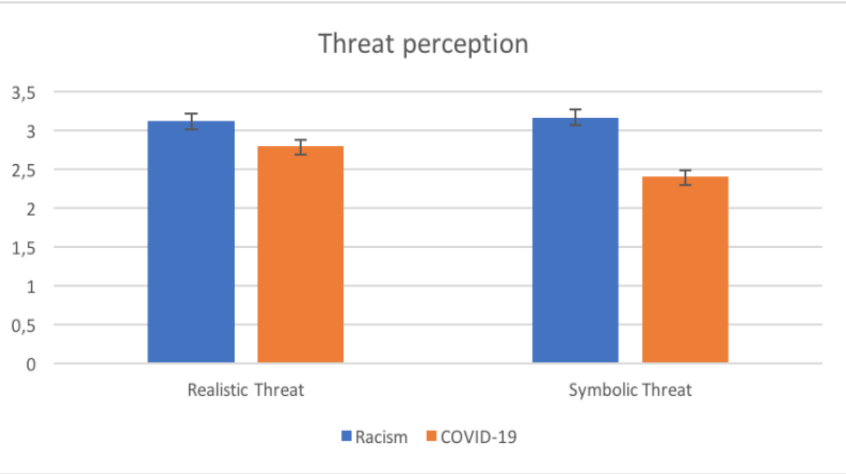

Figure 1. Threat Perception Levels: COVID-19 and Systemic Racism

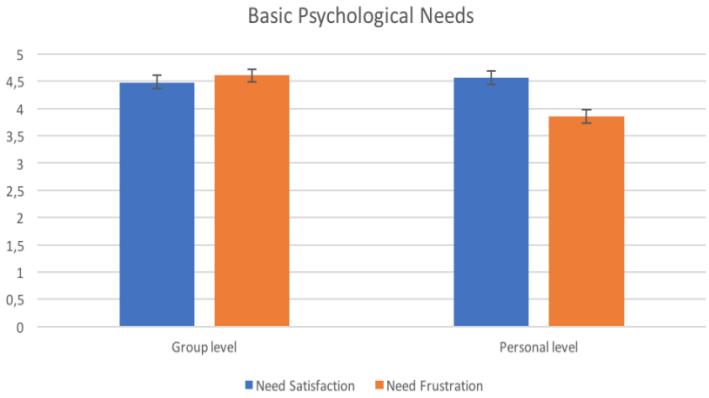

Figure 2. Basic Psychological Needs Balance at the Group and Personal Level

Main Results

The preliminary results point to the relevance of threat perception as it relates to systemic racism for the members of the Black community as well

as the potential role that group processes play in their lives. To understand this further, we conducted a linear regression analysis to predict realistic threat perception related to systemic racism from personal and group need satisfaction and need frustration levels (refer to Table 1 and Figure 3). We found that group-need frustration as measured in October (T1) was a significant positive predictor of realistic threat perception (T2), $b = .346$, $t(68) = 4.151$, $p < .001$. This means that an active thwarting of the basic needs at the group level was associated with a greater perception of realistic threat related to systemic racism. Group need satisfaction, personal need satisfaction and personal need frustration were not predictors of symbolic threat perception.

We conducted a similar regression analysis with symbolic threat as the outcome as opposed to realistic threat (refer to Table 2 and Figure 4). We found that personal need frustration (T1) was a significant positive predictor of systemic racism symbolic threat perception (T2), $b = .511$, $t(68) = 3.478$, $p < .001$. This indicates that greater need thwarting experienced at the group level predicted higher levels of symbolic threat as experienced by the Black community. Group need satisfaction, personal need satisfaction and personal need frustration were not significant predictors of the outcome. The pattern that emerges indicates that whereas both realistic threat perception and symbolic threat perception seem to stem from active thwarting of the three basic needs at the group level, personal need satisfaction and frustration seem to be completely unrelated to threat perception. In other words, threat perception is explained at the group level and does not relate to personal need satisfaction when looking at minority groups.

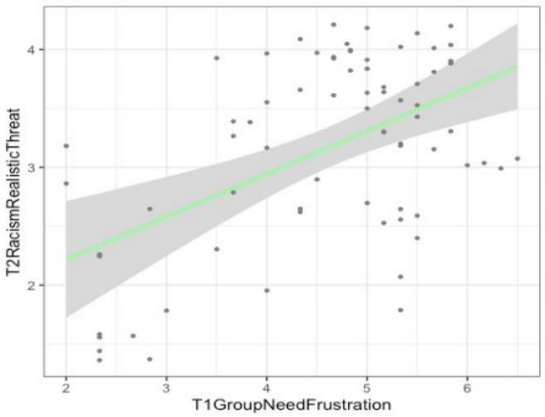

Figure 3. Regression Analysis: Realistic Threat Perception and Group Need Frustration

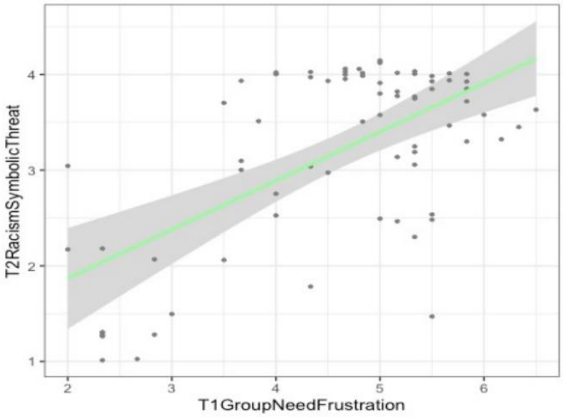

Figure 4. Regression Analysis: Symbolic Threat Perception and Group Need Frustration

Next, we evaluated the impact of the two types of threat on participation in the BLM movement. We regressed our measure of activism onto symbolic and realistic threats as they pertain to systemic racism, and we found that symbolic threat perception was a significant and positive predictor of involvement in the BLM movement at T2 controlling for realistic threat perception, $b = .663$, $t(70) = 2.246$, $p = .028$. This means perceiving high levels of symbolic threat was an active motivating factor for our participants to get involved in the BLM movement (refer to Table 3 and Figure 5). We conducted another regression analysis to focus our attention on the predictors of physically attending a protest. We regressed our single item assessing participation in protests onto symbolic and realistic threat perception related to systemic racism. Although we hypothesized that high realistic threat perception would be a negative predictor of attending in-person protests, we found that both types of threats were unrelated to protest attendance as measured at T2 (refer to Table 4). This points to the different consequences symbolic and realistic threat perception have. Symbolic threat perception is related to increased engagement in overall activism (internet posts, protests, difficult discussions, etc.), whereas realistic threat has not been identified as related to any significant increase or decrease in activism. Hence, symbolic threat is a motivator to get involved in social movements and realistic threat cannot be identified as a predictor of activism or protest

attendance, which is directly related to realistic threats such as police brutality.

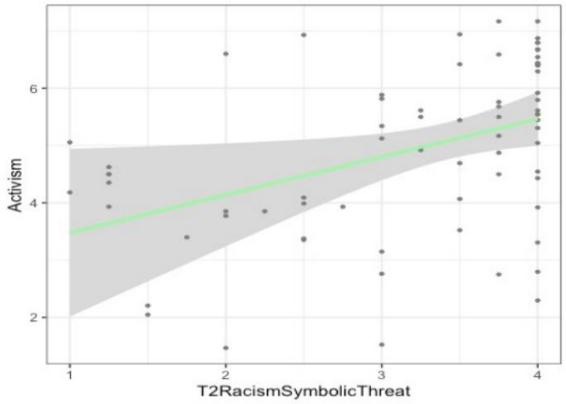

Figure 5. Regression Analysis: Activism Levels and Symbolic Threat Perception

Finally, we sought to evaluate the impact of threat perception on self-reported depressive symptoms. We regressed depression scores onto the two types of threat. Results indicated that realistic threat, but not symbolic threat, was a significant positive predictor of depressive symptoms experienced by our participants at T2, controlling for neuroticism and depression at T1, $b = .230$, $t(68) = 2.027$, $p = .047$). Refer to Table 5 and Figure 6 for completing reporting of the results. This means that perceiving a high realistic threat is a positive predictor of depression beyond personality predispositions. Beyond being unrelated to activism or protest attending, realistic threat also relate to depressive symptoms experienced by our participants.

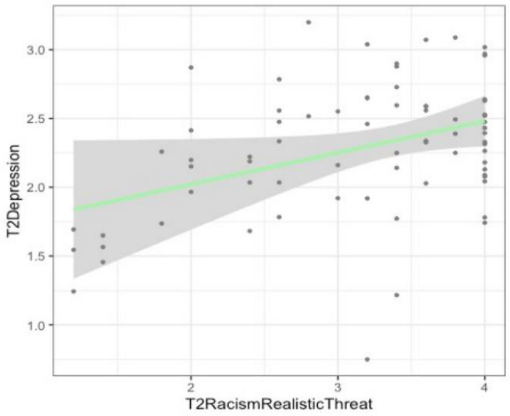

Figure 6. Regression Analysis: Depression Levels at T2 and Realistic Threat Perception

Discussion

Our results pointed to higher symbolic and realistic threat perception related to systemic racism than to COVID-19 at T2. Considering the well-documented damaging impacts of the COVID-19 pandemic to people's safety and way of life (University of Sherbrooke, 2020), the fact that members of Black communities are more concerned with systemic racism points to the importance of understanding the factors surrounding this issue more deeply. When their group needs were not met, Black young adults were more drawn to fearing systemic racism than fearing the global health pandemic. This heightened threat perception of systemic racism is probably at the root of their group-need thwarting, thus pointing to the relevance of considering and studying minority group's feeling of autonomy, relatedness and competence.

Our results also showed an imbalance in our participant's ratio of basic psychological need satisfaction and frustration at the group level at T1, whereas their personal needs satisfaction ratio was healthy (more satisfaction than frustration was assessed). This points to the lack of need satisfaction of the collective needs of the Black community, which can have negative impacts on their motivational levels collectively. According to the self-determination theory, higher levels of need satisfaction in comparison to need frustration should be sought to attain greater motivation and life satisfaction

(Ryan & Deci, 2017). However, our analyses demonstrate a problem in this domain at the group level for the Black population in Quebec.

Furthermore, we found that symbolic threat was a significant positive predictor of involvement in the BLM movement at T2, while no such relationship existed between realistic threat perception and activism. This means that although both types of threat are predicted by an active thwarting of group needs for autonomy, competence and relatedness, they have distinct effects and should be analyzed separately when detected in racial minority groups. While threat to one's sense of self and identity (symbolic) acts as a motivational factor to get involved in activism to fight for one's autonomy, competence and increase relatedness, threat to one's own health or economic security (realistic) has none of those motivational benefits. Even more, realistic threat has not only been unrelated to increases in activism, it's related to higher depression levels over a long period of time (T2).

Limitations

The limitations of these findings mainly concern the way our study was designed. Our survey longitudinally assessed our participants at two points in time only (October and December). However, these two assessment times were well after the start of the COVID-19 pandemic and the BLM movement of the summer 2020. Hence, it is impossible for us to know our participants' levels of well-being, need frustration or depression prior to these events. Similarly, we are unable to know whether involvement in activism had beneficial effects for our participants because we assessed their well-being variables after the events occurred.

Our sample size of 87 at T1 and 73 at T2 is also one of the strong limitations to generalizability. Our small sample size might not be representative of the Black community and the effects of the variables measured might have been magnified or reduced by the small sample size where each of the participant's responses had a higher impact on the results than in larger studies with more participants. Furthermore, we recruited the Black community of Quebec to represent the Black community as a minority group, but this poses limits to the generalizability of the results in minority groups outside of Quebec, who could be under different conditions (more or less discrimination and integration in popular culture of their country).

Furthermore, the online nature of this study poses limits to the legitimacy of the answers we obtained. Some participants might have answered in an unapplied manner, completed the survey with extreme answers only (extreme answering), or might not be aware of their true feelings about the issue of systemic racism, which is commonly known as self-knowledge problems.[140] Participants might also interpret scales and their ratings differently and the Black community might not answer in the same manner to the scales than one would expect from Europeans from which the scales were based on.[141] This is another limitation to the generalizability of the results. In addition, the scales included in the online surveys were all well-validated, except for the scale measuring involvement in the BLM, but there is no way to establish with certainty that they represent a perfect operationalization of depression, basic psychological need satisfaction or frustration and threat perception. These concepts are latent constructs and there is no way to directly measure them other than scales that are often variable depending on the context and the population being studied.[142] Hence, our online study in which participants were assessed through scales without supervision or guidance is a limitation to the legitimacy of our results and its generalizability.

Future Directions

Following the findings of this study, future directions in the field of motivation would be to have an increasing interest towards minority groups and motivation, since minority groups might have their needs satisfaction affected differently or further impacted by certain events than non-minority groups. For example, a particular attention should be paid to individual perceptions of group satisfaction in members of minority groups given that group need frustration was significantly linked to threat perception, while no

[140] Clark, L. A., & Watson, D. (2019). Constructing validity: New developments in creating objective measuring instruments. Psychological Assessment, 31(12), 1412.

[141] Clark & Watson, Constructing validity: New developments in creating objective measuring instruments, 1416-1417; Flake, J. K., Pek, J., & Hehman, E. (2017). Construct validation in social and personality research: Current practice and recommendations. Social Psychological and Personality Science, 8(4), 373-375.

[142] Flake, Pek, & Hehman, construct validation in social and personality research: Current practice and recommendations, 475.

significant relationship existed with personal need frustration or satisfaction and threat perception. Consequently, studying how group perceptions can be impacted and how they in turn affect the members of their group is of great interest. Other minority groups such as the Latinx and Asians were shown to identify more with the Black community than white people. Considering that they also got involved for various reasons in the BLM movement of 2020, it would be interesting to study how these groups perceive and react to threat perception to generalize the findings on threat perception to other racial minority groups.[143]

In addition, seeing as we identified symbolic threat perception as a motivational factor to get involved in activism and that realistic threat was a predictor of depression, a need for studies that examine the long-term impact of types of threat perception are needed. Discovering ways to predict who is more susceptible to certain threats and how to prevent or reduce threat perception (particularly realistic threat) could help increase motivation and reduce depression levels within minority groups, who are often most touched by crisis such as the COVID-19 pandemic and the BLM movement both physically and mentally.[144]

Finally, as mentioned in the limitations section, this study's results have limited generalizability due to its assessment techniques and sample size.[145] Further studies need to be made on the subject with larger sample sizes that are more representative of the minority groups on a larger scale (not limited to one province for example).

Conclusion

[143] Hope, E. C., Keels, M., & Durkee, M. I. (2016). Participation in Black LivesMatter and deferred action for childhood arrivals: Modern activism among Black and Latino college students. Journal of Diversity in Higher Education, 9(3), 203; Hordge-Freeman, E., & Loblack, A. (2020). Cops Only See the Brown Skin, They Could Care Less Where It Originated: Afro-Latinx Perceptions of the # Black Lives Matter Movement. Sociological Perspectives, 520-525.

[144] McCoy, Black lives matter, and yes, you are racist: the parallelism of the twentieth and twenty-first centuries", 469-472; University of Sherbrooke, COVID-19: Des troubles de stress et d'anxiété bien présents au Québec et au Canada, aggravés par la désinformation.

[145] Clark & Watson, Constructing validity: New developments in creating objective measuring instruments, 1422-1423; Flake, Pek, & Hehman, construct validation in social and personality research: Current practice and recommendations, 475-477.

To conclude, the COVID-19 outbreak and the BLM movement of the year 2020 have had important effects on the mental health of the Black population in Quebec, which is often underrepresented in studies.[146] Collective symbolic threat perception regarding systemic racism, related to a community's sense of identity or culture, predicted higher involvement in the BLM movement of summer 2020. Although this type of involvement cannot be directly linked to increases in collective basic need satisfaction, it can establish symbolic threat perception as a motivational factor or a driving force to get involved in activism in hopes of changing the situation at the root of the collective basic need frustration. Realistic threat perception was not significantly linked to involvement in the BLM movement, but it was significantly positively related to depression levels independently from the participant's neuroticism and depression levels in October (T1). Hence, this two-part longitudinal survey among the Black population of Quebec helped establish a possible link between symbolic threat perception as a motivational factor to get involved in activism and realistic threat as a depressing factor that could possibly damage motivation. This might have implications for the further understanding of motivational variables in discriminated groups. Furthermore, our results add to the body of literature that links social identity theory to self-determination theory. It suggests the importance of the collective feelings of autonomy, relatedness and competence for group members' well-being and motivation levels beyond personal basic needs satisfaction in members of the Black community.

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https://www.usherbrooke.ca/actualites/nouvelles/recherche/recherche-details/article/42735/

Table 1

Regression Analysis: Realistic Threat Perception and Group Need Frustration

Predictor	Estimate	*SE*	*t*	*df*	*p*
Intercept	1.852	0.872	2.123	68	.038
Group Need Satisfaction (T1)	-0.139	0.088	-1.585	68	.118
Group Need Frustration (T1)	0.364	0.088	4.161	68	<.001
Personal Need Satisfaction (T1)	0.037	0.093	0.400	68	.690
Personal Need Frustration (T1)	0.017	0.080	0.212	68	.833

Table 2

Regression Analysis: Symbolic Threat Perception and Group Need Frustration

Predictor	Estimate	*SE*	*t*	*df*	*p*
Intercept	0.683	0.929	0.735	68	.465
Group Need Satisfaction (T1)	-0.045	0.094	-0.482	68	.631
Group Need Frustration (T1)	0.511	0.093	5.478	68	<.001

Personal Need Satisfaction (T1)	-0.037	0.099	0.375	68	.709
Personal Need Frustration (T1)	0.047	0.086	0.549	68	.585

Table 3

Regression Analysis: Realistic Threat Perception and Group Need Frustration

Predictor	Estimate	*SE*	*t*	*df*	*p*
Intercept	3.780	0.589	6.413	70	<.001
Racism Symbolic threat (T2)	0.6627	0.295	2.246	70	.028
Racism Realistic threat (T2)	-0.284	0.329	-0.864	70	.390

Table 4

Regression Analysis: Protest Attendance and Threat Perception Levels

Predictor	Estimate	*SE*	*t*	*df*	*p*
Intercept	5.051	1.004	5.031	70	<.001
Racism Symbolic threat (T2)	0.382	0.503	0.760	70	.450

Racism Realistic threat (T2)	-0.930	0.559	-1.662	70	.101

Table 5

Regression Analysis: Depression Levels at T2 and Realistic Threat Perception

Predictor	Estimate	*SE*	*t*	*df*	*p*
Intercept	0.688	0.253	2.723	68	.008
Depression (T1)	0.515	0.105	4.879	68	<.001
Neuroticism (T1)	0.094	0.042	0.042	68	.028
Racism Symbolic threat (T2)	-0.155	0.102	0.102	68	.132
Racism Realistic threat (T2)	0.229	0.113	0.113	68	.047

Analysis of Strains of the Plant Arabidopsis thaliana in Altered Gravity Conditions

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Abstract

To enhance current knowledge on growing plants in microgravity and reduced gravity conditions (e.g., Moon, Mars), this research project aimed to find strains of the model plant Arabidopsis thaliana that showed possible resistance to gravitational stress. Gravitational stress resistance was displayed in strains that demonstrated a similar growth response to the strains grown under normal conditions. In this project, 70 wild-type strains of Arabidopsis thaliana were tested for their gravitational stress resistance by simulating microgravity with a 2-D clinostat, a device designed to randomize gravity. Surface-sterilized seeds were placed in Petri dishes with Murashige and Skoog nutrient agar and rotated on a clinostat or kept vertically (for controls) for seven days. The average shoot length, main root length, number of secondary roots, total root length, and number of root hairs per total root length of the clinorotated seedlings are compared to that of the vertically-grown controls using FIJI ImageJ, an image-analysis tool. Under clinorotation, most strains showed significantly reduced shoot growth and varying growth in root and other parameters. Seven genotypes, however, were specifically of interest, including CIBC-5, which showed no statistically significant difference in growth across all parameters tested. We hypothesize that these genotypes will adapt better to growing in microgravity conditions and will be our prime candidates for further ground-based and spaceflight testing.

Introduction

Tropisms are adaptations in plants that allow them to respond to environmental factors such as differences in the availability or wavelength of light, water, minerals, and the gravity vector. [147] Plants have developed many adaptations to help them survive in stressful conditions here on Earth. Among these plant, movements are tropisms, directed growth to external stimuli such as gravity (gravitropism) and light (phototropism). [148] However, there is a dearth of research on the molecular mechanisms of gravitropism. Thus, this research aims to aid in the understanding of this phenomenon. Other adaptations consist of resistance to droughts, increased soil salinity, and toxic metals. [149]

Due to gravitropism on the Earth at 1-g, plant shoots normally grow against the gravity vector (upward; Fig. 1) and roots grow towards the gravity vector (downward). [150] In space at microgravity or at a reduced gravity, plants experience gravitational stress, which negatively affects plant growth. [151] During long-term space missions, astronauts depend on plants for food, oxygen, and psychological benefits.[152] Studying plant responses to gravitational stress are particularly important for growing plants in space. [153]

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[147] Vandenbrink et al., "*Light and Gravity Signals Synergize in Modulating Plant Development"*; Vandenbrink and Kiss, "Plant Responses to Gravity."

[148] Kaufman, Song, and Pharis, "Gravity Perception and Response Mechanism in Graviresponding Cereal Grass Shoots."

[149] Nadeem et al., "The Role of Mycorrhizae and Plant Growth Promoting Rhizobacteria (PGPR) in Improving Crop Productivity under Stressful Environments."

[150] Swatzell and Kiss, "Journey towards the Centre of the Earth"; Vandenbrink and Kiss, "Plant Responses to Gravity."

[151] Kiss, "Plant Biology in Reduced Gravity on the Moon and Mars"; Matía et al., "Plant Cell Proliferation and Growth Are Altered by Microgravity Conditions in Spaceflight."

[152] Kiss, "Plant Biology in Reduced Gravity on the Moon and Mars"; Matía et al., "Plant Cell Proliferation and Growth Are Altered by Microgravity Conditions in Spaceflight."

[153] Correll et al., "Transcriptome Analyses of Arabidopsis Thaliana Seedlings Grown in Space"; Vandenbrink et al., "Light and Gravity Signals Synergize in Modulating Plant Development."

Natural plant strains vary in their resistance to stress factors. Thus, only stress-resistant plant varieties must be used to ensure the best growth and productivity in space or other space bodies such as the Moon or Mars. [154] Since the full genome of Arabidopsis thaliana plant has been sequenced, this plant serves as a suitable model for experimentation. If the genes that are responsible for adaptation to gravitational stress can be identified through our research, they could potentially be manipulated for plant varieties suitable for spaceflights. Since spaceflight experiments are very costly, initial studies often used so-called simulated microgravity via clinorotation. [155] The 2D-clinostat (Fig. 2) is a wheel-like device rotating at about 1-2 rpm and randomize gravity vector.[156] The goal of this research project is to use simulated microgravity through clinorotation to analyze 70 wild-type strains of Arabidopsis thaliana for their resistance to gravitational stress.

Methods

This research project uses Arabidopsis thaliana, a common flowering plant from the mustard family, to study the effects that microgravity has on plant growth. Seeds for 70 wild-type strains were obtained from Arabidopsis Biological Resource Center (Columbus, OH). For experimentation, the external coat of seeds from each strain of Arabidopsis thaliana were surface sterilized using a 4% (w/v) bleach solution and then placed in square Petri Dishes (10 cm x 10 cm) under a laminar flow hood. The petri dishes were filled with a 1% (w/v) agar with Murashige and Skoog nutrients as medium. Six plates were prepared for each strain, with each plate containing 12 individual seeds distanced by 1.0 cm apart.

Of the six plates, three were labelled as "control" and three as "clinostat". After a 2 to 3-day period in the refrigerator (to stimulate uniform germination), the plates were placed vertically on a tray (control) and the experimental plates were placed on a clinostat, rotating at 1.25 rpm at 22^{o} C. After a 7day period, the plates were scanned using an EPSON high-resolution

[154] Kiss, “Plant Biology in Reduced Gravity on the Moon and Mars.”

[155] Kiss, “Conducting Plant Experiments in Space.”

[156] Kiss et al., “Comparison of Microgravity Analogs to Spaceflight in Studies of Plant Growth and Development.”

scanner (model #J252A), and then each strain was analyzed using the FIJI Image-J image analysis software (version #2). Each strain's gravitational stress resistance was determined using t-tests for each growth parameter (shoot length, main root length, total root length, number of secondary roots, and root hairs per total root length) comparing the means from the experimental group of that strain to its control group. Images of control and clinorotated seedlings are shown in Fig. 1. A baseline p-value of 0.05 was used to determine statistical significance, however, p-values of less than 0.01 were also noted.

Shoot lengths were measured by measuring from the shoot apical meristem of the seedlings to the start of the root junction. Total root length was calculated by measuring from the root junction to the root tip and adding this measurement to the length of any secondary roots that were present. The number of secondary roots per total root length was calculated by first counting all the root hairs on a seedling, then dividing it by the total root length. For each genotype, the number of secondary roots per seedling between control and clinostat-treated were also noted and compared among other genotypes. The data for the number of secondary roots parameter was represented differently than other parameters due to the lack of continuity in the data, with some genotypes having no secondary roots in the control or treatment group (ie. Ct-1) which would pose a problem when taking percentages.

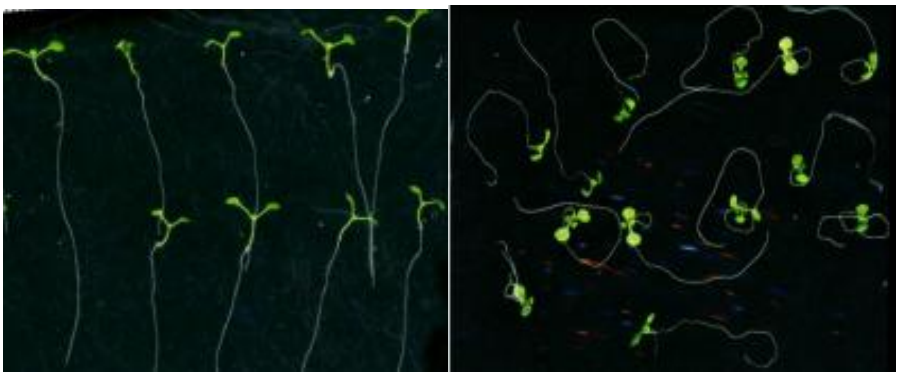

Figure 1: Control seedlings (left) and clinorotated seedlings (right).

Results

In most cases, seedlings grown on a rotating clinostat had a significant decrease in shoot growth compared to the vertical controls. However, from the 70 genotypes analyzed, two genotypes, CIBC-5 and Col-0 showed no significant difference in shoot length under simulated gravitational stress from the vertically-grown controls. The other 68 genotypes had a significant decrease in shoot length compared to the controls (Fig. 2A). In their total root length, 32 genotypes showed no significant difference from controls. Eight genotypes showed a significant increase in growth and 30 genotypes showed a significant decrease in growth compared to the controls (Fig. 2B). In the number of root hairs per total root length, 20 genotypes showed no significant difference from controls, 3 genotypes showed a significant decrease, and 47 showed a significant increase in root hairs (Fig. 2C). Forty genotypes had no significant difference in the number of secondary roots, nine genotypes had significantly fewer secondary roots, and 21 had significantly more secondary roots as compared to their vertically grown controls (Fig. 3).

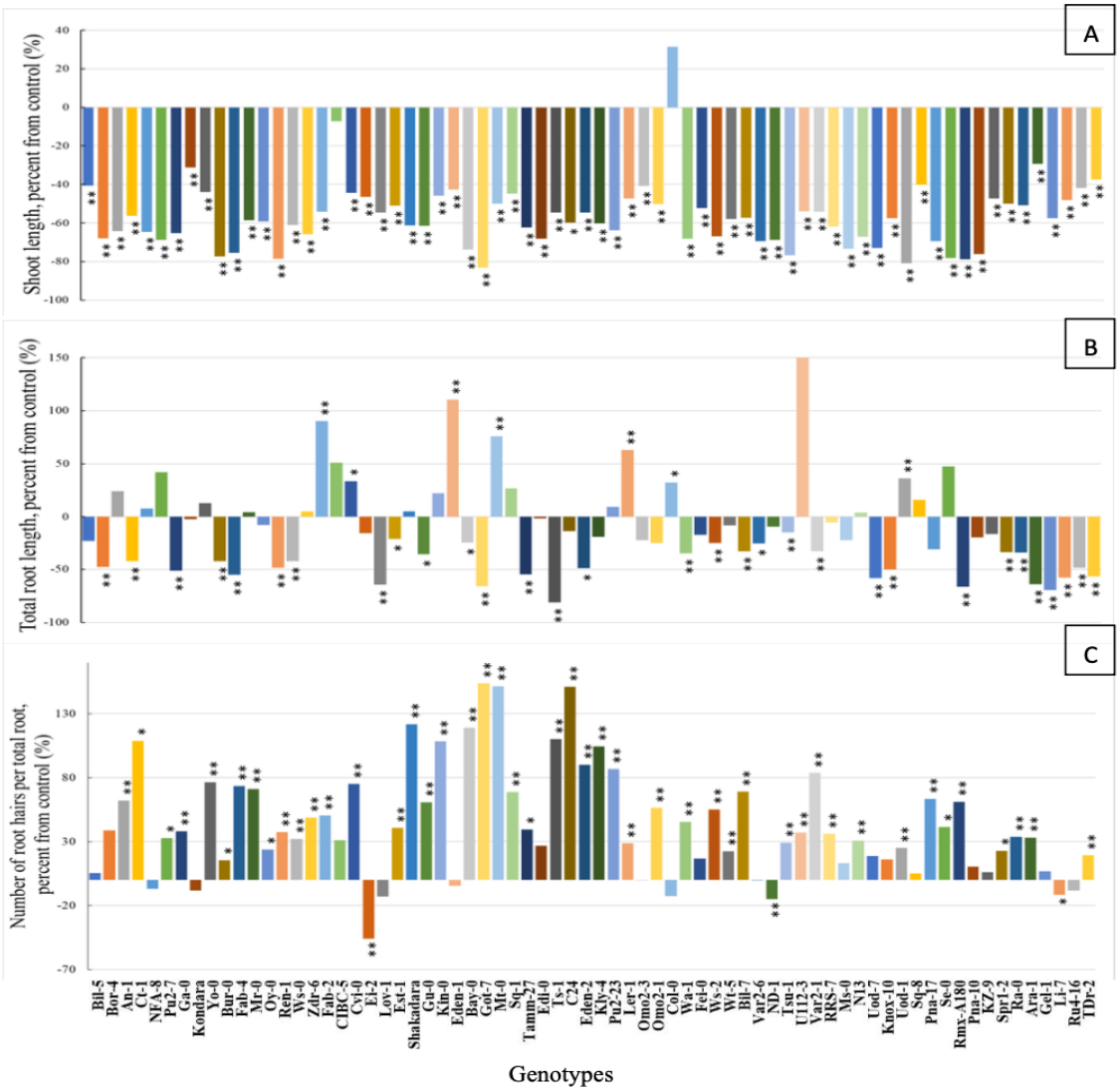

Figure 2: Comparison of seedling growth parameters for shoot length (A), total root length (B), and number of root hairs per total root length (C) for clinorotated versus vertically grown control seedlings for 70 Arabidopsis thaliana wildtype genotypes. Each parameter is shown as (mean clinorotated / mean control * 100) - 100. Asterisks indicate t-test p-values of < 0.05 (*), or < 0.01 (**).

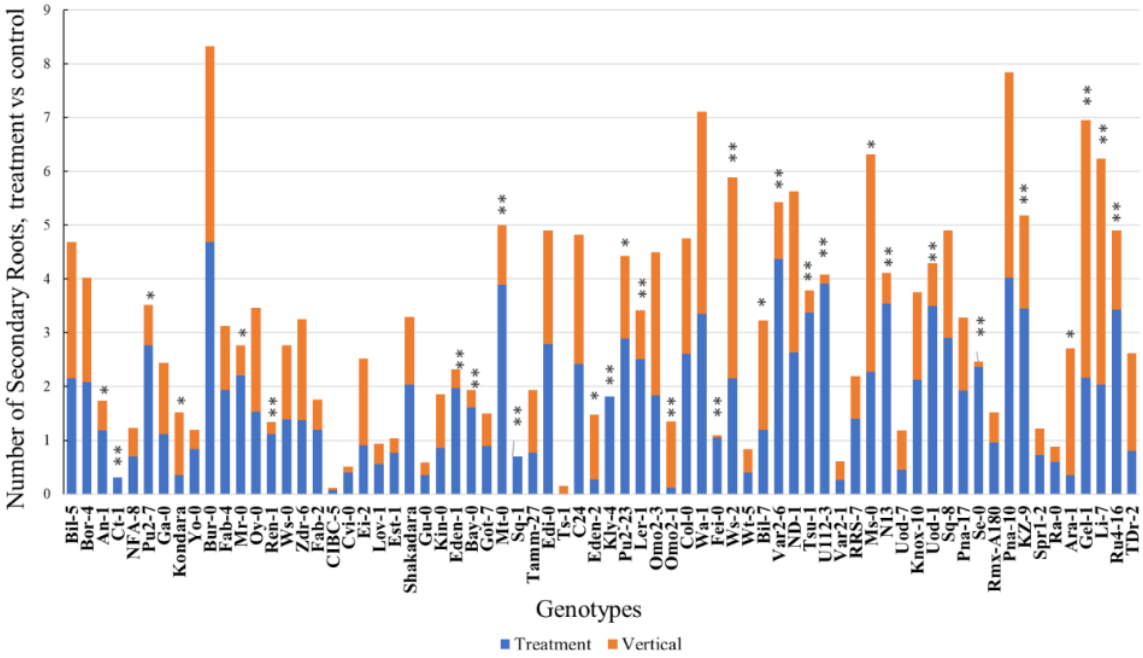

Figure 3: Comparison of average number of secondary hairs for clinorotated treatment group versus vertically-grown control group in 70 Arabidopsis thaliana wildtype genotypes. Asterisks indicate t-test p values of < 0.05 (*), or < 0.01 (**).

The genotype CIBC-5 was the only genotype found so far to show no difference in growth in all of the parameters measured. Apart from CIBC-5, five other genotypes, Sq-8, NFA-8, Omo2-3, Edi-0, and Pna-10, showed no difference in growth among all growth parameters other than shoot length, and eleven genotypes showed no difference in growth in at least 3 parameters (Table 1).

Table 1: Analysis of development of genotypes (strains) in altered gravity conditions compared to the control. Rows show genotypes in decreasing order of number of parameters (ranked A-F) with nonsignificant p-values (<0.05; NS) among 5 different parameters (shoot length, main root length, number of secondary roots, total root length, and number of root hairs per total root length) in vertical versus clinorotated seedlings. While there are more genotypes in the D-F categories, these genotypes shaded in dark grey are included for reference. *Genotype Col-0, while in tier C, is notable due to being one of the only two genotypes with nonsignificant *shoot growth under clinorotation compared to controls.*

Genotype	Shoot Length	Main Root Length	Number of S. Roots	Total Root Length	NRH/TRL	Tier
CIBC-5	NS	NS	NS	NS	NS	A
Col-0	NS	S	NS	S	NS	C*
Sq-8	S	NS	NS	NS	NS	B
NFA-8	S	NS	NS	NS	NS	B
Omo2-3	S	NS	NS	NS	NS	B
Edi-0	S	NS	NS	NS	NS	B
Pna-10	S	NS	NS	NS	NS	B
Kondara	S	NS	S	NS	NS	C
Pna-17	S	NS	NS	NS	S	C
Yo-0	S	NS	NS	NS	S	C
Oy-0	S	NS	NS	NS	S	C
Zdr-6	S	NS	NS	NS	S	C
SHAKADARA	S	NS	NS	NS	S	C
GU-0	S	NS	NS	NS	S	C
Kin-0	S	NS	NS	NS	S	C

C24	S	NS	NS	NS	S	C
ND-1	S	NS	NS	NS	S	C
RRS-7	S	NS	NS	NS	S	C
Fei-0	S	S	S	NS	NS	D
Omo2-1	S	NS	S	NS	S	D
Ws-0	S	S	NS	S	S	E
Tamm-27	S	S	NS	S	S	E
Ler-1	S	S	S	S	S	F

Discussion

As expected, the majority of seedlings grown under clinorotation had reduced growth parameters when compared to their vertically-grown controls. Most notably, shoot growth was negatively affected. Of the 70 Arabidopsis thaliana genotypes analyzed, 7 genotypes were of particular interest. CIBC-5, an ecotype from the United Kingdom region [157], showed no significant difference from controls among all growth parameters analyzed. Additionally, Col-0, an ecotype originally from Poland [158], was the only other genotype to not show a significant difference in shoot length. The Col-0 genotype also showed no significant difference in the number of secondary roots and root hairs per total root length. Furthermore, genotypes Sq-8, NFA-8, Edi-0, Omo-

[157] Anastasio et al., "Source Verification of Mis-Identified Arabidopsis Thaliana Accessions."

[158] Fernandez et al., "Elevated CO 2 May Reduce Arsenic Accumulation in Diverse Ecotypes of Arabidopsis Thaliana."

2-3, and Pna-10 all showed no significant difference in growth among all parameters analyzed except in their shoot lengths (Table 1), and may be ideal for further testing.

It is unknown whether clinorotation is a true prediction for growth response at microgravity conditions. In order to fully understand plant tropisms, experiments in true microgravity or altered gravity conditions must be performed. Nonetheless, genotypes such as Col-0 have also been identified by prior research as having possible gravitational resistance qualities, especially in root growth, based on spaceflight experiments. [159]

Prime candidates for testing on spaceflight experiments include genotypes that display possible gravitational stress resistance in phenotypic traits. This trait may be exemplified by genotypes that show similar growth under simulated gravitational stress by a 2D-clinostat. Therefore, the seven genotypes listed above, and particularly CIBC-5, will be our main candidates for further testing here on Earth and possibly in future spaceflight experiments. Selected candidates will have genetic studies performed and compared in order to identify possible genes responsible for gravitational stress resistance. Later, these genes can be checked or manipulated to produce plant varieties suitable for gravitational stress resistance.

While studies have shown that genotypes such as Col-0 can be made to adapt to spaceflight conditions through alteration of a single gene and several other methods to maintain root growth [160], most studies have not assessed shoot length and other parameters discussed in this research which can be important factors in a plant's response to gravity. Spaceflight studies which have focused on phototropism, however, found no significant difference in growth between microgravity and 1-g treatments in phytochrome A, phytochrome B, and wildtype (Landsberg; Ler) genotypes. [161] Additionally, most studies have focused on using Landsberg (Ler), Wassilewskija (WS), or phytochrome mutant genotypes of Arabidopsis thaliana. [162] Therefore, we aimed to use genotypes from a broad range of locations to expand on the

[159] Paul et al., "Genetic Dissection of the Arabidopsis Spaceflight Transcriptome."

[160] Paul et al.

[161] Vandenbrink and Kiss, "Space, the Final Frontier."

[162] Vandenbrink and Kiss.

current knowledge on A. thaliana's growth responses. Understanding the growth responses of more genotypes under gravitational stress provides for better assessment of said results for selecting candidates to alter for spaceflight experiments and genetic modification.

Spaceflight research comes with many challenges such as limitations in resources, the lack of a proper control group, limitations in sample size, safety concerns, and the effective processing and analysis of samples after spaceflight among many others. [163] Due to the many constraints of such experiments, development of effective ground-based models are an important part of furthering space biology research and ensuring the enhancement of spaceflight experiments when conducted. Learning from past experiments (e.g., [164]) for lighting and temperature and others such as determining a clinostat rotational velocity so as to prevent difficulty in root nutrient uptake shown to be a problem at higher velocitie. [165] The procedures used in this experiment were optimized to best determine the several growths parameters of A. thaliana under gravitational stress using a 2D-clinostat. Spaceflight experiment results can be compared to results from this experiment to determine the effectiveness of a 2D-clinostat in randomizing the gravity vector for plants.

Conclusions

Based on 2D-clinorotation treatment, CIBC-5, an A. thaliana genotype, is expected to be more tolerant at gravitational acceleration stress conditions among all growth parameters. Six other candidates mentioned also show similar results. Further tests using other gravity-randomizing models such as the random-positioning machine (RPM) could be used to verify results from this experiment. [166] Additionally, more testing will be needed to find other genotypes that may show vigorous growth under gravitational stress. In the

[163] Kiss, "Conducting Plant Experiments in Space."

[164] Kiss, "Plant Biology in Reduced Gravity on the Moon and Mars."

[165] Polinski et al., "2-D Clinorotation Alters the Uptake of Some Nutrients in Arabidopsis Thaliana."

[166] Kiss et al., "Comparison of Microgravity Analogs to Spaceflight in Studies of Plant Growth and Development."

long term, experiments in true microgravity conditions need to be performed to prove or disprove our predictions based on clinorotation treatment.

Acknowledgements

Melika Osareh carried out portions of this research along with support from lab mates Alexandra Settle, Alena Jones, Noah McMurry, Kelsey Taylor, and Ibeabuchi Iloghalu with supervision from postdoctoral fellow Dr. Tatsiana Shymanovich in Dr. John Z. Kiss' lab. Melika's contributions were fulfilled in part through requirements of Biology 499 Undergraduate Research, Biology 493 Honors Undergraduate Research at the University of North Carolina at Greensboro, USA, and the NASA North Carolina Space Grant Undergraduate Research Award in summer 2019. Additional funding for this research was through undergraduate research awards from the Department of Biology at the University of North Carolina at Greensboro to Melika as well as NASA grant funding to Department of Biology for Dr. John Z. Kiss.

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" Post COVID-19 Analysis of Barrier Method Use and Sex Practices Among Undergraduate Students"

Brianna Richardson

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Faculty Advisor, Terri Mitchell, Ph.D.

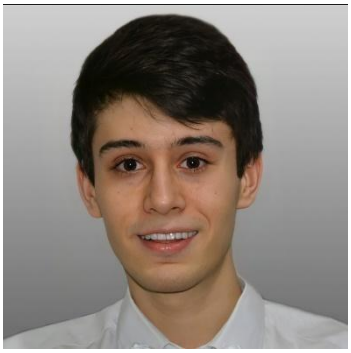
Abstract

Undergraduate students are often between ages 18–24 and have a high predisposition for engaging in risky sexual behaviors. The COVID-19 pandemic increased the normality of socially protective behaviors and communicable disease knowledge for public health defense. The goal of the study was to measure the frequency of barrier method use among undergraduate students in response to the COVID-19 pandemic including variables of relationship status, forms of sex, and barrier method communication comfort. In terms of methods, a researcher-created questionnaire was used to collect data on the COVID-19 safety habits, sexual behaviors, and communication practices of the previous 12 months among respondents. The results were that precautionary behaviors related to COVID-19 were not predictive of safer sex behaviors like barrier method use among the undergraduate population from August 2020–August 2021. Additional tests that demonstrated statistical significance included: Upperclassmen comfort in barrier method communication with non-monogamous partners; Increased face mask use and handwashing among fully-vaccinated participants before vaccination than afterward; and Self-identified "Lesbians" were the least likely sexual identity to use any form of barrier method. Finally, tests did not prove overall significance between socially and sexually protective behaviors, but future research could compare the identities and sexual practices of individuals on their knowledge and application of population and public health preservation.

For a PDF of the full document, please go to the following hyperlink:

https://honorscollege.uncg.edu/wp-content/uploads/2024/12/PDF-YDG-Brianna-Richardson.pdf

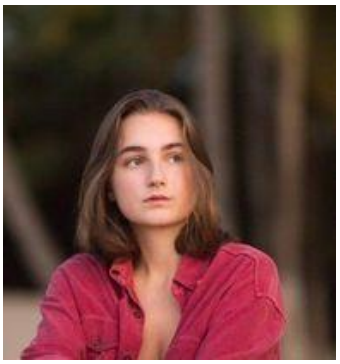
CONTRIBUTORS



Amir Reza Hashemi is an undergraduate student at Islamic Azad University, Central Tehran Branch, He is currently pursuing an undergraduate degree in computer science. He is very interested in mathematics and computer software issues, especially its programming, which allows him to develop his passion for generalizing programming to all sections of society.

Grace Clark graduated from UNCG with a B.S. in Psychology. As a Disciplinary Honors student, she completed a Senior Honors Project and received an URCA scholarship. She also presented her work at the 68th annual Southeastern Psychological Association meeting.

Emi Curia is in the Lloyd International Honors College at UNCG. She is a Full Honors student majoring in Psychology and Women's, Gender, and Sexuality Studies, and minoring in American Sign Language. She is a recipient of the Katharine Smith Reynolds Scholarship from the Honors College and has been on the Chancellor's List for the past two years. She serves the UNCG community through various organizations, such as being Language Chair of Japanese Club and a Psychology tutor at the Academic Achievement Center.



Gabrielle Gagnon is an undergraduate student at McGill University in psychology. Her interests in social psychology have led her to study the implications of social factors such as ethnicity, personality, and perceptions of threat influence levels of motivation. She is currently examining the perceptions of injustice that act as a maintenance factor for musculoskeletal pain following work-related incidents.

Melika Osareh received her Bachelor's of Science in Biology Honors with minors in Mathematics and Chemistry in May 2022. She was involved in space biology research for about 3 years as an undergraduate under the supervision of Dr. John Z. Kiss and received several awards and recognition at local and state conferences, including receiving the North Carolina Space Grant undergraduate award in 2019. Melika has also been involved in other programs such as the American Association of University Women Greensboro branch and being selected into the international Future Nobel Laureates Scholarship Program in 2021, promoting better access to education for women and in third-world countries.

Brianna Richardson is an Honors senior from Appalachian State University, she graduated in May 2022 with a B.S. in Public Health. She has a personal interest in sexual and reproductive health literacy within her field of public health and conducted her Honors College Thesis Project around that topic. Conducting a solo quantitative research project on barrier method use after the onset of the COVID-19 pandemic intended to combine both Brianna's interest of safer sex knowledge among college-aged individuals with the possible impacts of a global pandemic on general health knowledge. She hopes to continue this work in both her academic and professional career as she works in roles related to health education and promotion in the future.

Y ddraig goch means "the red dragon" in Welsh. First recorded around 829 C.E. in *Historia Brittonum*, the red dragon has long been a symbol of Wales and appears on the Welsh flag. The red dragon is also the mascot of Lloyd International Honors College in honor of its benefactress, Rebecca A. Lloyd, whose parents came to the United States from Wales. In 2013, the Honors College began a tradition of sending students abroad with a small red dragon to take a picture with and send back. See the *There Be Dragons Honors College student blog* at lihcdragonblog.blogspot.com.

May 29, 1929 - May 21, 2013

REBECCA A. LLOYD was a 1950 graduate of Woman's College (the name for the University of North Carolina at Greensboro prior to 1963). In 2006 she gave her family's name and her financial support to establish and endow Lloyd International Honors College by donating $4 million, the largest alumni gift the university has ever received. Of her support for the Honors College, Lloyd said, "The Honors College will give students the international viewpoint that's needed in their education. To the extent that my gift can help world peace come about, I'm happy to be making it."

The following Nota Bene was originally written in dialogue with Dr. Christopher Kirkman, Senior Honors Academic Advisor and beloved colleague, teacher, and mentor in Lloyd International Honors College. We have decided to keep it as it was before he passed away of cancer, and we lovingly dedicate this issue of YDG to him.

Nota Bene

Hydrogen

A tiny atom, not yet bright,

Born in the heat of the Big Bang's light.

In the beginning, just a spark.

In a universe, vast and dark.

Time passed on, and joining others, forming new elements, ever-larger:

Helium, Lithium, Carbon, Nitrogen

Gases swirling, stars emerging.

Light and life, forever converging.

Our atom drifted through space and time.

Riding on the winds of a cosmic rhyme.

Seeing stars born, some stars die.

Galaxies collide, new life arise.

And then on Earth, a new place of birth.

Joining with others, molecules forming.

Organisms living, always transforming.

Bacteria, plant, animal, sea to sky.

Our atom's journey never ceased to fly.

Flowing through veins, breathing in air.

A part of life, beyond compare.

And now full circle,

its journey complex yet simple.

From the universe's origin, to this day,

Its story, our story, all stories… so they say.

— OA and AI

Is it the dawning of a new era? A new period of uncertainty? Or, as Dr. Lois Holzman, Visiting Fellow at Lloyd International Honors College, shared in a series of conversations with the Honors community, hasn't there always been uncertainty—no new eras, but continuations, that is, continuations of ongoing human creation? With the advent of ChatGPT (and GPTZero to 'counter' this machine learning AI), can we think about this new technology as a continuation of the many ways we are already aided by technology—from the light we turn on to read at night, to the computers on which we type, when we Google something on our phones, or use YouTube to learn something, from spell checking our work to predictive texting? So why not use machine learning and AI to help us in our process of learning and creating? I don't know, as I suspect there are many (many) views on this emerging. For the moment, I offer this poem, which I wrote with AI. It was actually deemed "Your text is likely to be written entirely by a human" when running it through GPTZero after I worked on what came out using ChatGPT with the prompt "Please write a poem about the history of the universe as told through a single atom."

As Dr. Chris Kirkman, Honors Senior Academic Advisor at Lloyd, recently commented to me in a text exchange: "Last week Harvard University hosted Kal Khan of Khan Academy to talk about technology and education. He still places the highest value, I understand, on the student/teacher (in person) relationship. Much of his talk though was about ChatGPT and its enormous value to society … I think we may have to rethink the lingering Romantic concept of the 'genius' of the individual author even more now. For writing, it offers the potential to open new ways of constructing concepts, new juxtapositions, new phrasings. But it might also entrap us in structural relationships from which we're trying to evolve out of. I don't know. I'm very curious to see how this changes us."

Building on this philosophical curiosity, as Dr. Nadja Cech, Lloyd Honors Council member and Distinguished Professor of Chemistry recently stated in an email exchange with me, "AI [might be] the ultimate form of collaboration … it learns from all of us and synthesizes what we have each contributed … collective mind, not artificial."

What do you think?

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THE HONOR SOCIETY OF

PHI KAPPA PHI

Founded in 1897, The Honor Society of Phi Kappa Phi is the nation's oldest and most selective honor society for all academic disciplines. The organization inducts approximately 30,000 students, faculty, professional staff, and alumni annually from more than 300 select colleges and universities in North America and the Philippines.

Membership is by invitation only to the top 10 percent of seniors and graduate students and 7.5 percent of juniors. Faculty, professional staff, and alumni who have achieved scholarly distinction also qualify. Since its founding, more than 1.5 million members have been initiated into the ranks of Phi Kappa Phi. Phi Kappa Phi awards nearly $1 million each year to qualifying students and members through study abroad grants, graduate fellowships, funding for post-baccalaureate development, member and chapter awards, and grants for local, national and international literacy initiatives.

The UNCG Chapter (#352) of The Honor Society of Phi Kappa Phi was established and installed on March 13, 2019 and welcomed its inaugural and founding class of Chapter members on April 11, 2019 and will welcome its second class in Fall 2019. For detailed information on the Society and the benefits of membership, please visit https://PhiKappaPhi.org.

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The UNCG-McNair Scholars Program (UNCG-McNair) is a federal *TRiO* program funded by the U.S. Department of Education. Designed to prepare undergraduate students for the pursuit of a Ph.D. UNCG-McNair provides 25 UNCG undergraduate students with opportunities to complete research with faculty mentors, attend the UNCG-McNair Summer Research Institute, explore graduate school options, and prepare for graduate-level studies. Ultimately, the goal of UNCG-McNair is to diversify faculty demographics across the nation by providing experience and training to students typically under-represented in the academy.

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