THE EFFECTS OF BAROMETRIC PRESSURE ON ELEMENTARY SCHOOL STUDENTS' BEHAVIOR

by

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ABSTRACT

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Many organisms in the natural world, especially animals, are directly in tune with the environment around them. For example, birds seem to know precisely when to migrate south with the changing of the seasons, and it has been documented that white-tailed deer are more active when the barometric pressure is below 29.00 inches of mercury. Over the millions of years the human species has been in contact with that same environment, the question remains as to how much the human animal has been, and still is, influenced by the environment.

Biometeorology is a complex science that studies the various ways living organisms respond to the natural environment. It is a multifaceted science that researches multiple living and non-living variables, intertwined with the intricacies of sociology, meteorology, physiology, ecology, biology, and chemistry.

Much work has been done in the field, which includes research on how changes in atmospheric pressure affects people. Some claim as the pressure rises and falls, so to does the level of oxygen in the bloodstream. Once the brain is deprived of oxygen, it becomes sluggish. With an abundance of oxygen, the brain works more freely. Others maintain it is the short, rapid pressure fluctuations associated with approaching weather patterns that affect neural activity that causes behavior change in humans.

A setting where these findings may be of particular interest is schools. Teachers are continually adapting to the behaviors of their students. Some days the students can be flat, and getting them to do anything is like “pulling teeth.” Conversely, on other days, that same class can be on the verge of chaos. A common expression heard from teachers is that “they’re bouncing off the walls!" Often, these extreme swings in class behavior result in low productivity form the students and leaves teachers feeling like they have wasted a day.

Could these extreme behavior swings be the result of changes in atmospheric pressure? In this study, the researcher analyzed changes in atmospheric pressure with teacher observations of elementary class behavior. A microbarograph was kept on location in the school for the duration of the four-week study. It recorded continuous pressure changes on a paper drum throughout the course of each day. Twenty-two teachers, grades K-5, recorded their observations of their class’s behavior, three times per day, on a five point Likert scale. The Likert scale was set up so one represented lethargic behavior, three represented normal behavior, and five represented excitable behavior.

The goal of this study was to find out if atmospheric pressure changes affected student behavior, and to possibly uncover a potential indicator for teachers of what the behavior of their class may be on any given day, based on the weather. Being more able to accurately anticipate students’ behavior will allow teachers to adjust their lesson plans accordingly, and thus reduce wasted days.

For this study, the researcher analyzed daily barometric pressure changes with elementary teachers’ observations of their classes. An analysis of variance was run on the data, however, no significance was found ($F=1.392$; $p=.13$).

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CHAPTER I

Introduction

"The hollow winds begin to blow,

The clouds look black,

and the glass is low"
- Dr. E. Darwin (Humphreys, 1923)

Since the invention of the barometer, as referred to by Darwin in the above passage, and other meteorological instruments, humankind has been able to predict the weather. Prior to the invention of such instruments, people were not entirely left in the dark about what the dawn would bring. People often turned to the natural world for answers to the future. Over time, humans found that animals, birds, insects, and plants behaved differently with the presence of changing weather. A belief in superstition and folklore developed out of these translations, and modern meteorological instruments and scientific data have proven many of them true.

In their book, *Whitetails: Behavior, ecology, and conservation*, Erwin Bauer and Peggy Bauer researched the white-tailed deer's ability to predict the weather. In their studies, they found that many skilled outdoors people still used the white-tail and other animals to predict the weather because of their, "uncanny ability to anticipate a sharply rising or falling barometer" (Bauer & Bauer, 1993, p. 64). In trying to gather more empirical data on the subject, they consulted Dave Morris, manager of a Georgia hunting preserve. After several years of data collection, Morris noticed that the deer in the study area were much more active when the barometric pressure was below 29.00 inches, and the temperature and the humidity were low (Bauer & Bauer, 1993).

If the weather-related behavior of animals has been so consistent over time, could this be true of humans as well? In 1954, Dr. Helmet Landsberg was appointed as Director of Climatology for the U.S. Weather Bureau. He stated, "…as much as we humans like to think that we have gained independence from natural forces, we too are greatly governed by the weather, in our activities and in the reaction of our bodies" (1969, p. 2). Over time, such beliefs have developed into a new science called sociological biometeorology or bioclimatology. This "is the study of the social significance of both favorable and unfavorable meteorological conditions on the health, behavior, and cultural activities of a population group" (Tromp, 1980, p. 2).

There are many weather-related variables that may affect any one person throughout the course of a day. Heat, cold, humidity, air movement, visible light, atmospheric electricity, ultra violet light, and dust can all be a factor (Folk, 1966). One factor, whose effects on humans are well documented, is barometric pressure. In his 1903 book, *Weather folklore,* Dr. Edward B. Garriott, best known for his development of the most widely used tables to interpret barometric pressure readings, explained the tremendous weight of the atmosphere. The normal weight of the atmosphere is one ton of pressure on every square foot of surface area at sea level. A change of one inch of mercury in a barometer translates into a change of about seventy pounds of pressure per square foot of surface area. Figuring in the surface area of the average human, this amounts to a change of about a half a ton of pressure on the human body.

> The organization of diseased and delicate human bodies, and of many kinds of animals is extremely sensitive to atmospheric changes, and aches, pains, and nervousness in humans, and restless behavior on the part of animals, birds, and

> insects may, in a measure, be attributed to low, rapidly decreasing atmospheric pressure that precedes and attends storm periods. (1903, p. 18)

Dr. Norman Rosenthal, with the National Institute of Mental Health, stated that when barometric pressure falls, so too does the level of oxygen in the blood. When the brain is deprived of oxygen it becomes sluggish, and as the brain gets more oxygen, it functions more freely and with purpose (Sarage, 1990). More recently, researchers at Kiev University found that atmospheric disturbances such as storms can cause air pressure to fluctuate several times per minute. These 'atmospheric pressure perturbations' or APPs, have been found to affect heart rate and mental ability. "Researchers believe that the body senses atmospheric pressure and changes blood pressure accordingly, which in turn affects neural activity" (Got the bad weather blues?, 2000, p. 79).

A setting where these findings may be of particular interest is schools. Teachers are continually adapting to the behaviors of their students. Some days students can be flat, and getting them to do anything "is like pulling teeth." Conversely, on other days, that same class can be on the verge of chaos. A common expression heard from teachers is that "they're bouncing off of the walls" or "they sure are squirrelly today." Often, these extreme swings in class behavior result in low productivity from the students and leaves teachers feeling like they have wasted a day.

Could these extreme mood swings be the result of changes in barometric pressure? In this study, the researcher will analyze barometric pressure readings with teacher observations of class behavior. The goal of this study is to uncover a potential indicator for teachers of what the behavior of their class may be that day. Being more able to accurately anticipate students' behavior will give teachers time to adjust their lesson plans accordingly and thus reducing wasted days.

Problem Statement

The purpose of this study is to determine the effects barometric pressure has on elementary students' behavior as reported by teachers. Daily barometric pressure readings will be analyzed with daily teacher assessments of student behavior. The study will be conducted during September and October of 2001 at Woodland Elementary School in Barron, Wisconsin.

Null Hypothesis

There will be no relationship between student behavior as assessed by teachers and barometric pressure fluctuations.

Definitions of Terms

For clarity of understanding, the following terms need to be defined.

Atmospheric pressure - weight of the of the air that presses down on Earth.

Barometer - tool used to measure the weight of the Earth's atmosphere.

Coriolis effect - the effect the Earth's rotation on air movement.

Sociological Biometeorology - the study of the social significance of both favorable and unfavorable meteorlogical conditions on the health, behavior, and cultural activities of a population group (Tromp, 1980).

Station Pressure - an atmospheric pressure reading taken at an altitude other than sea level.

Assumptions

There are several assumptions which are apparent in this research. These include, first, that the fluctuations in barometric pressure will be measurable. Second, that the teachers observing the students will remain objective despite knowing the nature of the study. Third, barometric pressure does not operate independently of other measurable weather conditions.

Limitations

The researcher has identified several limitations. They include:

1. Cloud cover and other weather variables may affect student behavior as well as the barometric pressure.

2. September is a busy month for teachers and students and may be a cause of some behavior concerns.

3. There are many different variables that could affect the mood of a student outside of the weather. For example, nutrition, family life, friendships, relationships, and academic stress all could play a role in the overall mood of the student.

4. Teacher's perspectives of the students may not be objective.

5. School events such as vacations, end of term, assemblies, and field trips may affect student behavior.

6. Weather could affect the mood of a teacher trying to make accurate observations of students.

7. Basic instrumentation used for the study was not highly technical and data collection may be subject to human error.

CHAPTER II

Review of Literature

Introduction

The literature on the weather is varied and diverse. Books on meteorology, atmospheric physics, and ecology all address the issue of the weather. In this chapter, the researcher will be discussing two basic variables for this study. The first is barometric pressure, and the second is student behavior. The chapter will contain three main parts. The first will discuss barometric pressure specifically and how it relates to the weather. The second part of the chapter will address student behavior in the classroom. Teacher expectations and student behavior will be the focus. The final section of chapter two will discuss both barometric pressure and its effects on humans, including student behavior.

The Influence of the Weather

Since the beginning of time, humans have been in contact and in tune with their environment. Just as animals, humans have had a long history of living out in the elements. "Because 98% of our skin is in intimate contact with the ocean of air that engulfs us, at once our ancestral blanket, home, and master, the atmosphere conditions humanity" (Rosen, 1979, p. 5). Changes in the weather have been a debated phenomenon throughout the history of humankind. Perhaps the first to document any theories about how the weather affects humans was the Greek philosopher, Hippocrates. In his book, *Air, waters and places*, written around 400 B.C. and some 2300 years before any modern scientific studies were done on the subject, Hippocrates gave advice to future physicians. He stated, "Whoever wishes to pursue properly the science of medicine must proceed thus. First, he ought to consider what effects each season of the year can produce: for the seasons are not alike, but differ widely both in themselves and at their changes..." (Tromp, 1980, p. 5).

The Weather

And so we proceed, as Hippocrates suggested, to try to uncover some of the mysteries of the weather and its affects on humans. So what is the weather? The weather has many different facets and dimensions, but scientists and scientific data agree that the weather starts with the atmosphere. The Earth's atmosphere extends from sea level to more than 100 km above the Earth's surface. The atmosphere is composed of a number of gases including nitrogen (78.08 %), oxygen (20.95 %), and argon (.93 %). The remaining percentages are made up of neon, helium, krypton, hydrogen, xenon, ozone, and radon (Tromp, 1980). Scientists agree that the catalyst for all weather is the effects of warm air rising and colder air falling. This effect is primarily caused by the warmer air over the equator rising and the colder air over the poles falling. Although this scenario is played out on a large scale spanning continents, it is also being played out on a smaller scale, in more localized areas, all over the world. These smaller, more isolated areas of rising warm air and falling colder air are called low and high pressure areas (Haggerty, 1985).

Much like being drawn up by a giant straw, in an area where warmer air is rising, a type of vacuum is created near the surface of the earth. This area of a partial vacuum that is created is referred to as a low pressure area. Similarly, where cooler, denser air is piling up or falling, an area of high pressure is created. The start of this whole process, as stated earlier, is warm air rising, thus creating a vacuum, and cool, more dense air falling in to fill the vacuum space. All of this air movement creates what we know as the wind.

Because of the pressure differences, air, or the winds, move from areas of high pressure to areas of low pressure (Haggerty, 1985).

Because the earth is continually spinning, as the great air masses are rising from the equator and falling at the poles, in the Northern Hemisphere, they are deflected to the right, or from west to east, in what is known as the Coriolis effect. Because of the Coriolis effect, the weather systems in the Northern Hemisphere typically move from west to east. Closer to the Earth's surface, however, west to east air movements are slowed down because of friction with the Earth. Therefore, as air, or wind, moves from areas of high pressure to areas of low pressure, the Coriolis effect still deflects the air to the right, but is less drastic. This results in a gentle clockwise spiraling effect of air flowing out of a high pressure area, and as it moves towards a low pressure area, it switches to a gentle counterclockwise direction as it flows around the area of low pressure. These areas of high and low pressure are continually spinning as they generally move from west to east across the Northern Hemisphere (Haggerty, 1985).

Not all of the great masses of warm air rising from the equator are affected by the Coriolis effect. Some of the rising air does make it to the poles. As the cold air gathers at the pole, it begins to slip toward the equator. Eventually there is a meeting of the cold air from the north and warm air from the south. As these two air masses meet along a frontal boundary, the weight of the cold air gently creates an isolated ripple or wave along the warm air mass. In this isolated wave, the warm air rises, creating a low pressure area, which begins to spin counterclockwise as the cold air continues to rush in behind the newly formed wave. Within this mass of colliding warm and cold air, warm fronts and cold fronts develop (Haggerty, 1985).

Warm and Cold Fronts

On the leading edge of the wave of warm air, a warm front develops. A warm front develops when a warm air mass rides up over the top of an air mass that is cooler than itself. As the warm air rises high into the atmosphere, it cools, water vapor condenses, and clouds and precipitation are typically formed. Simultaneously, as the warmer air begins to rise, as stated earlier, the atmospheric pressure and thus the barometer, will begin to fall. Warm fronts are typically followed by cold fronts. As the low pressure area spins along from west to east, in a counterclockwise direction, the cold air mass that gently formed the initial wave along the original boundary, now gains speed as it typically heads south and east, and slams into the back of the warm air mass. Since cold air is heavier and more dense than warm air, it violently forces the warm air mass immediately, and abruptly upward. The rapid cooling of the rising air typically spurs violent storms. In addition, the already gradually falling barometer because of the passing warm front, will now fall sharply, reflecting the abrupt rise in warm air, thus lowering the atmospheric pressure rapidly (Haggerty, 1985).

Additional Weather Variables

All of the rising warm air and falling cool air, which changes the atmospheric pressure, however, does not act independently, but rather, simultaneously with other weather related occurrences. Temperature has already been discussed. The heat of the sun bearing down on the equator causes large changes in temperature across the globe. The tilt of the Earth on its axis as it circles the sun is also responsible for these temperature changes. Air acts differently in the presence of varying temperatures. The effects of the changes in atmospheric pressure have already been discussed. In addition, as warm air rises, the molecules expand and cool, and therefore cause the water vapor in the air to condense and form clouds and precipitation. This is the scenario that is played out as a warm front approaches, and the warm air gradually rides up over a mass of cooler air. This also happens more abruptly as a cold front passes, when a mass of cold air slams into a mass of warm air, violently thrusting it upward. The opposite holds true for cool air. As cool air sinks to the Earth's surface, the molecules become more compressed, and therefore causes a warming effect which evaporates all of the moisture in the air and the result is clear skies. Relative humidity is a measurement that indicates the amount of unseen water vapor in the air. With an approaching warm front, because of the rising air cooling and condensing, the temperature and the humidity increase, as the atmospheric pressure decreases. Clouds also typically form (Haggerty, 1985).

History of the Barometer

Much has been said in regards to atmospheric pressure and how it fluctuates with changing weather systems, but how is atmospheric pressure measured? The Earth's atmosphere contains a substantial amount of weight, and that weight exerts a pressure on the Earth. "To measure atmospheric pressure is to weigh the great mass of air that presses down upon Earth" (Reynolds, 2000, p. 25). In 1643, a student of Galileo, Evangelista Torricelli, developed the first tool to measure the weight of the Earth's atmosphere. It was called the barometer.

One of the greatest obstacles of the 17th century was the fact that with the primitive pumps of the day, water could only be drawn up a well thirty-four feet. At the time, the existence of a vacuum was debated. Aristotelian theory believed nature did not allow for a vacuum to exist. Galileo proved that a vacuum could exist, but he didn't fully understand how it worked. In the case of the well water, the pumps of the day expelled the air from the top of the well casing, and thus created a vacuum. Galileo believed it was the vacuum at the top of the well casing, created by the pump, that exerted a pulling force on the water, and that pulling force of the vacuum could only support a column of water thirty-four feet tall. After Galileo's death, Torricelli proved that it was not the vacuum itself that pulled liquids to the top of a column, but rather it was the weight of the atmosphere pushing down on the liquid that allowed it to rise into the vacuum. In the interest of eliminating cumbersome apparatus for experimenting with thirty-four foot columns of water, Torricelli began experimenting with liquids that were heavier than water. With heavier liquids, the same effects occurred, only in proportion to their weight. One day Torricelli filled a three foot tube of glass with mercury. Presumably with his finger over the open end, he inverted it, and put the open end in a pan of mercury. Upon removing his finger, the mercury descended in the tube to a level of approximately thirty inches, and the modern barometer was born (Allen, 1983).

Mercury and Aneroid Barometers

Barometers can be broken into two categories, mercury and aneroid. Most modern mercury barometers are not much different than the original barometer created by Torricelli in 1643. Most consist of a glass tube filled with mercury, sealed at one end, and inverted in a pool of mercury. It was found that the amount of mercury in the pool affected the overall accuracy of simple barometers. Modern barometers, such as the Fortin type barometer, are designed to adjust the mercury level in the pool to a fixed point before a reading is taken (Blair & Fite, 1965).

Barometers can be read using three different units of measurement. The English system uses inches (in) to measure the column of mercury. At sea level at 45 degrees latitude, a mercury barometer will read 29.92 inches of mercury. The metric system uses millimeters (mm) to measure the height of the column of mercury. At sea level at 45 degrees latitude, a mercury barometer will measure 760 millimeters of mercury. A third measure of atmospheric pressure is expressed in bars. Rather than a linear measurement of mercury, bars indicate a direct measure of pressure. For use with barometers, millibars (mb), or one one thousandth of a bar, is the most useful unit of measurement. At sea level at 45 degrees latitude, the atmospheric pressure will measure 1,013.2 millibars (Blair & Fite, 1965).

Through the decades after the invention of the barometer, scientists labored to calibrate and develop consistency among the different types of barometers being invented. It was found that several corrections needed to be considered for truly accurate readings. Temperature affects the density of mercury so all mercury barometers need to be read and corrected to a standard temperature. Because the Earth is not a perfect sphere, the force of gravity is different depending upon a barometer's location on earth. Therefore, barometer readings must also be corrected based on latitudinal location. Also, altitude plays a factor in how a barometer reacts. For this reason, most barometric pressure readings are converted from their actual station pressure reading to a sea level reading (Blair & Fite, 1965).

A second type of barometer used is called an aneroid barometer. Aneroid barometers do not use mercury, but rather a flexible vacuum chamber supported by a spring. These flexible chambers respond to the changing atmospheric pressure conditions. Aneroid barometers eliminate the concern of temperature and gravity corrections, but readings still need to be converted from station pressure readings to the standard sea level pressure readings. One drawback to the aneroid barometer is its accuracy. Aneroid barometers should be checked frequently and calibrated with a more accurate mercury barometer (Blair & Fite, 1965).

A barograph, which was the instrument used in the researcher's study, is essentially an aneroid barometer. The flexible chamber is attached to an arm, which travels up and down according to the atmospheric conditions. The arm has a pen on the end, which records a constant record of the changing pressure on a revolving drum. The drum can be calibrated to make one full rotation in either a twelve or twenty-four hour time period. The paper on the drum is designed and calibrated to express the pen marks in inches of mercury. Once the station pressure values are obtained from the barograph, they simply need to be converted to standard sea level pressure readings. The barograph is a valuable tool for meteorologists to determine trends in changing atmospheric conditions.

<u>Student Behavior</u>

Most teachers envision their classrooms as highly disciplined, highly productive, smooth running operations. Although most teachers strive for this ideal daily, many will admit this is not always the case. There are a multitude of variables that come into play that may disrupt a teacher's ability to reach perfection in the classroom. In his book, *Maintaining productive student behavior*, Kevin Swick wrote the following.

> The teachers' approach to classroom management, understanding of human development, knowledge of cultural and value differences among children, and

> ability to accommodate these differences in the classroom are perceived by researchers to be a key factor in solving many behavior problems in the classroom. (1977, p. 11)

Swick reported the following causes of disruptive behavior among students.

1. Teacher – student value conflicts.
2. Physical, mental, and social status of students.
3. Lack of teacher training.
4. Negative influence of home and community environment.
5. Inexperienced teachers.
6. Malnourishment of children.
7. Differences between teacher expectations and student reactions.
8. Failure of teachers to recognize unique individual students (1977).

Swick offered important information to teachers about the causes of classroom discipline problems, but a more thorough study of group behavior is needed to explain why entire classrooms of students sometimes behave in a similar manner that is undesirable. A book written by Mary Bany and Lois Johnson entitled, *Classroom group behavior*, offers insight into the occurrence of students' behaviors in the classroom. "Although teachers plan well, some days are puzzling and frustrating because the class group as a whole reacts in undesirable behavior" (1964, p. 4). They go on to say there are many factors that may affect a group of students. "The study of group dynamics attempts to explain the changes that occur within groups as results of forces or conditions that influence groups as a whole" (1964, p. 17). Bany and Johnson identified certain properties that are common to all groups, including classroom groups, affecting their behavior. They include structure and interaction, norms and goals, cohesiveness, and communication (1964).

Many of the challenges faced by teachers in regard to disruptive behavior, stem from issues from within the group itself. For example, most elementary classrooms are set up by a formal educational system. However, within the formal setting, informal groupings of students develop as well. Each of the groupings may or may not value the goals and norms established by the school and the teacher. "This informal association of members provides many member satisfactions and dissatisfactions. The psychological member relationships affects morale, work operations, and member participation in the group" (Bany & Johnson, 1964, p. 40). According to Bany and Johnson's research, the more cohesive a group, the more productive they are. "Cohesive groups, because they function relatively free from dissention and conflict, have more time for work" (1964, p. 56). In order for a group to have a high level of cohesion, it must be attractive to the individual students. "For a class group to be attractive to the individual, it must satisfy personal needs for affiliation, acceptance, recognition, and security" (Bany & Johnson, 1964, p. 65). Cohesion in a group is in turn affected by the previously mentioned informal groupings that develop in classrooms. Although sub-groupings or cliques among students are normal, Bany and Johnson cautioned that, "…clique formation…will decrease the cohesion of the total group" (1964, p. 60). Bany and Johnson go on to write that, "Until stability is established, groups may be highly sensitive to influences that disrupt the normal routine" (1964, p. 335).

Bany and Johnson pointed out the relationship between cohesiveness and classroom disruptions. "Many of the group behavior problems teachers face in the classrooms are created by the same disruptive forces that impair group unity" (1964, p. 63). "In classroom groups that are highly cohesive, the children make greater efforts to agree and greater efforts to make changes toward agreement than do groups low in cohesiveness" (Bany & Johnson, 1964, p. 63). Teachers can develop more cohesion in their classrooms by stressing the value and personal satisfaction in working with a group, how their own needs may be met by being a part of the group, and using various cooperative learning techniques in the classroom (Bany & Johnson, 1964).

Bany and Johnson also stressed the role open communication plays in the overall behavior of students. "There is considerable evidence to substantiate the idea that communication plays a central role in determining the kind of behavior a class group will exhibit" (1964, p. 94). It is important for teachers to establish two-way communication with their classes to not only allow them to express themselves to the teacher, but also to each other. Bany and Johnson warned if this is not the case, "Such conditions are unfavorable to the curricular learning and very favorable to the development of many types of group and individual behavior problems" (1964, p. 113). In conclusion they wrote, " A teacher's job is not to restrict or prevent communication, but to see that communication patterns are developed that facilitate learning and promote good relations" (1964, p. 113).

Perhaps Kevin Swick is most accurate when he stated, "…there is no single cause or effect of disruptive behavior within the learning environment" (1977, p. 13). Most teachers recognize the external forces affecting their students' behavior and are continually working to improve them. However, in a sense, all the different factors that affect student behavior such as lack of cohesiveness, communication difficulties, cliques, and value differences occur everyday and become somewhat the norm in the day-to-day workings of a classroom. As teachers chip away everyday at these normal classroom occurrences, they are aware of something different that affects their students. It goes beyond communication, cohesiveness, cliques, and value systems. It is something that affects them collectively, making them behave in ways that cannot be readily explained. Could it be the weather?

Physiological Effects Of The Weather On Humans

There have been many studies (Landsberg, 1969; Tromp,1980) and much research into the physiological effects that changing weather has on the human body. Many theories have developed from these studies. One of the earliest scientists to study the effects of the weather on the human body was Dr. William F. Petersen. In 1935 he published his views in a book called, *The patient and the weather*. In his volumes, Petersen made reference to polar fronts, more commonly referred to today as cold fronts. He was convinced that the continuous cycle of passing warm and cold fronts affected the body. Peterson's research suggested that when a cold front approached and the atmospheric pressure began to fall, the blood vessels in the body contracted, reducing the amount of oxygen to the heart, brain, kidneys, and other major organs. In turn, blood pressure begins to rise and the end result is an overall stimulation of the body. To counter the reduced oxygen availability, the body releases substances into the blood to dilate the blood vessels, restore normal blood flow, and lower the body's blood pressure. Petersen explained this is why some people appear to be upbeat and excited one day, and the next day be relatively sluggish. Therefore, Petersen suggested that every passing weather system involves a period of stimulation. He was quick to point out however, that each individual's reaction to the weather may be different, and the frequency of the passing weather systems may also affect the way people react (Petersen, 1935).

Tromp, in his book, *Biometeorology: The impact of the weather and climate on humans and their environment,* echoed many of Petersen's claims about the body's reaction to atmospheric pressure changes. Much of Tromp's (1980) research was done on Native populations living in high or low elevations (and therefore low or high atmospheric pressure conditions), and also on subjects in pressure chambers.

> It is well known that in a man exposed to a low ambient pressure several physiological changes occur. His pulmonary ventilation increases. This process partially compensates the drop in oxygen tension from inspired to alveolar air and, consequently, allows a higher acquisition of this gas by the blood haemoglobin in the pulmonary bed. (1980, p. 75).

Although Tromp reported factual findings of the effects of low atmospheric pressure and the human body, he contradicted Petersen in the fact that the day-to-day physiological changes in the human body occur simply because of a change in atmospheric pressure. Based on his research, Tromp suggested, "that the rise in blood pressure is always associated with falling temperatures suggests that the barometric correlation is not a causal one" (Tromp, 1980, p. 111).

Tromp's findings run parallel with those of prominent meteorologist Dr. Helmut E. Landsberg (1969), who developed an ingenious system to classify weather patterns as they approach and leave areas. He broke the pattern into six phases, and each phase is characterized by consistent, factual, weather occurrences.

Phase I -- high pressure, cool temperatures, light to moderate winds, low humidity, few clouds.

Phase II -- high pressure, light winds, sunny clear skies.

Phase III -- slightly falling pressure, high clouds moving in.

Phase IV -- falling pressure, rising temperature and humidity, thickening clouds, rain or snow.

Phase V -- rapidly rising pressure, rapidly falling temperature, falling humidity, gusty winds.

Phase VI -- slowly rising pressure, low temperature and humidity, slackening winds. (Sherretz, 1984, p. 25)

Having a measurable system in place for comparative purposes, allowed Lansberg (1969) to collect data on a variety of different human behaviors. Landsberg found such things as people having slower reaction times during phases III, IV, and V, and normal to above normal reactions during phases I, II, and VI. He also found that more industrial accidents occurred during phases III, IV, and V. In addition, he observed people to be more irritable during periods of sustained temperature increases. Due to the number of existing characteristics for each weather phase, Landsberg suggested that there is more than one single weather factor that affects the human body. Landsberg wrote, "…pressure is merely an index for the whole system of weather patterns" (Landsberg, 1969, p. 96).

<u>Electromagnetic Waves And Rapid Atmospheric Pressure Fluctuations</u>

With many scientists acknowledging some relationships between human behavior and the weather through their research, scientists began to take a closer look at the weather. Landsberg turned his attention toward the study of electromagnetic waves produced by thunderstorms. As barometric pressure falls rapidly during the passing of a cold front, thunderstorms often erupt, and there is an overall increase in electromagnetic activity in the surrounding atmosphere. Landsberg stated, "One hypothesis surmises that there is an interaction between fluctuating electric fields and human brain waves" (1969, p. 94). During one of Landsberg's studies, twenty thousand visitors to a traffic exhibition in Germany were given reaction time tests over a ten-week period. When compared with his six weather phases, Landsberg found that reaction times were quicker during phases I and II, and slower during phases II, IV, and V (1969).

Supporting Landsberg's ideas is one of today's most prominent biometeorologists, Dr. Micheal Persinger of Laurentian University, Sudbury, Ontario. With a background in neuroscience and clinical psychology, Persinger has done thousands of tests with electromagnetic waves, similar to those associated with storms, and the reaction of the human brain. Persinger believes electromagnetic waves influence how human cells function. Critics say the type of waves associated with storms are too low in intensity to affect humans. Persinger maintains it is not the waves' intensity, but their frequency and shape that are important. "Sooner or later, the body's automatic nervous system, the bundles of nerves and fibers that control our bodies' internal workings, will respond to the faint but persistent barrage" (D'Agnese, 2000, p. 3). By applying faint electromagnetic pulses to the temporal lobes of his volunteer subjects, Persinger has been able to produce a variety of different moods from mild euphoria to depression (D'Agnese, 2000).

There have also been studies done on rapid air pressure fluctuations that were found to occur during passing warm and cold fronts. Barographs are instruments that record gradual increases and decreases in atmospheric pressure as weather systems move in and out of an area. A barograph was used by the researcher in this study. A variograph is a more sensitive type of recording barometer that is able to detect and record the rapid minute pressure fluctuations also associated with approaching weather systems. From an experiment done on over 200 people working in an insurance companies offices, Zurich physicist, Hans Richner, discovered that rapid pressure changes occurring longer than four minutes correlated highly with his subjects' reports of well-being and ailments. Although statistical significance was shown between human reactions and rapid pressure fluctuations, Richner could not be sure it was the pressure fluctuations alone that had caused the reactions (Rosen, 1979).

Richner's views are shared by another scientist studying the affects of pressure changes on the human body. Dordick dismissed daily pressure fluctuations affecting humans based on the results of people traveling up and down elevators of tall buildings. It was determined that people experience more of a pressure change from riding in the elevator of a tall building, than is typically experienced in a day being exposed to natural pressure changes brought on by passing weather systems. Dordick then turned her attention to the small rapid pressure fluctuations also associated with passing weather systems. Her experiments involving the exposure of human subjects to a variety of rapid pressure fluctuations failed to turn up any conclusive evidence. "The small scale pressure oscillations of relatively small amplitude and short period, cannot be considered as exerting any unequivocal biological influence on humans" (Dordick, 1958, p. 363).

However, in a small article entitled, *Got the bad weather blues?,* Geographical Magazine reported that researchers at Kiev University found that rapid atmospheric pressure perturbations (APP's) can affect heart rate and mental ability. In an experiment using 12 volunteers, researchers found a controlled air pressure pulsation twice a minute improved the subjects' ability to recall objects and proof read texts. They believed the body senses atmospheric pressure and changes blood pressure, which in turn affected neural activity (Got the bad weather blues?, 2000, p. 79).

Studies Involving School Children and the Weather

There have been several studies that have made reference to the affect the weather has on school children. Landsberg found that school children performed better in classrooms in which climate conditions were controlled. He especially found this to be true when air conditioning was needed (1969). Tromp, who is a firm believer in the affects of temperature on humans, indicated that, " Unrest before thunderstorms is probably not due to changes in electric conditions in the atmosphere but due to the accompanying thermal stresses (heat and humidity) which affect the inefficient thermoregulatory system of young children" (Tromp, 1980, p. 231).

One of the earliest known studies on the subject was done by a public school teacher in Denver, named Edwin Dexter, around the time period of 1900. Dexter studied occurrences of murders and suicides in the Denver area, as well as records of corporal punishments in area schools. In a study that lasted eighteen years, Dexter determined that there was an above average number of disciplinary problems on days when the winds were high and barometric pressures were abnormal (Sherretz, 1984).

In 1964, George Brown published a study in the Journal of Educational Research, which looked at barometric pressure and relative humidity, and classroom behaviors of students. Brown's study included forty-seven different teachers' observations of their classes over a four-week period in November of 1959. Brown found a high level of significance for restless behavior of students on days when the relative humidity was high, and the barometric pressure was low (Brown, 1964).

Although the findings of various research on the subject of how the weather affects humans is often contradictory, there has been enough evidence to warrant researchers to continue investigating the subject. Because of the researcher's past teaching experience and from experiences relayed by other teachers, and because of such studies such as Brown's, the researcher was compelled to collect empirical data to try to determine if in fact atmospheric pressure changes could be used as an indicator to predict student behavior.

CHAPTER III

Methodology

Introduction

This chapter will contain information regarding the subject selection, instrumentation, data collection, and data analysis performed. The chapter will conclude with a discussion of the assumptions and limitations regarding the subject selection, instrumentation, and data collection.

Subject Description

For ease of data collection, the subjects were chosen from the site at which the researcher was doing his elementary counseling practicum experience. Selection of subjects was based primarily on grade level rather than gender or any other type of demographic information. Teachers were chosen as the subjects for this study because they spend the most time with the students everyday, and are usually most capable of detecting a change in their students' behavior. Subjects were made aware of the nature of the study in the hopes of calming their fears that they were being watched and their performance being judged.

Sample Selection

A cluster sample of Woodland Elementary School teachers were used for this study. A total of twenty-two teachers participated in the study. For data analysis purposes, no multi-age or elective classrooms such as music, art, and physical education were included in the study.

Instrumentation

Two instruments were used in the execution of this study. They included a microbarograph and a Likert scale. The microbarograph is a recording barometer that was placed in the school's office. It was kept in the same place for the duration of the study. The Likert scale was based on five varying degrees of behavior. One indicated lethargic behavior, three indicated average behavior, and five indicated excitable behavior. Refer to Appendices A, B, and C for the instrument and data collection forms.

Data Collection

Based on the data collected, trends of the barometric pressure changes were calculated each day between the hours of 8 a.m. -10 a.m., 10 a.m. - 12 p.m., and 1 p.m. - 3 p.m., throughout the course of the four-week study. The microbarograph was calibrated at the beginning of each day with a barometric pressure reading for the area, taken from the National Weather Services website. Since the microbarograph's paper drum was only designed to record station pressure, the calibrated sea level reading taken from the website had to be converted, using a pressure reduction computer, into a station pressure reading, based on Barron, Wisconsin's elevation above sea level. After the data was recorded by the microbarograph, the station level pressures had to be converted back to the more commonly reported sea level pressure readings.

The subjects in the study were given weekly booklets containing three Likert scales per day, for a total of fifteen readings per week. Subjects recorded their observations of the students between the hours of 8 a.m. - 10 a.m., 10 a.m. - 12 p.m., and 1 p.m. - 3 p.m., by circling a value on the appropriate Likert scale.

Data Analysis

The daily barometric pressure readings were graphed by the microbarograph to indicate the rising or falling trends in the atmospheric pressure. The Likert scale readings were averaged daily for each of the three readings. The averages were then analyzed with the amount of corresponding barometric pressure change. Analysis of variance was used to determine whether there was significance in the results.

Assumptions

The following assumptions were made in regard to the data collection for this study.

1. All of the subjects would take the readings at the precise time indicated.

2. Subjects would remain objective in their observations despite knowing the nature of the study.

3. All subjects would be present each day for the duration of the study.

4. There would be measurable changes in the barometric pressure.

Limitations

The following limitations existed in regard to the data collection for this study:

1. The Likert scale being used was not tested for reliability or validity.

2. The microbarograph being used was very basic and subjectively read, therefore subject to human error.

3. There were gaps in the data created by subject absenteeism.

4. The subjects selected were not representative of all elementary teachers.

CHAPTER IV

Results

This chapter will present the results of the study comparing barometric pressure changes with observed classroom student behavior. The demographic information and descriptive statistics will be reported first. Data collected on the research hypothesis will then be given.

Demographic Information

The study was conducted in the Midwest community of Barron, Wisconsin. The population of the community is approximately 3,000 residents. Woodland Elementary was chosen as the site for the study. Woodland Elementary is a K-5 school with just over 400 students enrolled at the school. There were a total of twenty-two teachers who participated as subjects for this study. There were three kindergarten, three first grade, four second grade, four third grade, four fourth grade, and four fifth grade teachers at each grade level. There was 100% participation among K-5 classroom teachers. Twenty of the subjects were female, and two of the subjects were male.

Daily Barometric Pressure Changes and Average Classroom Behavior Ratings

The raw data did reveal some notable findings (Table 1). On Tuesday (10/2) of the fourth week, the only cold front of the four week study moved through the area, and the barometric pressure dropped its greatest amount (.23 in. of mercury). On Wednesday (10/3), the overall average of the teachers' ratings was the highest of the four week study, indicating a tendency toward excitable behavior. This is concurrent with the findings of Brown's (1964) study.

Hypothesis

There will be no relationship between student behavior as assessed by teachers and barometric pressure fluctuations. Analysis of variance was run on the data. Results of the analysis indicated there was no significance ($F=1.392$; $p=.13$). Therefore, the researcher did not reject the stated null hypothesis.

TABLE 1
DAILY BAROMETRIC PRESSURE CHANGES & AVERAGE CLASSROOM BEHAVIOR RATINGS

DATE	Change in Pressure 8am-3pm	Overall K-5 Behavioral Rating	K Behavioral Rating	1 Behavioral Rating	2 Behavioral Rating	3 Behavioral Rating	4 Behavioral Rating	5 Behavioral Rating
9/10	0.17	3.0758	3	3.7778	3	2.75	3.0833	3
9/11	-0.16	3.3485	3.3333	4.3333	3.4167	3.0833	2.8333	3.3333
9/12	0.06	3.5227	3.1667	4.6667	3.375	3	3.625	3.5
9/13	0	3.4394	3.3333	4.2222	3.3333	3.6667	3	3.25
9/14	-0.11	3.3939	3.1111	4.1111	2.9167	4.0833	3	3.25
9/17	0	3.1746	3.5556	3.2222	3.25	3.4167	2.6667	2.9167
9/18	-0.05	3.3968	3.3333	4.1111	3.5	3.5833	2.6667	3.1667
9/19	-0.02	3.4762	4.3333	3.4444	3.25	3.75	3	3.1667
9/20	-0.08	3.5455	3.1111	3.5556	3.5833	3.9167	3.5833	3.4167
9/21	0.02	3.4561	3.1111	3.7778	3.25	3.8333	3.1667	3.4444
9/24	-0.04	3.254	3.4444	3.8889	3.1111	3.0833	3.0833	3.0833
9/24	-0.13	3.2857	3.3333	3.4444	2.8889	3.5	3.5833	2.9167
9/26	-0.08	3.2917	2.8889	4	2.8889	3.4444	No Data	3.25
9/27	0	3.2879	3.4444	3.6667	3.3333	3	2.9167	3.5
9/28	-0.02	3.5455	3	4.2222	3.75	4.1667	2.75	3.4167
10/1	-0.09	3.05	3	3.1111	2.9167	3	2.3333	3.75
10/2	-0.23	3.5088	3.2222	4.1111	3	3.5833	1.6667	4.1667
10/3	0.1	3.6349	3.4444	4.2222	3.4167	3.9167	2.8889	3.8333
10/4	0.01	3.4697	3.5556	4.1111	3	3.6667	3.25	3.4167
10/5	-0.05	3.3833	3.3333	3.8889	3.4444	3.25	3.1667	3.3333

CHAPTER V

Discussion, Conclusions, and Recommendations

Introduction

This chapter will include a discussion of the results of the study and conclusions. The chapter will conclude with some recommendations for further research.

Discussion

Based on the complexity of the topic being researched, the results of various studies have been contradictory. Although early studies done by Dr. William Petersen indicated that the body continually reacts to rising and falling atmospheric pressure by restricting and dilating blood vessels, and therefore producing a drowsy or stimulated cycle of behavior, this was refuted by the studies by Tromp (1980). Although Tromp recognized the physiological changes in humans brought on by changes in pressure, he believed more of the body's reactions occurred due to a change in temperature and not atmospheric pressure. With the development of Landsberg's (1969) six weather phases, the consensus among scientists seemed to agree that no individual weather occurrence such as humidity, temperature, pressure, and wind occurred independently of the other. Landsberg wrote, "…pressure is merely an index for the whole system of weather patterns" (Landsberg, 1969, p. 96).

Scientists continued to try to determine an independent variable related to the weather that caused behavior changes in humans. Landsberg (1969) also acknowledged the existence of electromagnetic waves associated with approaching storms. Although he could not prove the actual electromagnetic waves produced the results, one of his studies did show significant behavior changes in humans during the weather phases that would also most likely contain increased amount of electromagnetic waves. Dr. Michael Persinger (cited in D'Agnese, 2000) has set out to prove electromagnetic waves produce a mood change in humans. He has conducted thousands of studies which have given him evidence to show that the electromagnetic waves associated with approaching weather systems can produce a change in human behavior.

Yet another area of research focuses in on the small rapid pressure fluctuations also brought on by approaching weather systems. Scientists such as Dordick (1958) refute normal day-to-day pressure fluctuations produce any notable change in humans because people are exposed to greater pressure changes everyday riding elevators and no changes seem to occur. Dordick failed to find any conclusive evidence that even the small rapid pressure fluctuations associated with storms produces any noticeable change in humans. However, a recent study reported by researchers at Kiev University (Got the bad weather blues?, 2000) found that small rapid air pressure pulsations produced noticeable affects on the subjects they studied.

Research done in schools with students have also produced mixed results. Tromp (1980) maintained it is the change in temperature, not the change in pressure or electromagnetic fields that produce restlessness in children. In 1964, Brown conducted a study that resulted in significant behavior changes in students when the relative humidity was high and the barometric pressure was low.

Conclusions

The contradictory results from the various studies over the years has led the researcher to two conclusions. First, is that the subject area being studied is very complex and has a multitude of variables, and second, there is more research to be done in this field. Although it is highly recommended that researchers consider more than one weather variable, this study dealt with barometric pressure because of its proven indication that other variables are also present based on its configuration. The purpose of this study was not to determine if barometric pressure is specifically responsible for behavior changes in children, but rather that it can be used as a reliable indicator of behavior changes that many teacher will acknowledge occurs when the weather changes.

Recommendations for Further Research

Several suggestions are offered for further research on barometric pressure changes and student behavior. These are:

1. This study occurred during a very quiet weather pattern in September and October. A study lasting longer than four weeks would give future researchers more data and more of a variety in weather.

2. Involve more subjects from different schools and more grade levels.

3. Obtain a recording barometer that requires minimal calibration so there is a less likely occurrence of human error.

4. Subjects should only rate their classes once at the end of each day rather than three times per day.

5. Using a more sensitive recording barometer, such as a variograph, would give future researchers a better idea of not only gradual changes in barometric pressure, but also data on the small rapid pressure fluctuations referred to by Richner (cited in Rosen, 1979; Dordick, 1958).

6. Future researchers should collect more weather related data such as temperature, humidity, cloud cover, and wind speed.

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Appendix A
Subject Data Collection Form

Name____________________ Grade_______________ Week___________

Monday:

	lethargic		normal		excitable
8:00 a.m. - 10:00 a.m.	1	2	3	4	5
10:00 a.m. - 12:00 p.m.	1	2	3	4	5
1:00 p.m. - 3:00 p.m.	1	2	3	4	5

Tuesday:

	lethargic		normal		excitable
8:00 a.m. - 10:00 a.m.	1	2	3	4	5
10:00 a.m. - 12:00 p.m.	1	2	3	4	5
1:00 p.m. - 3:00 p.m.	1	2	3	4	5

Wednesday:

	lethargic		normal		excitable
8:00 a.m. - 10:00 a.m.	1	2	3	4	5
10:00 a.m. - 12:00 p.m.	1	2	3	4	5
1:00 p.m. - 3:00 p.m.	1	2	3	4	5

Thursday:

	lethargic		normal		excitable
8:00 a.m. - 10:00 a.m.	1	2	3	4	5
10:00 a.m. - 12:00 p.m.	1	2	3	4	5
1:00 p.m. - 3:00 p.m.	1	2	3	4	5

Friday:

	lethargic		normal		excitable
8:00 a.m. - 10:00 a.m.	1	2	3	4	5
10:00 a.m. - 12:00 p.m.	1	2	3	4	5
1:00 p.m. - 3:00 p.m.	1	2	3	4	5

Comments

Appendix B
Barometric Pressure Reading Data Collection Form

Barometric Pressure Recordings
Week ______

Monday

8:00 a.m.	10:00 a.m.	12:00 p.m.	1:00 p.m.	3:00 p.m.

Tuesday

8:00 a.m.	10:00 a.m.	12:00 p.m.	1:00 p.m.	3:00 p.m.

Wednesday

8:00 a.m.	10:00 a.m.	12:00 p.m.	1:00 p.m.	3:00 p.m.

Thursday

8:00 a.m.	10:00 a.m.	12:00 p.m.	1:00 p.m.	3:00 p.m.

Friday

8:00 a.m.	10:00 a.m.	12:00 p.m.	1:00 p.m.	3:00 p.m.

Appendix C
Five Point Likert Scale

Five Point Likert Scale

The Likert scale for this study has been set up on a continuum, with slow, lethargic behavior indicated by one, average, or normal behavior indicated by three, and energetic behavior indicated by five. Teachers will observe their classes between 8a.m. - 10 a.m., 10a.m. – 12 p.m, and 1p.m. – 3p.m., and then give their class a rating by circling a number on the Likert scale for the appropriate time period. Each teacher will take three readings per day for a total of 15 per week. The study will last for four weeks for a total of 60 readings.

1	2	3	4	5
lethargic behavior		average or normal		energetic behavior