The Effect of Color Therapy on Respiration Rate of Goldfish

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Abstract

Research shows that color therapy is an effective way to evoke emotions in living organisms. The purpose of this experiment was to explore the effects of color therapy on the respiration rate and behavior of organisms, specifically goldfish. This led to our research question: what is the effect of environment color on the respiration rate of goldfish? Our hypothesis stated that warm colors (red, orange, yellow) will increase respiration rate, while cool colors (blue, green, purple) will decrease respiration rate.

The effects of color therapy on fish was tested by surrounding the fish with various colored environments. The respiration rate was found by counting the number of breaths the fish takes in one minute. Each time the fish opens and closes its mouth is counted as one breath. Respiration rate and fish behavior for each color environment was recorded, and activity level of the fish was rated on a scale of one to five. In order to ensure accuracy, five trials were done with five different fish so that any data recorded was not by chance.

After conducting this experiment, we found that environment color does have an effect on the respiration rate of goldfish. After testing each different environment, we were able to support our hypothesis. The fish surrounded with cool colors had a significantly lower respiration rate than the warm colors and the control. With the knowledge acquired in this experiment, we will have a better understanding of color therapy and its possible benefits for humans.

Introduction

Research shows that color therapy is an effective way to evoke emotions in living organisms. The purpose of this experiment was to explore the effects of color therapy on the respiration rate and behavior of organisms. We decided to investigate this by testing the effect of environment color on the respiration rate of goldfish. We collected data to see if manipulating the color of the environment surrounding a goldfish causes it to breathe more often or less often. To make sure the experiment was valid, we had to be certain that goldfish see in color. Ellis R. Loew's (2001) study found the following:

> The common goldfish certainly sees in color... In order to have color vision, the retina in the back of the eye must have color detectors, called cones, present and the brain has to be wired to make use of the information it gets from the cones. We have three different kinds of cones in our eyes, called red, green and blue that make human color vision possible. The goldfish has four kinds of cones: red, green, blue and ultraviolet.

Through our research, we discovered that goldfish can not only see in color, but they can see more colors than humans can. "Many kinds of fish can actually see color. Some can see at least 24 different shades of color" (Vos, 2004). Fish have certain adaptations that allow them to see clearly underwater. "The lenses in the eyes of fish are round in shape. These round lenses are what lets them see clearly underwater... Fish eyes are best designed for seeing things that...contrast with the water around them. They also notice movement very well" (Vos, 2004). Fish also have no depth perception. "They [fish] see most things as flat," (Vos, 2004).

A very important concept to understand in order to understand the real-life applications of our experiment is color therapy. We conducted extensive background research regarding the effects of color therapy on both humans and other organisms. Throughout the course of our research, we discovered many studies on the concept of color therapy. Balch, J. & Balch, P.'s (1990) research found the following:

> Blue has a relaxing, peaceful, and calming effect. Blue lowers blood pressure, heart rate, and respiration... Green, like blue, has a soothing and relaxing effect... Green also helps with nervous disorders... LIke blue and green, violet creates a peaceful environment... The color red stimulates, excites, and warms the body. Red increases the heart rate, brain wave activity, and respiration... Pink has a soothing effect on the body, relaxing the muscles... Orange is the color of choice for stimulating the appetite and reducing fatigue... This color [yellow] also raises the blood pressure and increases the pulse rate but to a lesser degree than red does... yellow has an energizing effect... Black is a "power color."

Another study on color therapy had similar results. The Color Therapy Association's (2005) study found the following:

> Color therapy is an area of holistic healing which uses color in an attempt to affect our mood, emotions, and possibly even our health... Red is hot. It can stimulate and excite. Red is associated with courage, strength, vigor, alertness, and aggressiveness. Orange is warm and joyful. Orange is associated with happiness and optimism. Too much orange can result in irritability and slight

frustration. Yellow is warm to hot. It is associated with self esteem, empowerment, confidence, and energy. It eases depression, and too much can result in hyperactivity. Green is refreshing and cool. It is associated with peace, renewal, stress reduction, calmness, relaxation, and rest. Blue is cold and acidic. It connects us to holistic thoughts. Benefits of being surrounded are mental relaxation, calmness, and peace. It helps with hyperactivity in children. Too much blue can make someone feel tired and depressed. Violet is cool. Violet is associated with strong, deep sleep, calm nerves, and reduced excitement. Too much can result in depression. Pink is associated with relaxation, stress relief, and calming aggressions.

A color that many studies focus on is the color red, because it has been proven to have powerful effects on both humans and other organisms. Many tests have been done to see how humans react to the color red. Andrew J. Elliot and Markus A. Maier (2007) wrote “Color and Psychological Functioning.” It was a study that focuses greatly on the color red and how it increases stress levels. They mention Goldstein’s (1942) proposal about red and yellow, and how they are naturally shown to be stimulating.

As a general trend, longer-wavelength colors, such as red, are shown to be arousing, while shorter-wavelength colors, like green, are shown to be calming. However, it can be difficult to explain why these reactions occur when organisms are exposed to certain colors. Especially in humans, culture is shown to impact how people react naturally to certain colors. For example, in the United States black is often linked with evil and death, which can cause the color black to be linked to feelings of

aggression. Peoples of other cultures, however, may not have this idea about the color black, which could cause them to react differently when exposed to the color black. Because of this, it can be difficult to find the distinction between natural reactions to certain colors and reactions that have been somehow influenced by an organism's environment.

In "Color and Psychological Functioning," Elliot and Maier created a general model of the relationship between color and the way it affects our feelings and behavior. They explained that colors can carry specific meanings and communicate information. These color meanings are grounded in two basic sources. The first source is learned associations that develop from repeated pairings of colors with particular messages, concepts, or experiences. The second source for these meanings is biologically based proclivities to respond to particular colors in particular ways in particular situations. Some associations may emerge from learning alone, but color theorists suspect that many associations emerge from evolutionary ingrained responses to color stimuli. Research indicates that colors often serve a signal function for nonhuman animals, thereby facilitating fitness-relevant behavior.

Elliot and Maier also explained that the mere perception of color evokes evaluative processes and that the evaluative processes evoked by color stimuli produce motivated behavior. Positive meanings produce approach responses, while negative meanings produce avoidance responses. Color typically exerts these influences on psychological functioning in an automatic fashion; the full process process takes place without conscious intention or awareness. Color meanings and effects are also

contextual; a given color has different implications for feelings, thoughts, and behaviors in different contexts.

In 2007, Elliot and Maier conducted a study involving reactions to the color red. In this study, they administered IQ tests to three groups. One of the groups received test booklets with red covers, one received booklets with green covers, and others received test booklets with grey covers. The participants were not informed what the study was being conducted on. Participants that were given a booklet with red cover were observed to have an involuntary physical reaction when the test booklets were administered. They moved their bodies away from the cover more quickly and more dramatically than participants given green or gray. The results of the reactions for the green and gray color had little to no difference. Elliot and Maier concluded that red can carry the message of danger and failure, depending on the context of the situation. In different situations, red can also carry the message of love, passion, and sexual readiness. This is evident in the way that nonhuman male mammals often use red to attract possible female mates.

Goldstein's (1942) proposal involving the naturally stimulating properties of the colors red and yellow has been tested and multiple researchers have supported and expanded upon this proposal, for example Hoffman (2010), who proposed that "red produces the longest wavelengths, followed in order by orange, yellow, green, blue, indigo, and violet. Those colors with the longest wavelength are absorbed first."

The scientific basis for our topic as it relates to research is the benefit of color therapy and how certain colors evoke an emotional response in organisms. Color

therapy is a is a branch of psychology that helps people with their problems by surrounding them with a specific environment that will register a certain way in their brains. In this experiment we are looking at the physical effects of a certain environment color, shown through the increase or decrease in respiration rate. Generally, a raised respiration rate means that the fish is under stress. Decreasing respiration rate means that the fish is becoming calmer. This leads to our research question which is, what is the effect of environment color on the respiration rate of goldfish? After conducting background research, we hypothesized that colors that are warmer and have longer wavelengths, such as red, orange, and yellow, will increase the respiration rate, while colors that are cooler and have shorter wavelengths, such as green, blue, purple, and black, will decrease the respiration rate.

Materials:

The materials used in this experiment are: goldfish (5), fishnet, construction paper (red, orange, yellow, green, blue, purple, pink, black), lab tape, stopwatch, beakers (5, 500 mL), dechlorinator drops, tap water, graduated cylinder.

Methods:

The independent variable in this experiment was the environment color surrounding the fish. The environment color was simulated by surrounding the beaker containing the fish with construction paper in red, orange, yellow, green, blue, purple, pink, and black, as well as a control with no color. Constants in the environment included water temperature, the amount of light, and the amount of time the fish spent in the given environment. The dependent variable was the breathing rate of the fish, measured in breaths per minute. Each time the fish opens and closes its mouth is counted as one breath. A data table was used to record this quantitative data. In terms of qualitative data, observations were recorded regarding the behavior of the fish in each environment. Additionally, the activity of the fish was rated on a scale of one to five, with one being very calm and five being very agitated. Nine different environments were included in our experiment and five trials were performed in each color. The mean respiration rate for each color was calculated to ensure accuracy. Other forms of data analysis included median, mode, range, midrange, t-test, standard deviation, and line graphs.

The day before the experiment, tap water was dechlorinated so that it was safe

for the fish. This was done by filling five 500-mL beakers with 500 mL of tap water. Two drops of dechlorinator solution were added to each beaker. The beakers were left to sit overnight. A sleeve of each color construction paper (red, orange, yellow, green, blue, purple, pink, and black) was also made to fit around the beakers.

On the day of experimentation, one goldfish was retrieved and placed in the first beaker. The stopwatch was set for one minute in order for the fish to adjust to its environment. Qualitative observations were recorded regarding the fish's behavior. The activity level of the fish was also rated using a scale (see *Figure 1.1* Scale for Rating Fish Behavior) After one minute, the stopwatch was started and the breaths taken by the fish in one minute were counted and recorded for the control environment. Each time the fish opens and closes its mouth is counted as one breath.

Next, the red construction paper sleeve was placed on the beaker. Once again, the timer was set for one minute in order for the fish to adjust to the change. Qualitative observations were recorded regarding the fish's behavior and the activity level of the fish was rated according to the scale. After one minute, the stopwatch was started and the breaths taken by the fish in one minute were counted and recorded.

This procedure was repeated with each color. Attempts were made to alternate between warm and cool colors in order to better observe if there was a significant difference between the two, and to make sure that data would not be skewed by the exhaustion of the fish due to the constant changing of environment. The order of colors that was used in this experiment was: control (no color), red, blue, orange, purple, yellow, green, pink, and black. Once all nine trials were completed for one fish, another

fish was retrieved and placed in a second beaker and the procedure that was used for the first fish was repeated. The procedure was then repeated three more times until a total of five fish were used to record five trials for each color.

In terms of safety, gloves and goggles do not need to be worn. However, since live animals are being used, it is important to be aware of the safety of the fish. This includes doing things such as taking care not to move the beaker around excessively and being gentle when transferring the fish between the bowl and the beaker using the fish net.

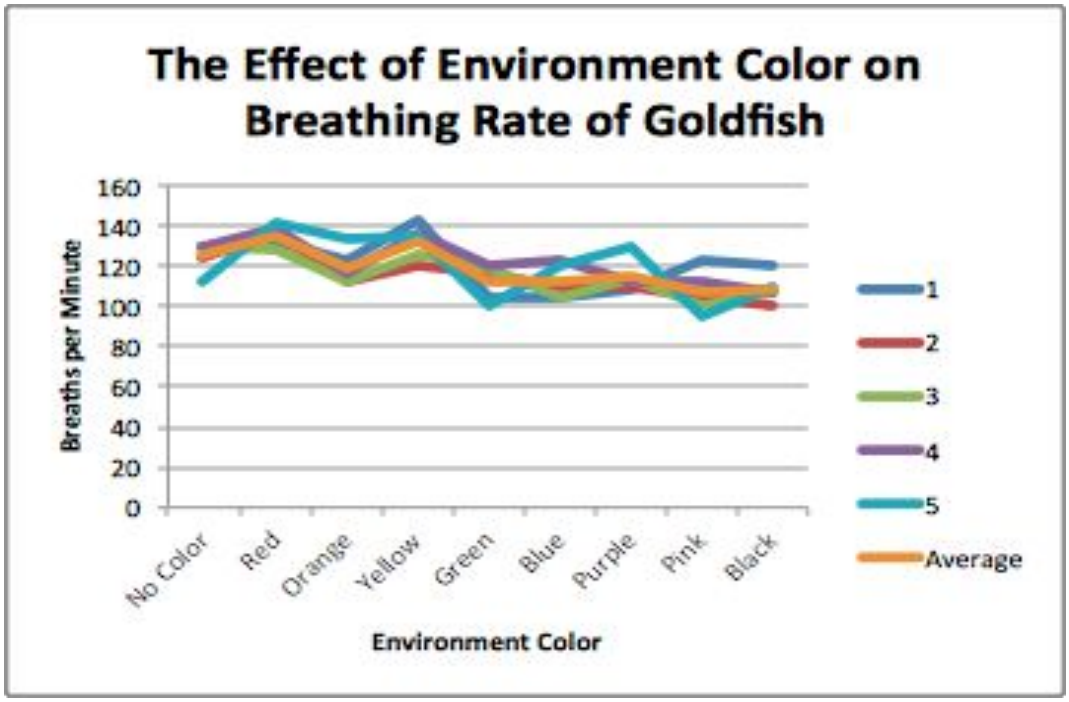
Results

As a whole, we found that color therapy did have an observable effect on the respiration rate of the fish. As seen in *Table 1.1,* even before we began data analysis we noticed a clear difference between the breathing rate of the fish when placed in warm colors when compared to that of the fish in cool colors. As a general trend, fish surrounded with warm colors experienced a higher respiration rate than fish in cool environments. This data is visually represented in *Graph 1.1.*

Table 1.1 The Effect of Color Therapy on the Respiration Rate of Goldfish (measured in breaths per minute)

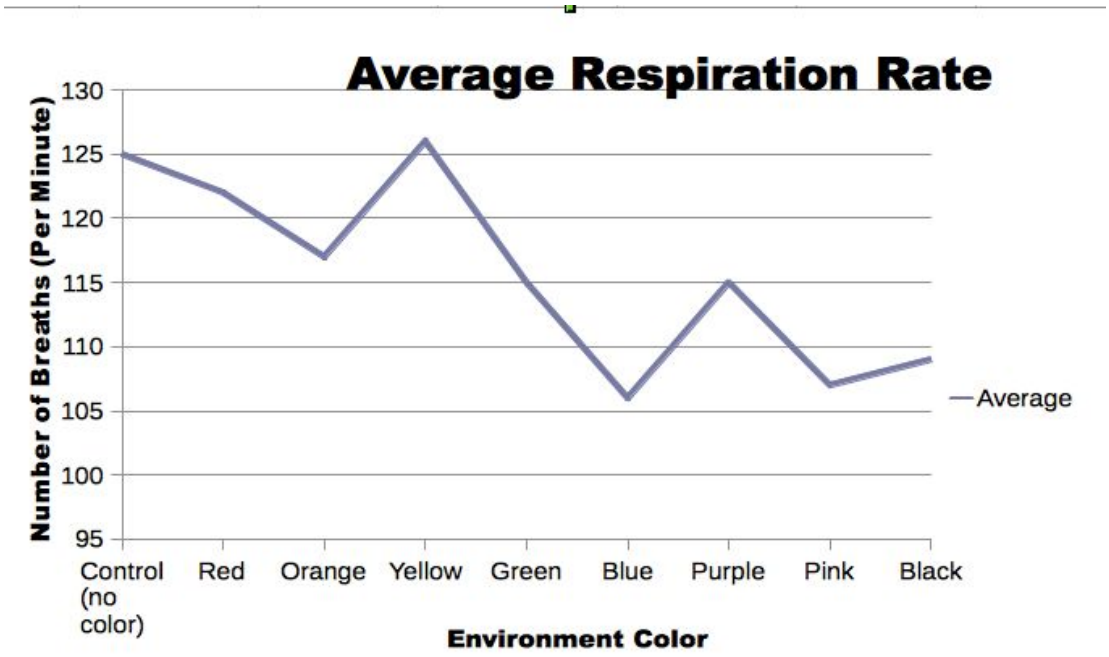
	1	2	3	4	5	Average BPM
Environment Color						
Control (no color)	130	124	130	130	113	125
Red	132	136	128	139	142	122
Orange	123	112	112	116	134	117
Yellow	143	120	126	136	135	126
Green	104	116	119	120	100	115
Blue	104	110	104	123	120	106
Purple	108	110	114	112	130	115
Pink	123	105	100	112	95	107
Black	120	100	107	107	110	109

Graph 1.1 The Effect of Environment Color on Breathing Rate of Goldfish



The control, which was the breaths per minute of the fish with no color, had a mean of 125 breaths per minute. The highest average was the yellow environment, with an average respiration rate of 126 breaths per minute. Red and orange were not far behind, with an average breathing rate of 122 and 117 breaths per minute, respectively. The lowest average was blue, which had an average respiration rate of 106 breaths per minute. Other colors that showed a low respiration rate included pink and black, with a rate of 107 and 109 breaths per minute. Green and purple also had a respiration rate of 115 breaths per minute.

Graph 2.1 Average Respiration Rate



In terms of qualitative data, we recorded observations regarding the behavior of the fish in each color environment. Using these observations, we formulated a rating system for the behavior of the fish. The activity level of the fish in each environment was rated on a scale from one to five, with one being very calm and five being very agitated. A detailed description of the scale can be seen in *Figure 1.1*, Scale for Rating Fish Behavior. Once the activity level for each fish was quantified according to our scale (see *Table 3.1),* the data was averaged and graphed, as seen in *Graph 3.1.* In general, one can see that fish in warmer colored environments experienced a much higher activity level than fish that were placed in cooler colors.

Table 3.1 Fish Activity Level in Each Environment (on a scale of one to five)

	1	2	3	4	5	Average
Environment Color						
Control (clear)	3	4	3	4	4	3.6
Red	5	5	5	5	5	5
Blue	1	1	1	1	1	1
Orange	4	3	3	3	5	3.6
Purple	1	3	2	1	2	1.8
Yellow	4	5	4	3	5	4.2
Green	2	1	3	2	1	1.8
Pink	1	2	2	1	2	1.6
Black	1	1	1	2	1	1.2

Figure 1.1 Scale for Rating Fish Behavior

1- Calm, Relaxed, Barely Moving, Little to no fin movement

2- Calm, Relaxed, Little Movement, Some fin movement

3- Normal, some movement, swims around but seems calm

4- Lively, swims around rapidly (but not in circles), much movement

5- Extremely agitated, swims in circles, much rapid movement

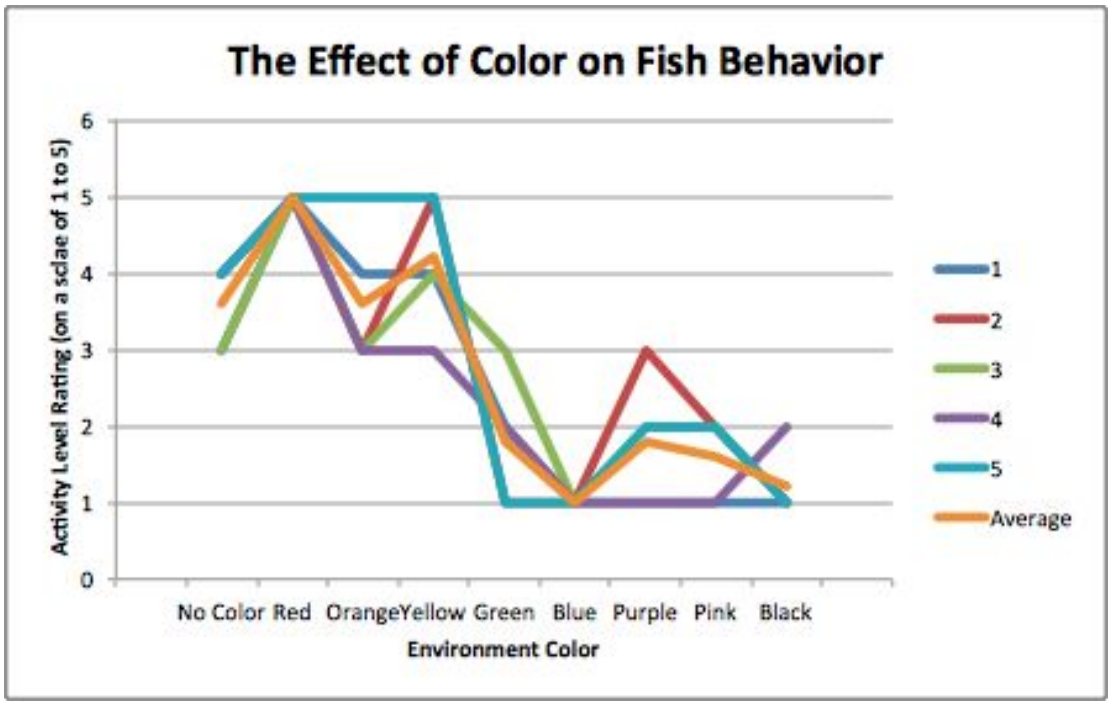
Specific observations have been recorded about fish behaviors during tests.

Table 3.2 Fish Behavior Observations

Color	Behavior
Control	Fish swims around somewhat quickly, lively yet calm

Red	Swims around extremely fast, swims around in rapid circles around beaker, seems agitated, swims near surface of water
Blue	Immediately calms down and stops moving, slow breaths
Orange	Swims rapidly, bursts of energy and movement
Purple	Swims around very little, calm
Yellow	Lively, a lot of random movement
Green	Calm, swims around slowly
Pink	Little movement, very calm
Black	Stayed still almost the entire time, extremely calm, stays at bottom of beaker

Graph 3.1 The Effect of Environment Color on Fish Behavior



In terms of statistical analysis, we performed t-tests, standard deviations, mean, median,

mode, and midrange. The means of the data are shown in *Table 1.1* and can be seen visually in *Graph 2.1*. In terms of t-tests, we compared each color to the control to find if the data was significantly different. As shown in table 4.1, green, blue, pink, and black were shown to be significantly different from the control. We also compared the respiration rate of a fish in a red environment and one in a blue environment, because we noticed that during our research these colors were generally found to have the greatest emotional effects on organisms. We found a very large statistical difference between the respiration rate of fish in red and blue environments, with a p-value of 0.002.

Table 4.1 T-test Results

Environment Color	T-test Result
Red to Control	0.26
Orange to Control	0.29
Yellow to Control	0.24
Green to Control	0.03
Blue to Control	0.04
Purple to Control	0.07
Pink to Control	0.02
Black to Control	0.01
Red to Blue	0.002

The results of the standard deviation are shown in *Table 4.2*

Table 4.2 Standard Deviation

Environment Color	Standard Deviation Value
Colorless (Control)	7.40
Red	5.55

Orange	9.32
Yellow	9.03
Green	9.18
Blue	8.90
Purple	8.79
Pink	10.93
Black	7.26

In terms of median and mode, most were accurate, although there were few outliers in our data set. Even though we used a different fish for each trial, there were some environment colors with modes, meaning that different fish had the same respiration rate for the same environment color. These results can be seen in table 4.3 and table 4.4.

Table 4.3 Median

Environment Color	Median Value
Colorless (Control)	130
Red	136
Orange	116
Yellow	135
Green	116
Blue	110
Purple	112
Pink	105
Black	107

Table 4.4 Mode

Environment Color	Mode Value
Colorless	130
Red	none
Orange	112
Yellow	none
Green	none
Blue	104
Purple	none
Pink	none
Black	107

Most of the mid-range values were very similar. The control was 121.5, which is in the center of the midrange data. Red had a mid-range of 135, orange had a mid-range of 123, and yellow had a mid-range of 131.5. The cooler colors had a lower mid-range. Green had a mid-range of 110, blue had a mid-range of 113.5, and purple had a mid-range value of 119. Pink had a mid-range of 109 and black had a mid-range of 110, which are very similar.

Discussion

In this experiment, we have discovered that environment does have an observable effect on goldfish respiration rate. We found that, as a general trend, colors such as green, blue, purple, pink, and black had a significantly reduced respiration rate from that of the warm colors (i.e. red, orange, yellow) and the control. Our findings support our hypothesis, which stated that fish placed in warm colored environments would have a higher respiration rate than fish in a cool colored environment. Fish placed in a yellow environment showed the highest average respiration rate, followed by no color, red, orange, purple, green, black, pink, and finally blue, which had the lowest average respiration rate.

In terms of qualitative data, we also noticed behavior patterns that correlated with specific color environments. For example, fish in the red environment were extremely agitated and showed lots of frantic movement. In contrast, fish that were placed in the blue or black environment experienced a calming effect almost immediately after being placed in the environment. There was a correlation between the behavioral patterns of the fish and the respiration rate of the fish; fish that were observed to have high activity level and lots of movement had higher respiration rates than those who were calm and exhibited little movement.

Of course, like any experiment, one must take into consideration possible sources of error that could have had an impact on the accuracy of the results. For example, although care was taken to prevent counting mistakes, it is difficult to follow the fish's rapid movements all the time, especially in the warm colors when the fish was

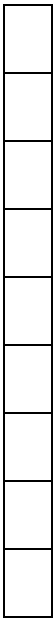
moving very quickly and in an agitated manner. This could have led to mistakes in the counting of the breaths per minute of the fish. Another possible error that could have impacted our data is the health of the fish. In fact, over the first weekend after data was collected, many of the fish did not survive. This meant that it was necessary to purchase new fish within 24 hours of performing our second day of experimentation, which is not ideal because the fish may have been affected by the travel that was required to transport them. Another possible source of error could have been exhaustion of the fish. Each fish was used to perform a total of nine trials, and seeing as each trial involved moving the fish to change the color of the environment, this could have caused stress to the fish. Lastly, one must take into consideration that conducting studies involving living organisms contributes a whole set of variables involving natural differences between individuals. We tried to eliminate this source of error by using a total of five different fish to collect data throughout the course of this experiment.

Through performing this experiment, we learned that color does indeed have an observable effect on the physical behavior of organisms. Fish that were exposed to warm colored environments had a significantly higher respiration rate than fish that were exposed to cool colors. The results that we obtained comply with the background research that we performed before beginning experimentation.

To take this experiment a step further, it would be interesting to test the effects of color therapy on other types of organisms and see if similar results are found. For example, different species of fish could be used to determine if certain types of fish are more affected by color changes that others. Experiments could also be conducted

involving changes in human heart rate as it relates to the exposure to different colored environments.

In this lab, we learned that environment color does have an effect on the respiration rate of goldfish. These results have real-life applications as well, because color therapy is often used to treat certain disorders in humans.



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