Relationships Between Meteorological Variables and Academic Performance and Behavior in Children with Autism

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ABSTRACT

Professionals working with children in educational settings have made inferences that weather variation has an effects student behavior and performance. Scant research supports that some meteorological variables have relationships to student behaviors in neurotypical adults and children. No research to date has investigated the relationships between meteorological variables and the behavior and academic performance of individuals with autism spectrum disorders (ASD).

Two boys and one girl with ASD took part in this study (ages=8 and 5). Daily observational data were collected on targeted behaviors and academic performance tasks for each student for one hour in the morning. Meteorological data concerning barometric pressure, humidity, moon illumination, and temperature were collected from the national weather service for the time period of observation. Data for target behaviors and academic performance tasks were compared to meteorological variables using scatter plots for identification of existing relationships.

Results indicated no significant relationships between student behavior and academic variables and meteorological variables. Some weak relationships were identified that indicate this area requires additional investigation to identify any relationships that could be generalized to the population of individuals with ASD.

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Chapter 1

Introduction

Individuals with Autism Spectrum Disorders (ASD) exhibit a wide variety of diagnostic characteristics (Simpson & Myles, 2008), including noteworthy features identified in the widely used *Diagnostic and Statistical Manual of Mental Disorders IV-TR* (DSM-IV-TR, American Psychiatric Association, 2000). Meeting the DSM-IV-TR diagnostic criteria for ASD (pervasive developmental disorder, per DSM diagnostic terminology) requires the presence of: (a) a qualitative impairment in social interaction; (b) a qualitative impairment in communication; (c) restricted, repetitive, and stereotyped patterns of behavior, interests, and activities; (d) delays or abnormal functioning in at least one of three areas (social interaction, language used in social communication, or symbolic or imaginative play), with an onset before age 3; and (e) disturbance not better accounted for by Rett's syndrome or childhood disintegrative disorder (DSM IV, 2000). Although the DSM IV-TR does not specifically mention hyper- and hypo-sensitivity to sensory stimuli as a criteria for an autism diagnosis, theories of autism indicate that atypical sensory experiences and reactions are core symptoms of ASD and affect the perceptual abilities of individuals with autism related disorders(Ben-Sasson et al., 2009; Bertone, Mottron, Jelenic, & Faubert, 2005; Happe, 2005; Just, 2004; Lane, Young, Baker, & Angley, 2010; Mottron & Burack, 2001). Theories relating to the causes of atypical behaviors of individuals with ASD are based on observations of hypo- and hyper-arousal (Hutt, Hutt, Le, & Ounsted, 1964) and unusual reactions to sensory input (Kootz, Marinelli, & Cohen, 1982; Lane et al., 2010; Ornitz, 1974; Ornitz, Guthrie, & Farley, 1977), as well as evidence of atypical physiological, attentional, and neurological responses to sensory tasks (Hermelin & O'Connor, 1970; Hutt et al., 1964; Lane et al., 2010; Ornitz, 1974). Additionally, families of children with

ASD report that overall functional abilities of individuals with ASD are affected by individuals' need to seek sensory stimuli, to avoid certain types of sensation, or failure to notice sensory cues (Dunn, 2002, 2008; Dunn, Myles, & Orr, 2002; Kientz & Dunn, 1997). In firsthand accounts, adults with ASD describe how sensory processing difficulties adversely affected their lives (Grandin & Scariano, 1986; Williams, 1992, 1994). Accordingly, in light of the sensory processing deficits specific to this population, environmental sensory stimuli might influence daily functioning and performance of students with ASD.

Background and Context for the Present Study

The general purpose of this study was to determine if relationships exist between various meteorological factors and the academic and behavioral performance of students with ASD. These meteorological factors are environmental stimuli and include barometric pressure, temperature, moon illumination, and humidity.

Professionals who taught or otherwise worked with students with regularly perceived and reported that difficulties in academic and behavioral performance were associated with or influenced by meteorological variables and related factors, including storms, moon phases, precipitation, and changes in barometric pressure (Essa, Hilton, & Murray, 1990). While responses to meteorological events among students are thought to be common, little research has been done to determine if there is a direct link between student behaviors and specific weather and related factors. Much of the assumed association between weather and human behavior has been based on anecdotal and non-empirical observation and intuition.

Research has suggested that weather is associated with emotions, mood, and behavior in adulthood (Lagacé-Séguin & d'Entremont, 2005). Seasonal affective disorder has been linked to anxiety, depression, and negative emotional states overall (Rohan & Sigmon, 2003; Soames, 2003; Wilson, 2002). Such weather and seasonal factors have been thought to influence childhood behavior, performance, and emotions by those working with children. However, little is known about these potentially significant factors relative to the functioning of students with ASD. Scientific investigations of this potentially significant explanation for children's behavior have been overlooked, including the impact of weather patterns on academic performance and behavior.

Studies of biometeorology comprise the majority of the relevant literature concerning the influence that weather has on human behavior (Essa et al., 1990). Biometeorology is the study of the atmosphere and life processes (Essa et al., 1990). Studies within this discipline generally focus on health-related issues, such as migraine headaches, strokes, epilepsy, and heart attacks, but fail to explain common, everyday affect and behavioral changes that might be modulated by current weather patterns (Essa et al., 1990). As previously noted, results in the literature linking weather with childhood emotions and behavior are extremely limited and specific studies on students with ASD are nonexistent.

Biometeorological pioneer Volker Faust and his colleagues found that a sizable portion of Swiss adolescents noted complaints related to the weather including changes in energy level and mood (Faust, Weidmann, & Wehner, 1974). Howarth and Hoffman (1984) found that high humidity levels and low barometric pressure might negatively affect children's abilities to focus in the classroom; and Clarke (1967) found that delinquent acts are directly related to meteorological fluctuations such as daylight hours, temperature, and sunshine. Essa et al. (1990) reported that preschool children showed an increased interaction with in-class materials during times when the weather was stable. When the weather was inclement the children interacted more with peers and adults. In addition, researchers in one study found that various specific positive emotions correlated with calmer and more pleasant weather conditions over a 33-day period (Lagacé-Séguin & Coplan, 2001). Inclement weather was found to have a positive association with negative mood variables in the same study. Lagacé-Séguin & d'Entremont (2005) reported a positive relationship between humidity and externalizing problems and a negative relationship between humidity and prosocial behavior (2005). The pattern of results in these studies suggests that inclement weather is associated with problematic behaviors in childhood (Lagacé-Séguin & d'Entremont, 2005).

Considering this limited research, it is logical to assume or at least speculate that weather factors could influence students with ASD. This contention is based on the fact that individuals with ASD are often hypersensitive to change and apt to be hyper and hypo sensitive to sensory stimuli (Dunn, 2008).

Research Questions

Using objectively measured and reliable daily meteorological data and daily academic performance and behavioral data on students' with ASD in a public school setting, the following research questions were addressed:

Q1: What is the relationship between meteorological conditions, including barometric pressure, humidity, moon illumination, and temperature, and students' daily academic and behavioral performance of students with ASD?

Specific questions include:

Q1a: What is the relationship between barometric pressure and academic performance and classroom behaviors of students with ASD?

Q1b: What is the relationship between humidity and academic performance and classroom behaviors of students with ASD?

Q1c: What is the relationship between moon illumination and academic performance and classroom behaviors of students with ASD?

Q1d: What is the relationship between temperature and academic performance and classroom behaviors of students with ASD?

Data were collected on the temperature, moon illumination, humidity, and barometric pressure each day at a specified hour for an 8-week period to aid in the exploration of these research questions. These meteorological data were then compared to behavioral and academic performance data collected during the corresponding 1 hour time period for three students with ASD in a special education classroom to determine if there was a relationship between student and meteorological data.

Chapter 2

Review of the Literature

The purpose of this study is to determine if relationships exist between various meteorological factors and the academic and behavioral performance of students with autism spectrum disorders (ASD). These factors included barometric pressure, temperature, moon illumination, and humidity.

Relevant literature exists that established that individuals with ASD process sensory stimuli differently than neurotypical individuals (Adrien et al., 1987, 1992, 1993; Baranek, 1999; Dahlgren & Gillberg, 1989; Kientz & Dunn, 1997; Ornitz, 1989; Ornitz et al., 1993; Osterling & Dawson, 1994). Children with ASD often have a disrupted balance between sensory functions which precipitates unusual behaviors as they try to generate appropriate responses with distorted information (Dunn, 2008). Common environmental stimuli that go unnoticed by neurotypical individuals may elicit behavioral reactions and sensory processing difficulties in individuals with ASD (Dunn, 2008). Additionally, individuals with ASD often exhibit persistent behaviors that interfere with learning and daily functioning (Boyd & Corley, 2001). These behaviors, in turn, put a child at risk for issues including poor social adjustment (Hartley et al. 2008) and limited access to less restrictive placements (Horner, Carr, Strain, Todd, & Reed, 2002). Due to the sensitive and vulnerable nature of individuals with ASD, meteorological variables could have a greater affect on their daily functioning and behavior than on those without ASD. The amount of established research on the affect of meteorological variables on human behavior is limited; however, evidence exists to support the concept that some variables did influence behavior in adults (Moos, 1976; Sanders & Bizzolara, 1982). Researchers have found links between variables such as barometric pressure, temperature, and humidity and behaviors including aggression, suicide, drug use, and cooperation as well as effects on concentration, mood, anxiety, depression, fatigue, and optimism (Howarth & Hoffman, 1984; Rohan, & Sigmon, 2003; Sanders & Brizzolara, 1982; Whitton et al., 1984; Wilson, 2002)

Sensory Processing and Students with Autism Spectrum Disorders

Sensory processing, taking in and determining the meaning of sensations, takes place within the nervous system (Kandel, Schwartz, & Jessell, 2000; Miller, 2000). The nervous system uses sensory information to process and relate information about the body and the environment, thereby allowing individuals to understand their bodies and their contexts (Coren, Porac, & Ward, 1984). According to Dunn (2008), the nervous system has seven sensory systems that provide information: olfactory (smell), gustatory (taste), tactile (touch), visual (vision), auditory (hearing), vestibular (movement), and proprioceptive (body position). Olfactory and gustatory senses provide information to the central nervous system about smells and tastes in the environment through the nose and tongue. The olfactory system has the potential to establish emotions and associations and can quickly increase a person's level of responsiveness, while the gustatory system provides information about tastes and textures, often leading to food preferences (Dunn, 2008). The tactile sense is located in the skin and provides information necessary to know the boundary between the body and the outside world (Dunn, 1991a, 1997b). This system assists individuals in building a body map to plan movements that will be precise and useful when engaging in activities (Kolb & Whishaw, 1996). The visual system supports other sensory systems in verifying sensory experiences as the eyes continuously change position to activate new cells in the retina and continually gather information (Dunn, 2008). The auditory system processes sound and primarily facilitates communication. This system also filters information so that attention is paid to more important sounds in the environment and less important sounds are screened out (Dunn, 2008). The movement or vestibular system provides constant and ongoing information via the middle ear about how the body interacts with the environment. It assists an individual to orient in space and time (Dunn, 2008). Lastly, the proprioceptive or body position system gathers sensory information from the muscles, tendons, and joints and in conjunction with the vestibular system automatically maintains postural control even while attention is focused elsewhere (Dunn, 1991a; Kornhuber, 1974).

Sensory processing knowledge is grounded in neuroscientific principles (Kandel et al., 2000). This knowledge provides a way to apply basic science to understanding human behavior (Ayers, 1972; Dunn, 1997b). The function of the sensory system is to supply the brain with information about our bodies and the world around us (Dunn, 1991, 1997a). “Brain maps” formed from this information allow individuals to be oriented in space and time in order to make appropriate decisions about actions (Dunn, 2008). Knowledge of how the central nervous system operates with regard to intersensory integration, modulation, central nervous system motivation, and homeostasis is helpful in interpreting the behavior and needs of children with ASD (Huebner & Dunn, 2001).

Intersensory integration is the brain’s ability to organize information from several sources simultaneously (Dunn, 2008). Children’s responses to single sensory modalities can appear overactive or underreactive relative to input (Dunn, 2008). Intersensory integration allows the brain to wait for verification from other senses before responding (Dunn, 2008). For example, a child who is touched typically looks towards whatever touched them before they respond. This adds visual input to the touch input to form an appropriate response, not just a reaction to one sensation (Dunn, 1991b). According to Dunn (2008), when children with ASD react too quickly in a situation they may be responding to one sensation without the benefit of intersensory integration allowing the input of information from other senses. Additionally, children with ASD may also seem unaware of relevant stimuli, distorting their response due to the lack of complete sensory information (Dunn, 2008). The integration of sensory information supports development of complex maps of the body and environment which, in turn, enables an individual to interact appropriately in various situations (Huebner & Dunn, 2001).

The nervous system also operates on complementary functions of excitation and inhibition (Kandel et al., 2000). Some parts of the brain initiate movement while other parts stop or control the amount of movement (Dunn, 2008). Typically, the brain uses modulation to balance excitation and inhibition (Berkson, 1996; Guess & Carr, 1991) Throughout the day individuals are bombarded with sensory stimuli and the brain determines which stimuli require attention and response and which stimuli can be safely ignored (Dunn, 1997b). Children with ASD exhibit behaviors that can be attributed to an imbalance or poor modulation in the central nervous system (Berkson, 1996; Guess & Carr, 1991). Individuals who are distractible may have difficulty because they are constantly attending to too many available stimuli in the environment. Excessive excitement in the central nervous system might lead an individual to take more notice of sensory input than is necessary for everyday activities (Dunn, 2008). Other children may fixate on one stimulus while ignoring other important stimuli, such as someone calling their name (Dunn, 2008). In this example, too much inhibition or inadequate excitation from other sources also interferes with engagement (Dunn, 1997b).

According to Dunn (2008), in order to perform tasks the brain must internally recognize some need such as hunger, cold, desire, or social interest; at the same time the external environment must provide adequate cues to enable desired performance. The central nervous system is motivated to meet internal needs. These needs arise because the system has moved away from a comfortable state called *homeostasis* (Dunn, 2008). The central nervous system is motivated to return to homeostasis because it represents a calm, predictable, and safe state (Dunn, 2008). Often-observed persistent behaviors of students with ASD (e.g. rocking, banging, or flicking lights) can be attributed to the central nervous system's motivation to reestablish homeostasis. In these instances other activities, such as conversing, diminish as the primal motivation to return to homeostasis is strong and prevails over other activities (Berkson, 1996; Guess & Carr, 1991)

The central nervous system has thresholds which dictate the amount of stimuli needed to notice or react to stimuli (Dunn, 1997a). Sensory input accumulating below a threshold will not stimulate a response or action, while input at or above a threshold will lead to an action or response (Dunn, 2008). Children's participation capacities can be affected by their variability in thresholds based on physiological states and within particular sensory systems. There must be a balance of action related to central nervous system thresholds. Low thresholds result in children responding too frequently to stimuli and being highly distracted from everyday tasks. When thresholds are too high, individuals tend to miss important stimuli about what is going on in their environment and thus may appear oblivious or self-absorbed (Dunn, 1997a).

All sensory systems bring information from the world to the brain for processing and this process has multidimensional features to help individuals understand responses (Dunn, 2008). Each sensory system transmits information to the brain to generate awareness, (arousal or alerting) and to gather information to construct maps of self and the environment (discrimination and mapping) that help the brain organize this data and plan responses (Royeen & Lane, 1991). Typically, the arousal/alerting and discriminating/mapping functions complement each other to support participation. Working together these functions allow individuals to interact with their environment and effectively organize responses, all the while primed to notice potentially harmful stimuli (Royeen & Lane, 1991). This balance requires constant assessment of sensory input so that all potentially important stimuli are noticed without interfering with purposeful activity (Dunn, 1991a). Children with ASD often have a disrupted balance between arousal/alerting and discriminating/mapping functions which precipitates unusual behaviors as they try to generate appropriate responses from distorted information (Royeen & Lane, 1991).

Dunn (1997a) proposed a four-component model of classifying patterns of sensory difficulties according to behavioral responses to stimuli, which included low registration, sensation seeking, sensory sensitivity, and sensation avoiding. Individuals thought to fall in the low registration sensory pattern notice things in the environment less than other children (Dunn, 2008). Not noticing things can also mean that they do not respond to their name, may seem disconnected during activities, and have a more difficult time completing tasks in a timely manner (Dunn, 2008). An individual considered to have the sensory seeking processing pattern enjoys sensory experiences and may move a great deal throughout the day. That individual's interests and pleasures in sensory events might lead to difficulties with task completion because of the distraction created by new sensory experiences and the subsequent inability to keep track of daily-life tasks (Dunn, 2008). The sensory sensitivity pattern of sensory processing describes an individual who notices things in the environment more than others (Dunn, 2008). These individuals are more easily distracted and bothered by external stimuli than their peers. Consequently, they are distracted more often, making it difficult to complete tasks in a timely manner (Dunn, 2008). Finally, individuals who fall within the sensory avoiding subtype both notice and are bothered by sensory experiences much more frequently than others and thus actively avoid sensory experiences. These individuals might be more isolated and interested in being alone or in quiet places (Dunn, 2008). In environments that are too overwhelming with sensory experiences these individuals may withdraw and not complete activities in daily life (Dunn, 2008).

Research has shown that up to 95% of children with autism have some degree of sensory processing difficulty compared to 16% of typically developing children (Tomchek & Dunn, 2007). Other studies have estimated that the prevalence of sensory processing difficulty in children with autism ranges between 69% and 95% (Baranek et al., 2006; Schaff & Benevides, 2007; Tomchek & Dunn, 2007). Baker et al. (2007) found that poor sensory processing ability was associated with higher levels of behavioral and/or emotional problems for students with ASD. Additionally, a moderate correlation was found between decreased functioning in the area of daily living skills and poor sensory processing ability (Baker et. al., 2001). Children with an over-responsivity to tactile input are more likely to display extreme anxiety, distractibility, inflexible behaviors, repetitive verbalizations, social withdrawal, and abnormal focused attention (Baranek, Foster, & Berkson, 1997; Grandin, 1995).

Lane et al. (2010) investigated the relationship between sensory processing patterns and subtypes and adaptive behavior. Overall, the results of the study were mixed, but a clear predictive association between sensory processing patterns, communication performance, and general maladaptive behavior was revealed (Lane, Young, Baker, & Angley, 2010). In this study, processing function in individuals accounted for 50% of the variability in maladaptive behaviors, suggesting a strong predictive association between processing difficulties and presence of maladaptive behaviors (Lane et al., 2010). This study found three sensory processing subtypes: sensory-based inattentive seeking, sensory modulation with movement sensitivity, and sensory modulation with taste/smell sensitivity (Lane et. al., 2010). Based on a comparison of these subtypes to adaptive behavior, researchers concluded that difficulty in sensory modulation without movement elements was predictive of communication impairments, and general sensory modulation difficulties were predictive of maladaptive behavior (Lane et al., 2010).

Behavior Problems and Students with Autism Spectrum Disorders

The DSM-IV-TR diagnostic criteria for ASD include the presence of restricted, repetitive, and stereotyped patterns of behavior (DSM-IV, 2000). Individuals with ASD have varied and often persistent behavioral challenges that impede their daily functioning (Boyd & Corley, 2001). Additionally, children with ASD can display irritability that is manifested in aggression toward others, deliberate self-injurious behavior, temper tantrums, and quick changes in mood (Gabriels, Cuccaro, Hill, Ivers, & Goldson, 2005; Johnson, 2007). Aggressive behaviors might be used by individuals with ASD as a form of communication (Holden & Gitlesen, 2006). This is especially significant for children with ASD because of their expressive language deficits (Mitchell et al. 2006).

Challenging behaviors exhibited by individuals with ASD cause distress for both the child and the family (Dominick, Davis, Tager-Flusberg, & Folstein, 2007). The communication and social impairments of children with ASD place them at increased risk of developing problem behaviors which, in turn, adversely affect student options for educational placement in less restrictive environments and opportunities for social inclusion (Horner, Carr, Strain, Todd, & Reed, 2002). In fact, researchers have shown that aggressive behavior is one of the most prominent barriers to placement in less restrictive environments (Shoham-Vardi et al., 1996). Atypical eating behavior, abnormal sleep patterns, self-injurious behavior, aggression, and temper tantrums are among the most common atypical behaviors observed in children with ASD (Dominick, et. al., 2007). For the purpose of the current study, self-injurious behavior, aggression, and temper tantrums in students with ASD are reviewed because these behaviors have the most immediate impact on educational functioning.

Self-injurious behavior has been studied thoroughly in individuals with mental retardation, but less in individuals with ASD (Oswald, Ellis, Singh, Singh, & Matson, 1994; Rojahn et. al., 2001). Researchers found that self-injurious behavior was related to both receptive and expressive communication in a meta-analysis of studies on challenging behaviors in individuals with intellectual disabilities (McClintock, Hall, & Oliver, 2003). It is estimated that 20% to 71% of individuals with autism display self-injurious behaviors (Ando & Yoshimura, 1979b; Bartak & Rutter, 1976; Poustka & Lisch, 1993). Additionally, Baghdadli et al. (2003) found that lower levels of expressive functional language and extreme scores on the communication, socialization, and daily living skills domains on the Vineland Adaptive Behavior Scales were associated with increased self-injury in individuals with autism.

Aggression has been found to be more common in individuals with intellectual disabilities (ID) than the general population (Holden & Gitleson, 2006). There is an added risk factor for individuals with a dual diagnosis of ID and ASD with regard to aggression (Hill & Furnis, 2006; McClintock, Hall, & Oliver, 2003). According to some researchers, aggression by individuals with developmental disabilities is a learned behavior that achieves a desired outcome (Foxx & Meindl, 2007). Outcomes or functions of aggression might be to gain attention (Thompson, Fisher, Piazza, & Kuhn, 1998), gain access to tangible reinforcers (Deleon, Fisher, Herman, & Crosland, 2000), escape or avoid unpleasant situations or demands (Horner, Day, Sprague, O’Brien, & Heathfield, 1991), or achieve some combination of these outcomes or functions (Braithwaite & Richdale, 2000). Mitchell et al. (2006) suggested that challenging behaviors exhibited by individuals with ASD may be due to marked deficits in communication. Chiang (2008) found that children from 3 to 16 years of age with speech impairments exhibited challenging behaviors as a means of expressing their needs.

Dominick and colleagues (2007) investigated atypical eating behavior, abnormal sleep patterns, self-injurious behavior, aggression, and temper tantrums in students with ASD and students with a history of language impairments because both groups have communicative impairments that may contribute to these behaviors. The results of this study indicated that atypical eating behavior, abnormal sleep patterns, temper tantrums, and self-injurious behaviors were significantly more common in children with ASD than in those children who had only a history of language impairment (Dominick et al., 2007). Aggressive behaviors were found to be associated with lower nonverbal IQ and expressive and receptive language scores (Dominick et al., 2007).

Meteorological Factors and Human Behavior

The extant literature that specifically links human behavior and meteorological factors is scant. However, some research supported the idea that weather factors might have had an effect on behavior. Based on reactions to short-term variations in weather, individuals can be divided into two main groups: weather-resistant and weather- sensitive (Yackerson et al., 2011). Individuals in the first group had a stable adjustment to the habitual weather, or its moderate variations, because of the protection of a variety of internal mechanisms (Yackerson et al., 2011). Weather-sensitive people make up more than 30% of the whole population (Sulman, 1982; von Mackensen et al., 2005). According to Yackerson et al. (2011) the nervous system is the first to respond to changes in the environment and influences the endocrine system. The most common weather-triggered biological reactions have a psychological, emotional, or behavioral character (Yackerson, et al., 2011). The parallel channels of the nervous system are referred to as negative feedback loops. These loops maintain the stable state of the nervous system and lead to physiological adaptability to ambient conditions (Yackerman et al., 2011). However, weather-sensitive individuals have an impressionable nervous system and are more sensitive to periods of atmospheric variation than others (Yackerman et al., 2011). The instability of meteorological factors alone or in conjunction with each other may cause multiform disorders in the normal life of sensitive individuals, including such conditions as depression, seasonal affective disorders, rowdy crowd behavior, aggravation of chronic diseases, headache, migraine or other symptoms (Aikman, 1997; Cantor et al., 2000; Doganay et al., 2003; Lee et al., 2006; McConville et al., 2002; Morion et al., 1999; Stoupel et al., 1995; Sulman, 1982; Yackerson & Zilberman, 2005).

Meteorological conditions have been linked to a range of adverse human behaviors in neurotypical individuals (Moos, 1976; Sanders & Bizzolara, 1982). Seasonal affective disorder has been linked to depression, anxiety, and an overall negative emotional state in adults (Wilson, 2002; Rohan & Sigmon, 2003). Additionally, researchers explored the relationships between weather and aggression (Cyr, 1985; Friedman & Becker, 1965; Matlin, 1995). Bell (1992) found that the relationship between temperature and aggression follows an inverted U association, which has been termed the *negative affect escape model*. This model posits that aggression increases with temperature to a certain point (around 85˚F), but then declines at higher temperatures that cause further discomfort as the aggressor becomes more consumed with escaping the uncomfortable situation than aggressing (Anderson, 1987; Baron, 1977; Bell 1992; Cohn & Rotton, 1997; Ganjavi et al., 1985). This research is often cited in explanations of the increase in aggressive behavior during warm summer months or in geographic locations where the ambient temperature remains high for prolonged periods of time.

Other researchers have indicated that antisocial activity may be related to changes in the environment and weather variables (Banziger & Owens, 1978; Barker et al., 1994; Cerbus & Dallara, 1975; Cohn, 1990a, 1990b; Friedman & Becker, 1965; Raps & Stoupel, 1992; Rotton, 2001; Stoupel, 1999). Positive relationships between temperature and assault, homicide, and domestic complaints have been reported (Cohn 1990a, 1990b). Cunningham (1979) found that in summer there was a positive correlation between temperatures and helping behaviors; in winter a negative correlation was found between these variables. This study also reported that high humidity decreased the frequency of cooperative behavior. It has also been reported that suicide increased with a rise in barometric pressure and decreased in periods of high wind (Barker et al., 1994; Stoupel, 1999); drug addiction increased with changes in warm and cold fronts, and psychiatric admissions increased with warmer temperatures (Banziger & Owens, 1978; Cerbus & Dallara, 1975; Friedman & Becker, 1965; Raps & Stoupel, 1992; Rotton, 2001).

While limited research exists to explain fully the interaction of meteorological factors and positive and negative moods, some studies show a direct linear relation between these factors. Whitton et al. (1984) found a link between lower barometric pressure, temperature, and humidity and positive moods. Additional research indicated lower physical energy levels, lower social interest, and higher positive affect are associated with higher temperatures, levels of humidity, and barometric pressure (Sanders & Brizzolara, 1982). Goldstein (1972) examined the relationship between six weather variables and three self-reported mood states beginning at the end of October in Staten Island, New York. Subjects in this study rated how they felt on the semantic factors of evaluation, potency, and activity for 11 consecutive days. Correlational analysis of the data revealed that positive evaluation of mood and high ratings accompanied low humidity and high barometric pressure. High potency ratings were correlated with high barometric pressure and lower temperatures (Goldstein, 1972). Additional researchers found that mood variables such as vigor, social affection, and elation were negatively correlated with high levels of relative humidity (Sanders & Brizzolara, 1982).

Howarth and Hoffman (1984) examined weather variables in relation to various human dimensions including concentration, cooperation, anxiety, aggression, depression, fatigue, and optimism. The findings of this study suggested that humidity had the greatest effect on all dimensions of behavior. Specifically, concentration and potency (a measure of self-confidence and self-assurance) decreased while reports of sleepiness and fatigue increased when humidity levels were high (Howarth & Hoffman, 1984). Additionally, results of this study indicated that humidity might be a variable that influences important aspects of performance, such as attention and alertness. These researchers found three predictor variables for mental concentration. In order of importance, these were humidity, temperature, and hours of sunshine (Howarth & Hoffman, 1984). In the same study, it was found that increasing humidity and dropping barometric pressure were associated with lower scores on concentration. Although aggressive behavior was not directly assessed in this study, data did indicate that aggressive feelings were positively related to colder temperatures.

Relatively few studies have assessed the relationships between weather variations, behavior, and emotional states in children (Essa et al, 1990; Lagacé-Séguin & Coplan, 2001; Lagacé-Séguin & d'Entremont, 2005). Badger and O'Hare (1989) investigated the correlation of students' disruptive incidents with staff to weather variables such as maximum and minimum temperature and wind speed over a period of time from September to July. The results of this study indicated that the range of temperature over a day was a powerful predictor of the number of disruptive incidences (Badger & O'Hare, 1989). It was found that wind speed was slightly negatively correlated with disruptive pupil behavior (Badger & O'Hare, 1989).

Lagacé-Séguin and d'Entremont (2005) examined the relationships among various meteorological conditions, affective states, and behavior in young children. In this study, parents in Italy were asked to complete a questionnaire on their child's affect at the end of each day during February and March (Lagacé-Séguin & d'Entremont, 2005). Additionally, teachers were asked to rate children's behavior problems and prosocial behavior for comparison to direct behavior observations. The results of this investigation revealed a positive relationship between humidity and externalizing problems; and a negative relation between humidity and prosocial behavior (Lagacé-Séguin & d'Entremont, 2005). Further examination revealed negative relations between sunshine hours and internalizing and externalizing behaviors in young children, suggesting that inclement weather is associated with problematic behaviors in childhood (Lagacé-Séguin & d'Entremont, 2005).

A study by Lagacé-Séguin and Coplan (2001) examined children's emotional states in relation to a variety of weather patterns for a 33-day period during winter. The results of this investigation suggested that greater amounts of sunshine were paired with an increased feeling of enthusiasm and emotional strength. Higher levels of relative humidity were correlated with higher levels of irritability and significantly positive relationships were found between temperature and children's alert state (Lagacé-Séguin & Coplan, 2001).

Essa and colleagues (1990) observed 67 preschoolers daily and rated them on 10 behavioral categories. This data was compared to data from the National Weather Bureau to assess the relationship between children's behavior and weather. The observations were conducted during a free-choice activity time when children could choose from a variety of available activity options. The behavioral categories examined in the observations were

- appropriate interactions with peers,
- appropriate interactions with adults,
- appropriate interaction with materials,
- physically aggressive behavior,
- verbally aggressive behavior,
- disruptive behavior,
- degree of engagement in activities or interaction with others,
- shifting from one activity to another,
- crying and
- other behaviors (Essa, et al., 1990).

The weather patterns for each day were categorized into four categories: stable (characterized by sunshine, little or no cloud cover, no precipitation, little or no wind, and stable barometric pressure), Transitional I (moving from stable to unstable), Transitional II (moving from unstable to stable), and unstable (characterized by combinations of rain or snow, cloudiness, poor visibility, high wind, unstable barometric pressure and low temperature).

Results indicated that when weather was stormy or emerging from stormy conditions, children tended to engage in more appropriate interactions with peers and adults (Essa et al., 1990). Additionally, during stable or recently stable weather children were observed to engage more appropriately with materials and activities. These researchers also found that girls' interactions with materials was more frequent than boys', specifically during Transitional II, when the weather was moving from unstable to stable, than in other weather patterns (Essa et al., 1990). A third finding was that older preschoolers seemed to have more varied responses to the weather than younger students in relation to interaction with adults. When the weather was Transitional II (moving from unstable to stable) and when it was unstable, older preschoolers sought out adults significantly more often than when the other two weather conditions prevailed (Essa et al., 1990).

Ciucci and colleagues (2011) examined meteorological factors of air temperature, relative humidity, air pressure, and solar radiation and compared them to response variables of activity level, attentional focusing, frustration, sadness, and aggression for children in a day-care facility during 3 weeks of winter. Analysis of this study data suggested that the mean relative humidity and the mean solar radiation were the main predictors of children's emotional and behavioral states. Humidity had a significant positive correlation with frustration, sadness, and aggression. A rise in relative humidity values was associated with an increase in negative feelings. Solar radiation had a significant negative correlation with sadness.

Summary

Existing research on meteorological factors and human behavior provide a basis for the current study. Researchers have established that some weather factors seemed to have an influence on adult and childhood behavior. Specifically, meteorological factors such as temperature, relative humidity, and changing barometric pressure were found to be related to various moods, feelings, and behaviors (Badger & O'Hare, 1989; Ciucci et al., 2011; Essa et al, 1990; Howarth & Hoffman, 1984; Lagacé-Séguin & Coplan, 2001; Lagacé-Séguin & d'Entremont, 2005; Sanders & Brizzolara, 1982; Whitton et al., 1984). While research specifically investigating the effects of weather on children is limited these studies provide initial observations supporting the idea that meteorological factors might influence the functioning and behavior of children.

Research supports the existence of a disturbance in sensory processing and sensory sensitivity for students with ASD (Dunn, 2008). According to Dunn (2008), children with ASD exhibit behaviors that can be attributed to an imbalance or poor modulation in the central nervous system. Individuals who are distractible may have difficulty because they are constantly trying to attend to all available stimuli in the environment. Excessive excitement in the central nervous system leads to an individual noticing more than is necessary for everyday activities (Dunn, 2008).

Meteorological variables represent one form of sensory stimuli and research supports the concept that weather and related environmental factors can affect human behavior. Researchers have found links between variables such as barometric pressure, temperature, and humidity and behaviors including aggression, suicide, drug use, and cooperation as well as effects on concentration, mood, anxiety, depression, fatigue, and optimism (Howarth & Hoffman, 1984; Rohan, & Sigmon, 2003; Sanders & Brizzolara, 1982; Wilson, 2002; Whitton et al., 1984). In accordance with these findings it is possible that meteorological variables have an effect on the behaviors of students with ASD as a result of these individual's propensity to be abnormally sensitive to environmental stimuli and to experience commonly disturbances in processing sensory stimuli. Investigation into the extent of the relationship between meteorological variables, academic performance, and challenging behaviors is important for understanding the complex population of individuals with ASD. Thus, there is a significant need for research on the impact of meteorological factors on the classroom functioning of learners with autism-related disorders.

Chapter 3

Research Design and Methodology

The methodology of the study is described in this chapter. It begins with the purpose of the study and the research questions and variables. Next is a description of the method and study design used, setting, participants, procedures, and instruments. This chapter concludes with a description of the data analysis procedures.

Purpose of the Study

The purpose of this study was to determine if relationships exist between various meteorological factors and the academic and behavioral performance of students with autism spectrum disorders (ASD). The factors that were studied included barometric pressure, temperature, moon illumination, and humidity.

Research Questions

Using objectively measured and reliable daily meteorological data from the National Weather Service website (http://www.crh.noaa.gov/eax/?n=observations) and daily academic performance and behavioral data on students with ASD in a public school setting, the following research questions were addressed:

Q1: What is the relationship between meteorological conditions, including barometric pressure, humidity, moon illumination, and temperature, and daily academic and behavioral performance of students with ASD?

Specific questions include:

Q1a: What is the relationship between barometric pressure and academic performance and classroom behaviors of students with ASD?

Q1b: What is the relationship between humidity and academic performance and classroom behaviors of students with ASD?

Q1c: What is the relationship between moon illumination and academic performance and classroom behaviors of students with ASD?

Q1d: What is the relationship between temperature and academic performance and classroom behaviors of students with ASD?

Methods and Study Design

This study used a single subject design format. Daily classroom academic performance and behavioral data on three elementary school aged students diagnosed with ASD were collected and compared with meteorological variables to assess relationships between barometric pressure, humidity, moon illumination, and temperature, and students' individual academic performance and classroom behaviors. Data were collected on daily student performance on previously mastered tasks specific to each subject's Individual Education Plan (IEP) and annual goals and benchmarks. Daily data on observable classroom social and management-related behaviors which impede student learning or that of peers were also collected, evaluated, and analyzed relative to meteorological variables, including barometric pressure, temperature, moon illumination, and humidity.

Setting

This study took place in Center School District in the Kansas City metropolitan area. An elementary autism program serving students in grades Kindergarten through grade 5 exists within the school district. This program provides special education services to students who spend less than 40% of the school day in general education. Participants in this study were enrolled in this special education program for the majority of the day. They participated in regular education inclusion for homeroom; lunch; recess; and art, music, and PE classes.

Participants

Once permission to conduct the research was secured from the University of Kansas Internal Review Board's Human Subject Committee (HSC-L) and the participating school district, voluntary student participation was sought from the students' parents. Parents and/or guardians of the students were asked to provide informed consent for inclusion in the study. Appendix A contains the informed consent form signed by each participant's parents and/or guardian. Specifically, participants of this study were selected from a convenience sample at Center School District, a public elementary school in Kansas City, Missouri. Three participants with medical and educational diagnoses of autism were included in this study. The three participants selected for this study were also selected based on teachers' reports of observable problem behaviors which impeded their learning or the learning of other students.

Three (N=3) students, ages 5 and 8 participated in this study. Two of the participants were 5-year-old kindergarten students, one male and one female. The third participant was an 8-year-old male. Each of the three students demonstrated significant observable problem behaviors that impeded learning, including screaming, falling to the floor, head butting, hitting, and elopement. For this data collection, elopement was defined as the student moving away from the area where activities were occurring. Each student receives special education services through Individual Education Plans (IEPs) outlining academic and behavioral goals for each year. The respective IEPs governed the activities the students are asked to complete in the classroom.

Student 1: S.

Student S was a 5-year-old female with both medical and educational diagnoses of autism. During this study she spent the majority of her day in the Center School District program for students with autism spectrum disorders. S had severely limited spontaneous verbal communication skills. S required one-on-one adult assistance to participate in age appropriate activities, remain in designated school and classroom areas, focus on tasks, and follow classroom directions and procedures. At times, S communicated through echolalic phrases from favorite television shows. For example, when she needed help, this student would often say, “Wonder Pets to the rescue”; she would utter, “Bye, bye, Elmo” when she wanted to stop an activity.

S was observed screaming and crying, as well as falling to the floor on her knees, to protest non-desirable activities. Due to S’s limited communication abilities and difficulty following classroom routines and activities, a paraeducator accompanied her throughout the day to ensure her participation and safety. S’s communication was severely limited and when she became overwhelmed and distressed she screamed with no discernable words. During a physical transition, S was also observed falling to the floor on her knees and refusing to move to the next activity area. During the study S was engaged in using the Picture Exchange Communication System (PECS), (Frost & Bondy, 2002) to strengthen her communication skills, but she still screamed as a way to communicate her dislike. During the study S was working on academic acquisition tasks such as: (a) writing her name, (b) imitating actions, (c) responding to a greeting, (d) identifying her name and picture, (e) sitting for a structured activity, and (f) appropriately protesting a non-preferred activity. Tasks that S had previously mastered were included in maintenance activities to ensure retention of skills. These activities included matching same items, identifying letters of the alphabet, putting numbers 1 through 10 in order, and identifying common objects.

Student 2: K.

Student K was a 5-year-old male with a medical as well as educational diagnosis of autism. He spent the majority of his day in the Center School District program for students with autism spectrum disorders. K was non-verbal; he had severely limited communication skills. He was observed making various noises throughout the day which seemed to serve no communicative purpose. K was an active student who required frequent prompting to follow classroom routines, remain seated in his chair, stay in designated areas, and follow directions. He also required consistent monitoring to stay in designated areas of the classroom. Left unsupervised, K would leave the classroom and run down the adjacent hall.

During this study, K was working on academic tasks that included receptively identifying the letters in his name, identifying shapes, playing cooperatively with peers, and copying the letters in his name. Academic work tasks which K had mastered were included as maintenance tasks to ensure retention of skills. These tasks included matching same items, placing numbers 1 through 10 in order, and receptively identifying common pictures of objects. During structured work sessions K was observed engaging in off-task and protesting behaviors. These behaviors were also observed during large group instruction, although to a lesser degree. K exhibited behaviors that impeded his participation in school activities including hitting, biting, and head-butting the adult who gave him directions to perform non-preferred activities or tasks.

Student 3: E.

Student E was an 8-year-old male with a medical as well as educational diagnosis of autism. He spent the majority of his day in the Center School District program for students with autism spectrum disorders. E had limited verbal language skills and required high levels of systematic reinforcement to complete non-preferred activities. During this study he utilized a visual schedule with the activities of the day listed on a vertical strip of laminated paper. The paraeducator or teacher who was working with him reviewed his schedule approximately every 30 minutes as activities changed, and allowed him to identify the reinforcer he would be working for in a space following the identified work time. E commonly failed to follow directions or complete work tasks. He would often protest non-preferred activities by walking or running away from the adult directing him to an activity, kick or hit the adult, and flip a straw in front of his eyes. At times, E would lie on the floor or under a table when asked to transition or move to a location to work on structured tasks. During the study E sometimes would avoid group activities in the classroom by moving to an unoccupied adjacent classroom. When asked to join the group he would sometimes engage in the previously mentioned avoidance and protesting behaviors.

During the study E's academic tasks included adding and subtracting two digit numbers, reading sight words, matching sentences to pictures, identifying numbers 1-100, writing simple sentences, and spelling words for pictures. Tasks that E had mastered were included as maintenance tasks to ensure retention of skills, including matching at least 40 words to pictures, spelling 14 words for pictures of common objects, and adding and subtracting one digit numbers. E exhibited hitting, kicking, and elopement when presented with non-preferred activities, and these behaviors were the targets for data collection.

Table 1 identifies the three participants. Table information includes demographic information, target behaviors, and academic task information.

Table 1

Subject Demographics and Data Collection Targets

Subject	**Gender**	**Age**	**Diagnosis**	**Target Behaviors**	**Mastered Academic Tasks**
K	*M*	*5*	Autism	Hitting	Ordering numbers 1-10
				Biting	Matching pictures of the same item
				Head-Butting	Handing a picture of a requested common object
S	F	5	Autism	Screaming	Ordering numbers 1-10
				Falling to the floor	Verbally labeling letters A-Z
					Verbally labeling 10 pictures of common objects
					Matching pictures of the same item
E	M	8	Autism	Hitting	Matching 20 common object words to pictures
				Elopement	Writing 10 words for common object pictures
				Kicking	Writing the answers to 5 addition and 5 subtraction problems

Note: M = male, F = female

Procedures and Data Collection

Daily classroom data were collected at school for an 8 week period on students' performances on mastered work tasks associated with their respective IEP annual goals. Tasks were considered mastered if the student routinely performed the task with an accuracy of 80% or higher. Appendix B shows the data sheets used for tracking performance on these tasks. Daily data were also collected on specified observable behaviors of individual students. Target behaviors included screaming, falling to the floor, kicking, head butting, hitting, and elopement. Daily data were collected by individuals assigned to work with the students in classroom settings, including paraprofessionals and classroom teachers. Each student had a data collection folder that contained data sheets and operational definitions of the behaviors to be evaluated. Appendix C shows the data collection sheets for each student.

The data collection period for this study was from 9:00 a.m. to 10:00 a.m. daily. Data were collected on two general types of behavior: (a) management-related behaviors which interfered with class participation, and (b) academic performances on mastered tasks. Each targeted management-related behavior was recorded using a direct observation method; specifically, a frequency count for the number of instances of each behavior. Individuals collecting the data were trained how to use the data sheets and the operational definition of each behavior. Prior to beginning data collection staff practiced collecting data under the guidance of the principal investigator. Each individual had three 1 hour training sessions with the principal investigator during which the student was observed and frequency counts were recorded on behavior data sheets. Similarly, the individuals who collected data were trained to calculate and record student’s daily percent correct scores on academic activities using data collection forms for mastered academic tasks.

Interobserver reliability checks were conducted on a weekly basis for each student by the principle investigator. One time each week the principle investigator observed the students for one observation period and independently collected data while the person working with the student also collected data using the aforementioned data sheets. These once-a-week interobserver reliability checks for each student constituted eight (23%) of 35 total observations. A frequency ratio with a percentage was used to compute the agreement between the totals of the two independent observations of the recorded behaviors for each student. Observer agreement instances were totaled and then divided by the total frequency of behavior for an overall agreement of 86% (187/218). The agreement for individual subjects ranged from 77% to 93%.

During the designated observation time, students participated in a group calendar time activity where the date, days of the week, and weather were reviewed. This calendar time was a whole group activity that used a SmartBoard® (n.d.) with interactive icons and words for the days and weather. Approximately six students participated in this activity. The number of adults varied in accordance with the amount of support students required to engage in the activity. This calendar time activity lasted approximately 30 minutes each day. During this 30 minute time period observational data were collected on the number of times each student displayed his/her respective target behaviors. For example, when K was observed to hit, head butt, or bite an adult during this activity a tally mark was placed on a data sheet. Likewise, when S was observed to scream with no discernable words, or fall to the floor on her knees a tally mark was placed on her data collection sheet. Finally, when E was observed to elope from the designated area (move away from the activity), hit, or kick an adult a tally mark was placed on his data collection sheet.

After the calendar activity each student engaged in individual work one-on-one with an assigned paraeducator. This work time lasted approximately 30 minutes and consisted of the student completing designated maintenance activities. For example, K’s work tasks were to place numbers 1 through 10 in order, match 10 same pictures of objects, and receptively identify common objects by choosing the requested picture from a field of three. S’s tasks were to place numbers 1 through 10 in order, match 10 same pictures of objects, verbally identify capital letters, and verbally identify 10 common objects from pictures. Lastly, E's maintenance tasks were to write the words for 14 pictures, match 20 words to corresponding pictures of objects, and write the answer to 10 1-digit addition and subtraction problems. For each student, correct or incorrect response data was collected for each task. During this 30 minute work session, data were also continually collected on the previously discussed management-related behaviors for each student. Appendix B shows copies of the data collection sheets used for each student's maintenance academic tasks.

Once each week the principal investigator entered students' data into a Microsoft Excel® spreadsheet along with data collected from the national weather service on the (a) barometric pressure (expressed in millimeters of mercury), (b) humidity (expressed in percent), (c) moon phase (expressed in percent of illumination), and (d) air temperature (expressed in degrees Fahrenheit [^{o}F]).

Data for barometric pressure, humidity, and air temperature were independently collected for the 9:00 to 10:00 a.m. observation time. Measurements of barometric pressure, humidity, and air temperature were gathered from the National Weather Service website (http://www.crh.noaa.gov/eax/?n=observations). This highly reliable and publically available resource offers archival data on weather conditions collected from specific weather stations at specific times each day. The weather station located closest to the study site was the Kansas City Downtown Airport, which is 10.6 miles from the school where the study occurred. The previously mentioned website reports archival data at specified times throughout each 24 hour period, roughly on an hourly basis. After selecting the Kansas City Downtown Airport weather station as the station of interest, a spreadsheet of the past 7 days' weather information can be generated. The principal investigator chose to use weather data reported by the National

Weather Service at 9:54 a.m. each day. This report was the closest in time to the daily observation period. On one day of the study the time for data collection was adjusted to 8:54 a.m. because data was not reported at the 9:54 time point. Weather data was generated from the website on Sundays at the end of each data week and resulted in a seven day spreadsheet of weather variables. The measurements for barometric pressure, humidity, and temperature were incorporated into the Microsoft Excel® Spreadsheet corresponding to the date for each observation.

Data for the measurement of the moon phase was collected for each day expressed in percent of illumination. Specifically, this variable was gathered from a moon illumination calendar provided as a link on the National Weather Service website (http://paulcarlisle.net/mooncalendar/). These data were also reported on the Microsoft Excel® Spreadsheet, along with behavioral, academic, barometric pressure, temperature, and humidity data. Reliability checks were performed on the meteorological data one time per week by a third party observer to confirm that the recorded data for the day was indeed what was reflected in the aforementioned data sources. The third party observer used previously described weather data generated from the National Weather Service. The third party observer recorded the 9:54 a.m. daily weather information using the same procedures as the principal investigator. This was compared to data collected by the principle investigator and was found to be 100% in agreement.

Data Collection

This study used quantitative data to explore research questions. Behavioral data were frequency counts for each occurrence of target behaviors; academic maintenance task data were percentage correct scores. Thus data on participants in this study were empirical classroom data on individual students, including academic task performance and classroom behavior. Data for meteorological variables were expressed in Fahrenheit degrees for temperature, millimeters of mercury for barometric pressure, percent humidity, and percent of illumination for moon phase. Data on students' daily academic task performance and target behaviors was compared with meteorological factors 5 days per week over an 8 week period.

Instruments

Instruments used throughout this study consisted of previously established data collection sheets consistently used by school staff for the purpose of monitoring student performance on specific mastered IEP goals and data collection sheets for observable target behaviors. A spreadsheet generated by the National Weather Service was used to record daily humidity, temperature, and barometric pressure for the Kansas City Downtown airport, as well as the percent illumination of the moon for each day of the month. The maintenance tasks and corresponding data recording forms were individualized for each student and focused on academic performance. Appendix B provides examples of data collection forms for students' work tasks; Appendix C shows examples of data collection forms for behaviors. Appendix D provides an example of the spreadsheet obtained from the National Weather Service detailing meteorological variables for the Kansas City Downtown Airport. An example of the moon illumination calendar used to gather the percent of illumination for the moon each day of the month is provided in Appendix E.

Data Analysis

Data analysis for this study began with descriptive statistics (means) for each student's behavioral variables. Next, scatter plots for variable combinations for each of the three students were created, including a line of best fit (Hill & Lewicki, 2006). For each subject, a scatter plot was created displaying one meteorological variable on the y-axis and one behavioral variable on the x-axis. This process was used to examine the relationship between the two variables. This procedure was repeated to examine each behavioral target variable in relationship to each weather variable. For example, eight scatter plots were created for student S displaying information for screaming and falling to the floor behaviors with each of the four weather variables: temperature, barometric pressure, humidity, and moon illumination. For each set of behavioral data, extreme outliers that were more than two standard deviations from the mean were excluded from the scatter plots (Department of Commerce, 2003). Due to the low variability of barometric pressure, these values were multiplied by 100 for graphic display on scatter plots. This allowed a clear visual inspection of the variability in barometric pressure. Additionally, scatter plots were created with the same procedure to display the relationship between performance on different academic tasks and the four meteorological variables. Each scatter plot was also displayed with a method of least squares best line of fit in order to determine the direction of any relationships. The scatter plots were then examined for strength and directionality of relationships among variables.

Chapter 4

Results

The results of the study are presented in this chapter. It begins with the purpose of the study and the research questions and variables. Next the data collected in relation to each research question along with supporting graphs and tables is presented. Results are organized by research questions for each participant. This chapter concludes with an overall summary of the findings of this study.

Purpose of the Study

The purpose of this study was to determine if relationships exist between various meteorological factors and academic and behavioral performance of students with autism spectrum disorders (ASD). The factors that were studied were barometric pressure, temperature, moon illumination, and humidity.

Research Questions

Using objectively measured and reliable daily meteorological data and daily academic performance and behavioral data on students' with ASD in a public school setting, the following research questions were addressed:

Q1: What is the relationship between meteorological conditions, including barometric pressure, humidity, moon illumination, and temperature, and daily academic and behavioral performance of students with ASD?

Specific questions include:

Q1a: What is the relationship between barometric pressure and academic performance and classroom behaviors of students with ASD?

Q1b: What is the relationship between humidity and academic performance and classroom behaviors of students with ASD?

Q1c: What is the relationship between moon illumination and academic performance and classroom behaviors of students with ASD?

Q1d: What is the relationship between temperature and academic performance and classroom behaviors of students with ASD?

Results

In order to determine the relationship between student classroom behaviors and academic performance and meteorological variables, data scatter plots were produced. This data presentation method best serves as an efficient and graphic means of describing the relationship of students' academic and behavioral performance and meteorological factors (Department of Commerce, 2003). Scatter plots for each pair of school-related student behavior/performance and meteorological variables for each student are shown and discussed. The meteorological variables are displayed along the y-axis and behavioral or academic performance data are displayed on the x-axis.

Scatter plots are useful for displaying trends and comparisons between two variables (Department of Commerce, 2003). The shape and direction the markers appearing on the scatter plot configuration convey information regarding the relationship between variables. The stronger the relationship between two variables the closer the points will fall on a straight line as indicated by a higher R^2 value. When points are spread out in the graph area there is a weak or no relationship between the variables of interest (National Institute of Standards and Technology/Semiconductor Manufacturing Technology e-Handbook of Statistical Methods, n.d.). Additionally, a line of best fit can be added to the scatter plot showing the direction of the relationship between variables. If the line begins in the bottom left corner and extends to the top right corner these variables are said to have a positive relationship. That is, when one variable increases the other also increases. In contrast, if the line extends from the top left corner to the bottom right corner a negative relationship exists, i.e., when one variable increases the other decreases (Hill & Lewicki, 2006). The results of this study are presented and discussed in terms of both strength and trend or direction of relationships.

Barometric Pressure.

Q1a: What is the relationship between barometric pressure and academic performance and classroom behaviors of students with ASD?

Student E. Student E was an 8 year old male with a medical and educational diagnosis of autism. He had limited expressive vocabulary but was able to express his basic wants and needs. Student E had some management related behaviors that impeded his learning and the learning of others, including kicking, hitting, and elopement. During observation periods for this study student E engaged in the academic maintenance tasks of matching 20 words to pictures, writing words for 14 pictures, and solving addition and subtraction problems. His performance on these tasks was then compared to the barometric pressure measurement for each day during the observation time and displayed in a simple scatter plot with a line of best fit. Figures 1-3 present the scatter plots of academic performance in relation to barometric pressure for student E.

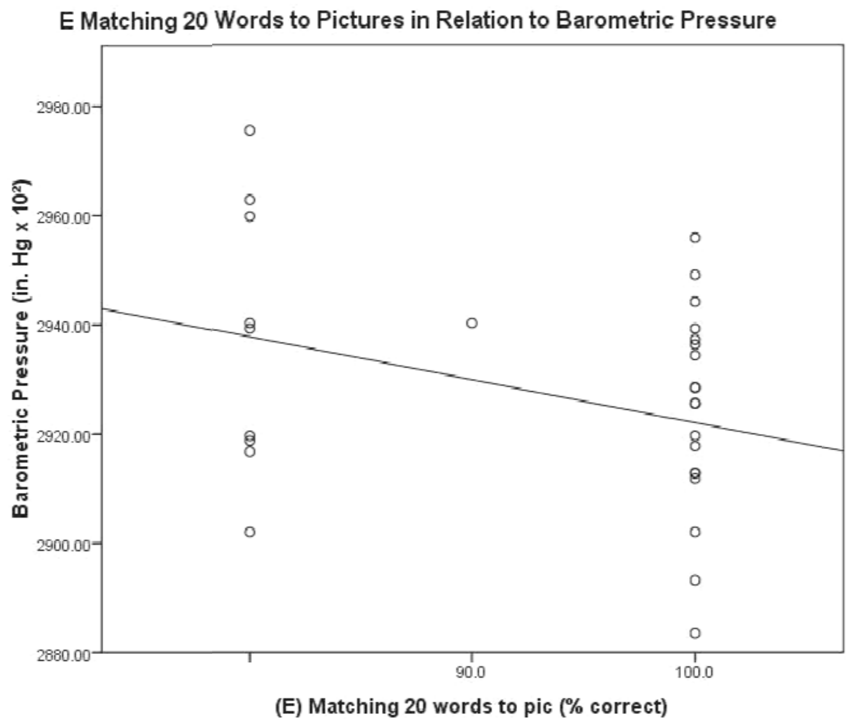

Figure 1. Points on far left are barometric pressures from observation periods during which student did not comply with academic tasks

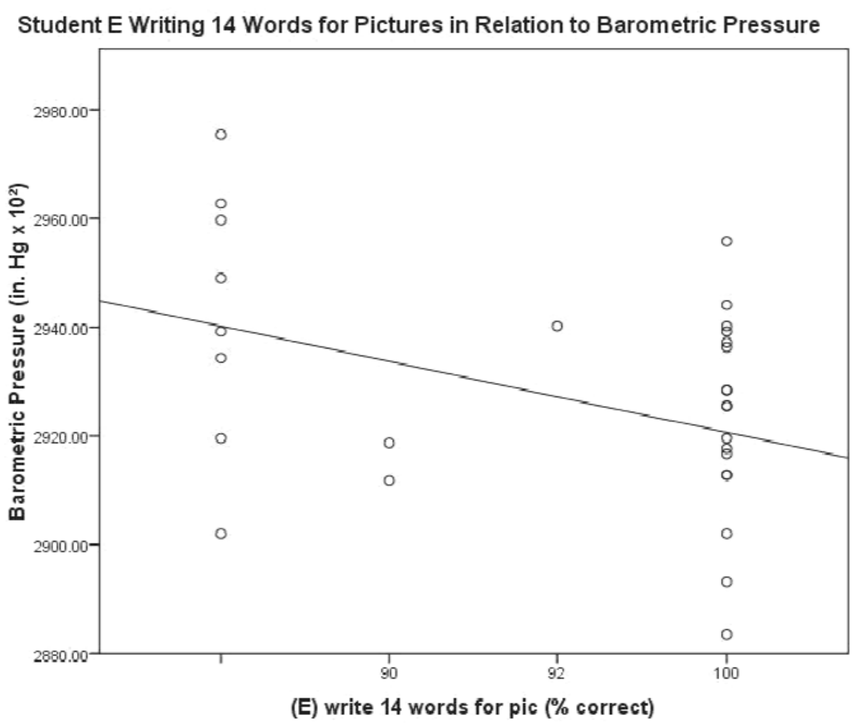

Figure 2. Points on far left are barometric pressures for observation periods during which student did not comply with academic tasks

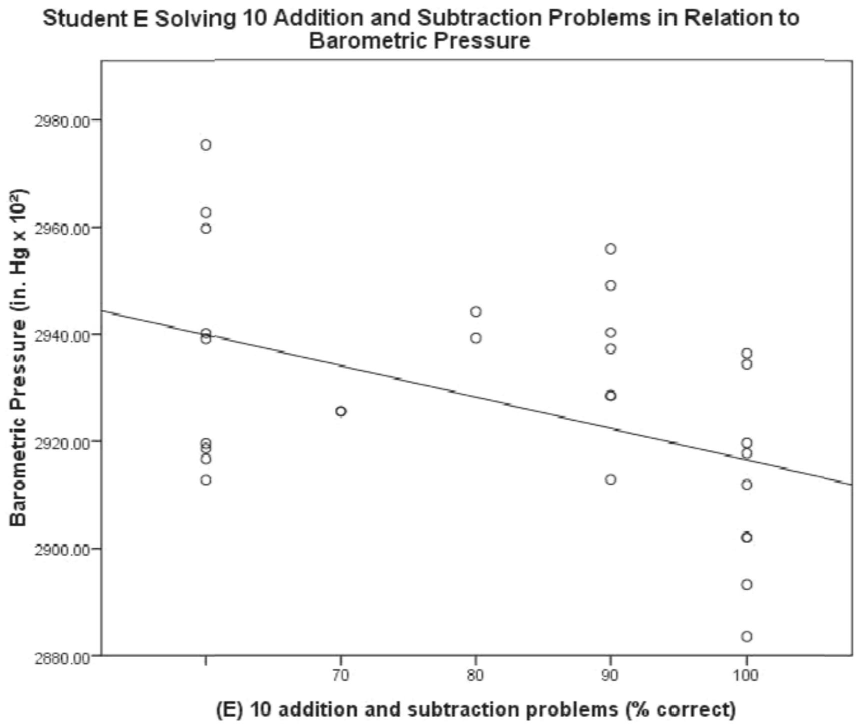

Figure 3. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

Minimal variability was observed in student E's academic performance data. The mean for student E's matching 20 words to pictures was 100. The mean for writing 14 words for pictures was 99 and solving addition and subtraction problems 92. In addition, student E had observation periods where he would not comply with academic tasks. Those instances are presented on the far left on the scatter plot. The points on each scatter plot are not tightly arranged, but tend to form vertical lines at the high and low ends of the x-axis. Therefore, the inference is that there is little to no relationship between the variables. The best-fit line on all 3 scatter plots moves from the upper left to lower right of the graph, indicating that a weak negative relationship may exist between the variables (Department of Commerce, 2003). This suggests that as the barometric pressure increases student E's accuracy on academic tasks decreases. Additionally, due to the fact that the points to the far left are instances where E was noncompliant with the task, it could also be concluded that there is a weak negative relationship between barometric pressure and compliance, although this was not directly measured in the current study. The results for student E thus indicate a weak negative relationship between the academic performance variables and barometric pressure.

Data on the frequency of elopement, kicking, and hitting were collected for student E and compared to barometric pressure data to determine the relationship between barometric pressure and observable classroom behaviors. The daily mean for hitting was 3.09 with a range of 0 to 27 instances. Student E's kicking behavior per observation period had a mean of 1.19 with a range of 0 to 7 instances. Elopement had a mean of 2 and a range of 0 to 10. Figures 4-6 show the scatter plots for each behavior in relation to barometric pressure.

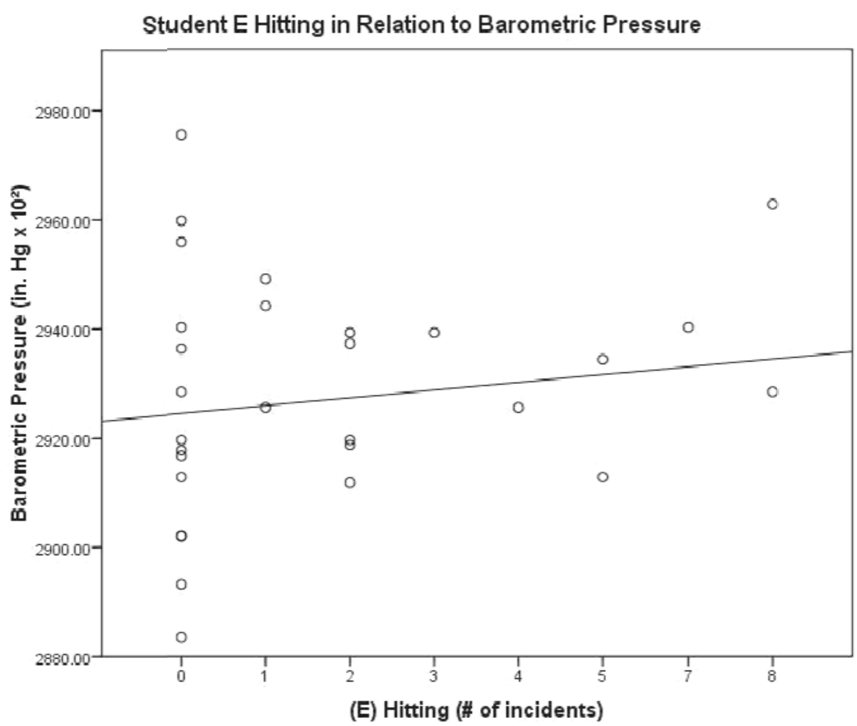

Figure 4.

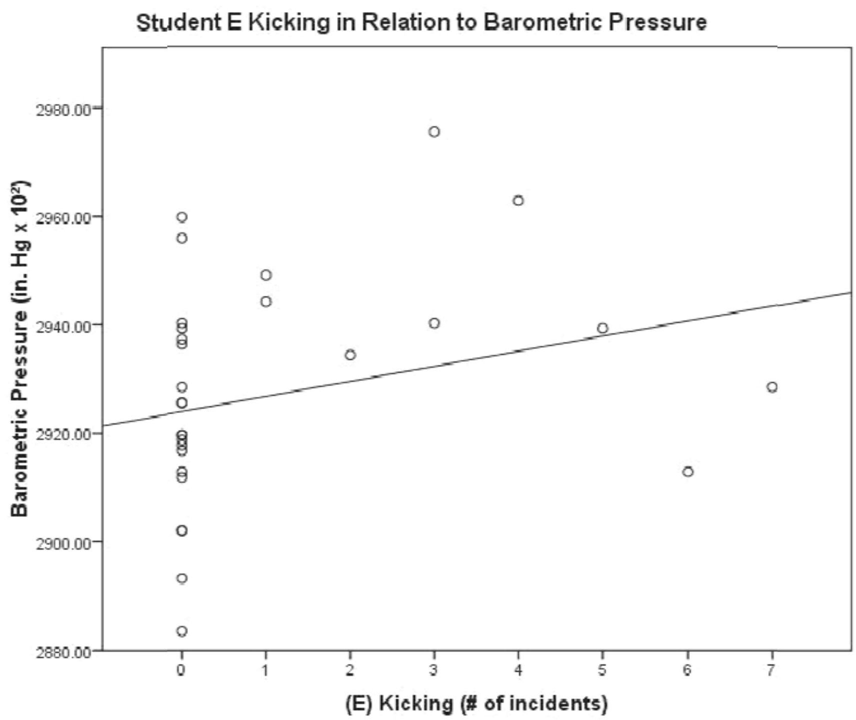

Figure 5.

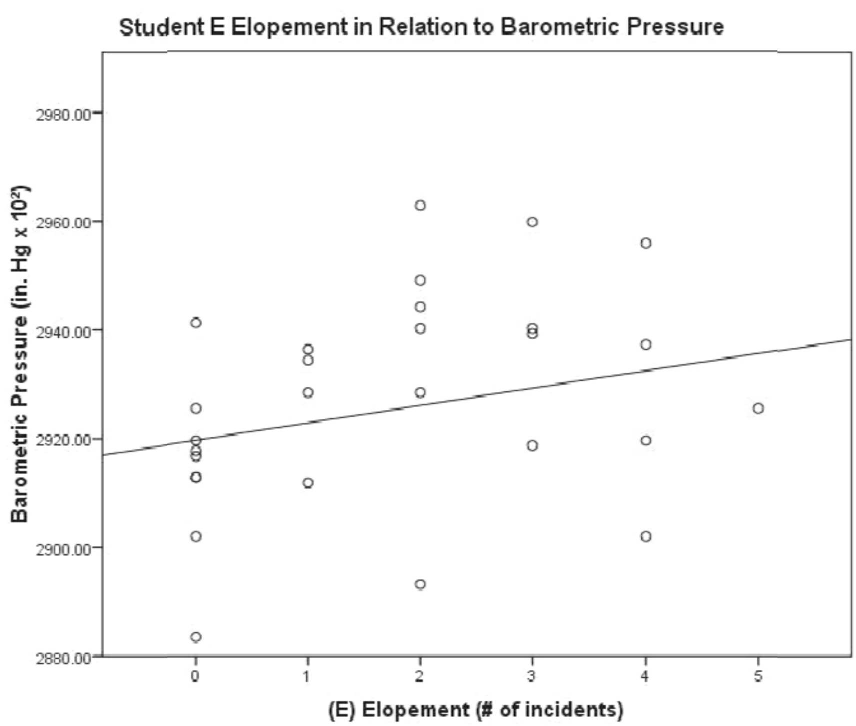

Figure 6.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The direction of the best-fit line is relatively flat for all three scatter plots. These results indicate that there is little to no relationship between kicking, hitting, and elopement when compared with barometric pressure.

Student S. Student S was a 5 year-old female with a medical and educational diagnosis of autism. Her language skills were limited to echoic phrases that she used to indicate her basic wants and needs. Student S also displayed behavior problems that impeded her learning and the learning of other students, including screaming and falling to the floor. Relative to the study, student S engaged in the academic maintenance tasks of ordering numbers 1 through 10, matching same pictures, expressively identifying letters of the alphabet, and expressively labeling pictures of common objects. Her performance on these tasks was compared to the barometric pressure measurement for each day during a specified observation time and displayed in a simple scatter plot with a line of best fit. Figures 7-10 present the scatter plots of academic performance in relation to barometric pressure for student S.

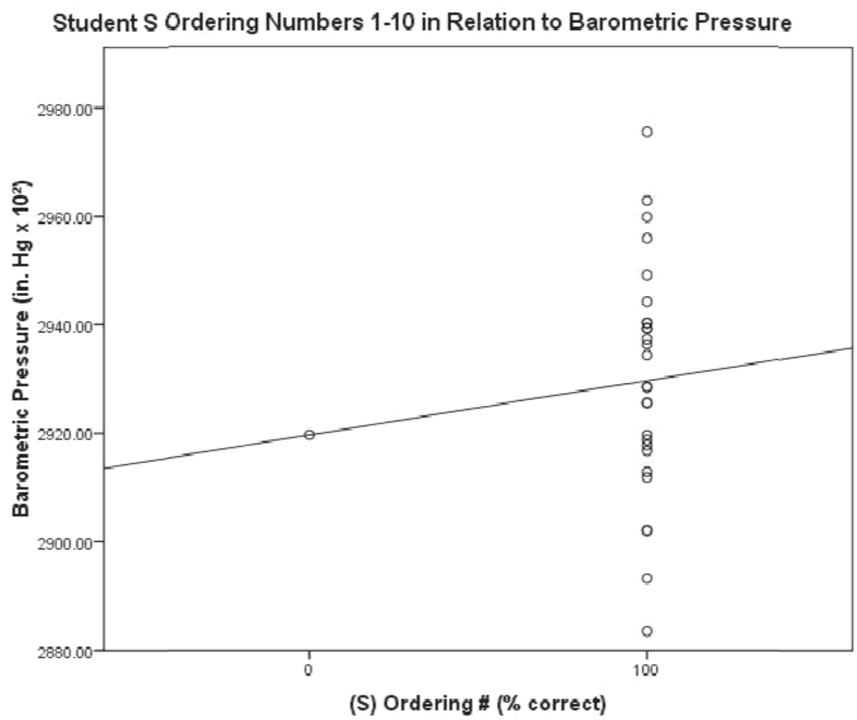

Figure 7.

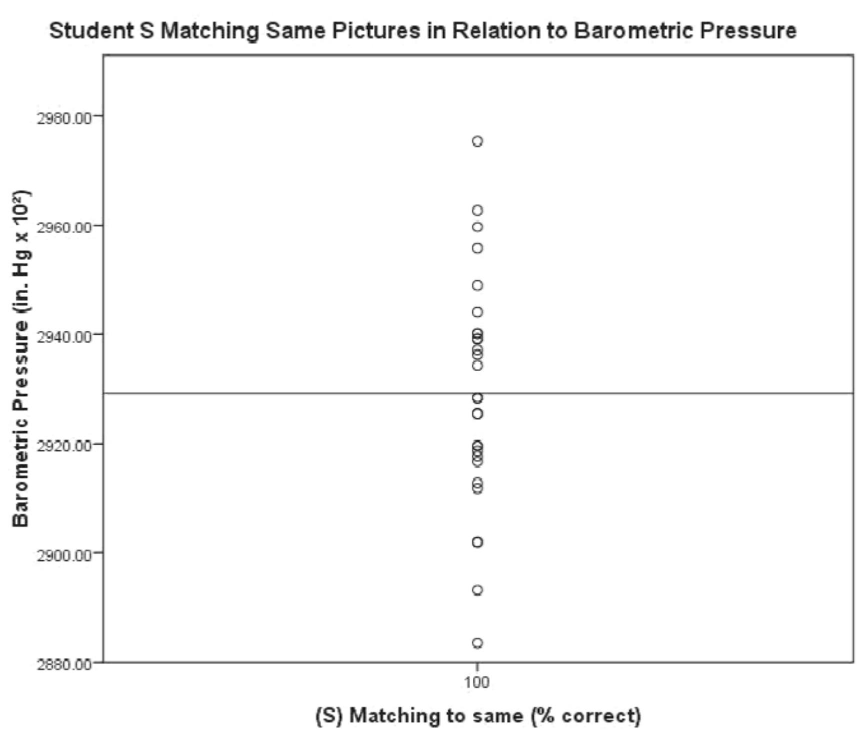

Figure 8.

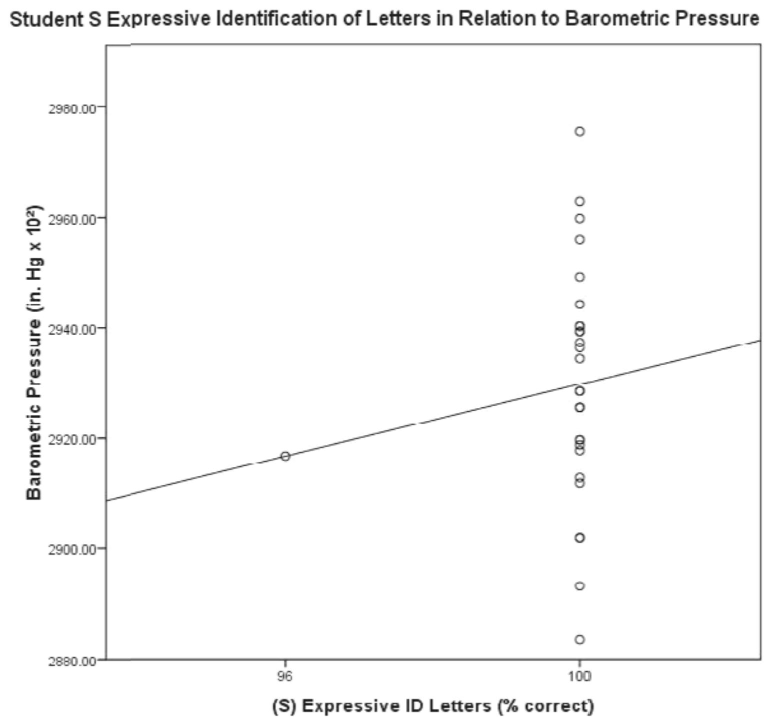

Figure 9.

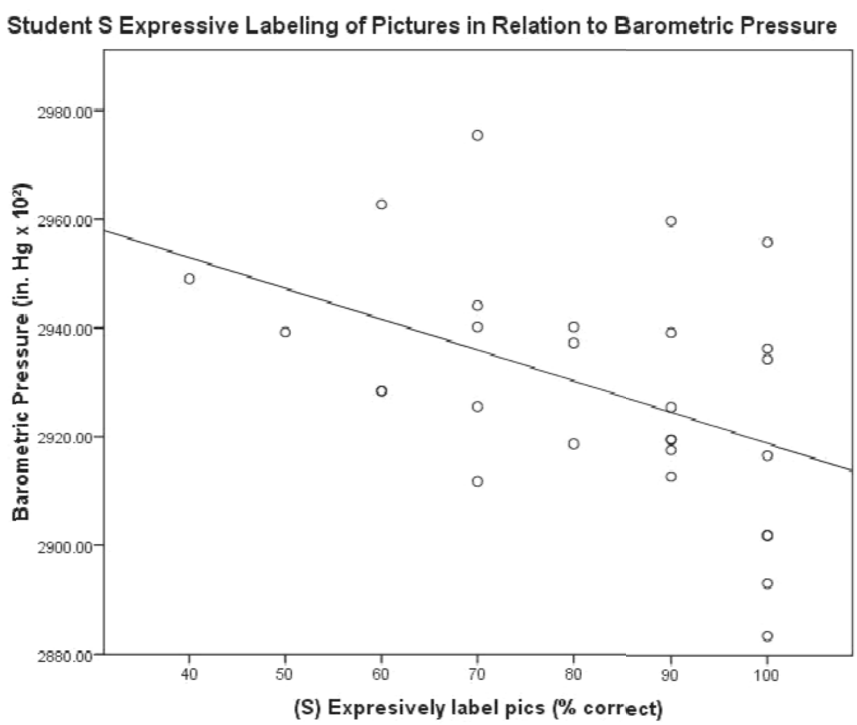

Figure 10.

Minimal variability was observed in student S's academic performance data, which was measured as percent correct on assignments. The mean for student S's ordering numbers 1 through 10 was 96.56. The mean for matching same pictures was 100. The academic performance data for expressively identifying letters had a mean of 99.56 while expressively labeling pictures of common objects had a mean of 82.19. The scatter plots for ordering numbers, matching same pictures, and expressively identifying letters compared to barometric pressure reflect relatively flat best-fit lines with the majority of data points creating a straight vertical line due to the limited variability in scores. The scatter plot for expressively labeling pictures shows more variability and the best-fit line moves from the upper left to lower right quadrants of the graph indicating a weak negative relationship between barometric pressure and expressively labeling pictures. Therefore, the inference is that when the barometric pressure increases student S's accuracy in expressively labeling pictures tends to decrease, albeit in a very weak relationship. The results for student S thus indicate no relationship between ordering numbers, matching same pictures, and expressively naming letters with barometric pressure. A weak negative relationship is indicated between expressively labeling pictures of common objects and barometric pressure.

Data on the frequency of screaming and falling to the floor were collected for student S and compared to barometric pressure data to determine the relationship between barometric pressure and observable classroom behaviors. The daily mean for screaming was 5.39 with a range of 0 to 22 instances. Student S's falling to the floor behavior had a daily mean of 1.09 with a range of 0 to 8 instances. Figures 11 and 12 show the scatter plots for each behavior in relation to barometric pressure.

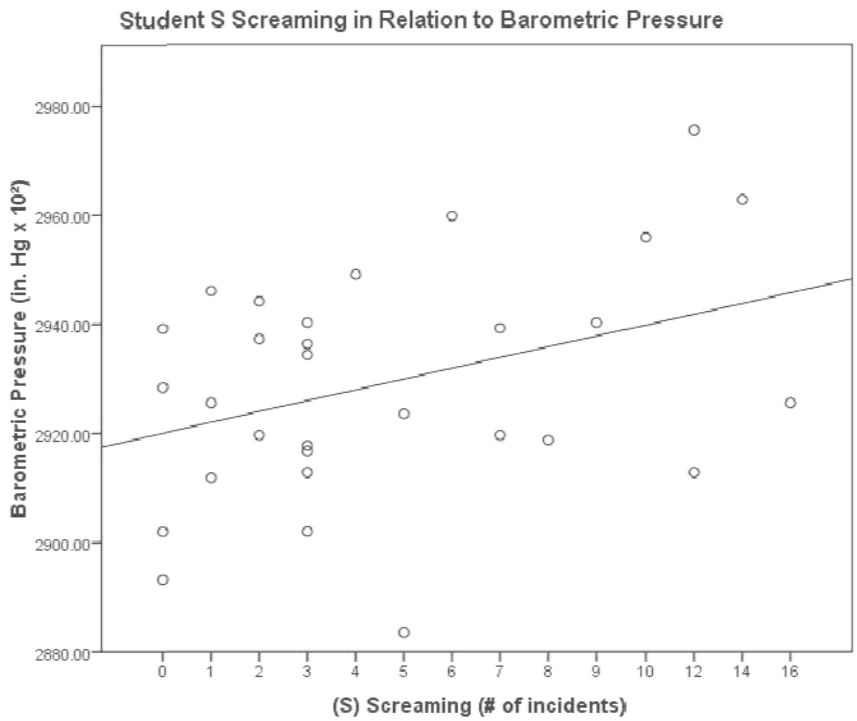

Figure 11.

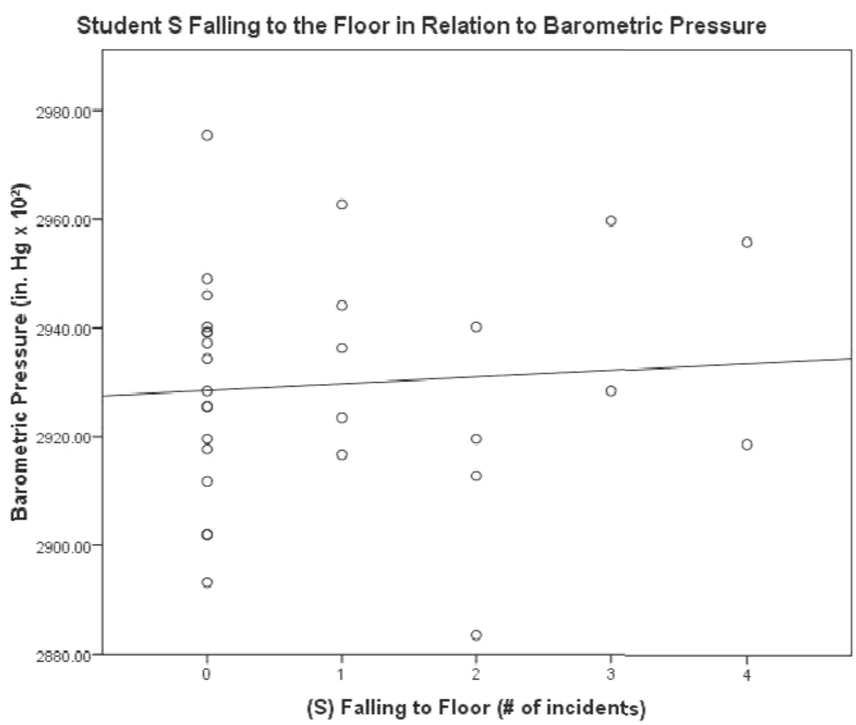

Figure 12.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The best-fit line is relatively flat on the scatter plot for falling to the floor. This indicates that there is little relationship between student S's behavior of falling to the floor and barometric pressure. The best-fit line for the scatter plot showing the relationship between screaming and barometric pressure indicates a positive relationship as it moves from the lower left to the upper right quadrant of the graph. The inference for this scatter plot is that as the barometric pressure increases student S tends to scream more at school. These results indicate no relationship between student S's falling to the floor behavior and barometric pressure and a weak positive relationship between screaming and barometric pressure.

Student K. Student K is a 5-year-old male with educational and medical autism diagnoses. K was a non-verbal student with severely limited communication. He was observed to make various noises throughout the day which seemed to serve no communicative intent. K was an active student who required frequent prompting to follow classroom routines, remain seated in his chair, stay in designated areas, and follow directions. Student K frequently engaged in behaviors that impeded his learning and the learning of others, including biting, hitting, and head-butting adults. During the observation periods for this study student K engaged in the academic maintenance tasks of ordering numbers 1 through 10, matching same pictures, and receptively identifying pictures of common objects. His performance on these tasks was compared to the barometric pressure measurement for each day during a specified observation time and displayed on a simple scatter plot with a line of best fit. Figures 13-15 present the scatter plots of academic performance in relation to barometric pressure for student K.

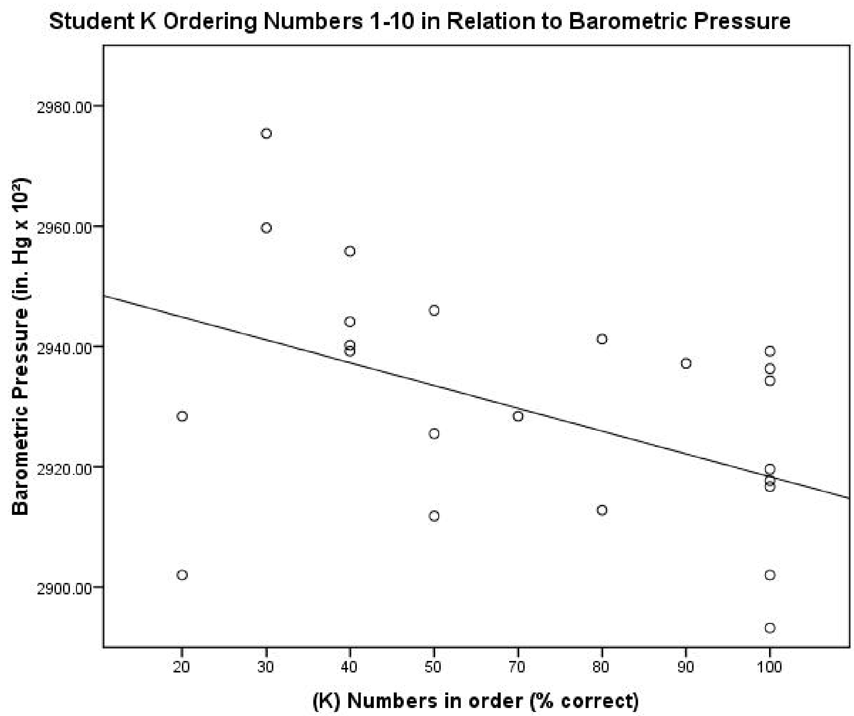

Figure 13.

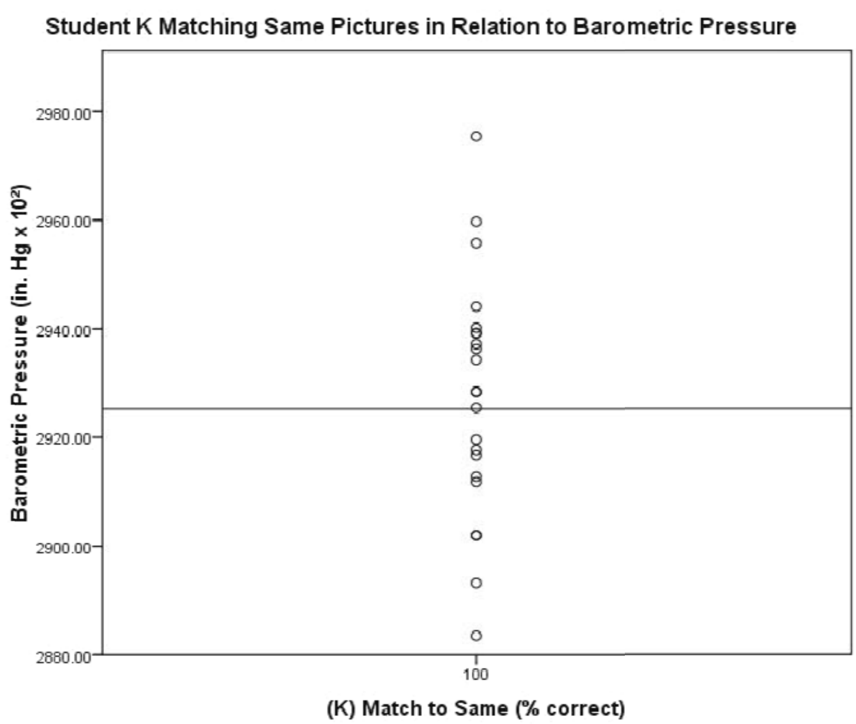

Figure 14.

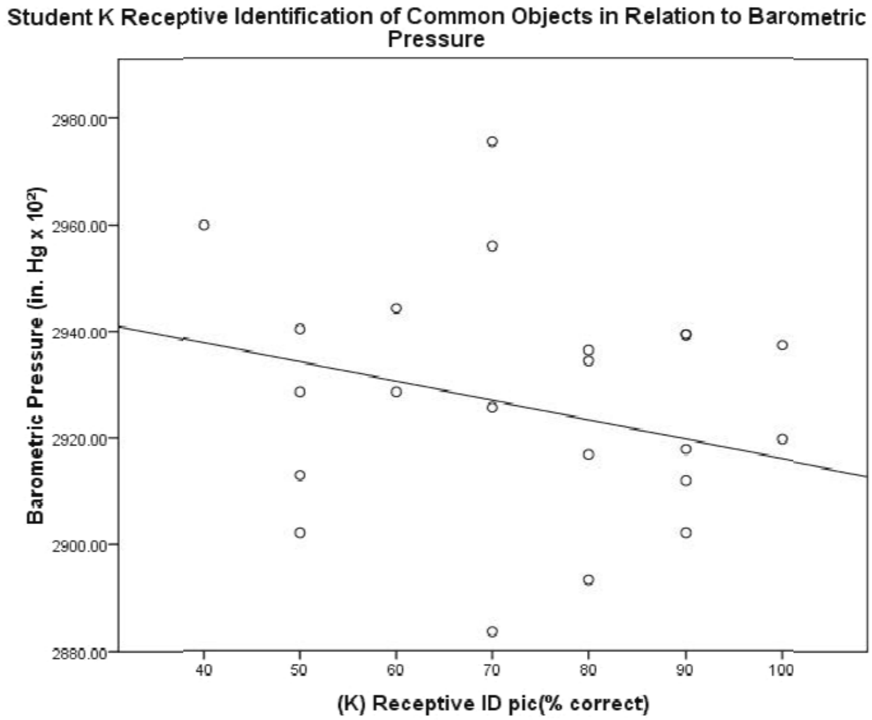

Figure 15.

Minimal variability was observed in student K's matching same pictures, which was measured as percent correct. His academic performance tasks of ordering numbers and receptively identifying pictures of common objects show more variability. The daily mean for student K's ordering numbers 1 through 10 was 69, with a range of 20% to 100% correct. The mean for matching same pictures was 100. The academic performance data for receptively identifying pictures of common objects had a mean of 75 with a range from 40% to 100% correct. The scatter plot for matching same pictures relative to barometric pressure reflects a flat best-fit line with the majority of data points creating a straight vertical line as there is no variability in scores, indicating no relationship between variables. The scatter plots for ordering numbers 1 through 10 and receptively identifying pictures of common objects show more variability. The best-fit lines for ordering numbers and receptively identifying pictures of common objects move from the upper left to the lower right quadrants of the graphs indicating negative relationships. This would suggest that as the barometric pressure increases student K's accuracy ordering numbers and receptively identifying pictures of common objects tends to decrease. The results for student K thus indicate no relationship between matching same pictures and barometric pressure, and a weak negative relationship between barometric pressure and ordering numbers and receptively identifying pictures of common objects.

Data on the frequency of biting, head-butting, and hitting were collected for student K and compared to barometric pressure data to determine the relationship between barometric pressure and observable classroom behaviors. The daily mean for biting was 1.04 with a range of 0 to 13 instances. Student K's hitting behavior had a mean of 8 with a range of 0 to 56 instances . Head-butting had a mean of 7.33 with a range from 0 to 48. Figures 16-18 show the scatter plots for each behavior in relation to barometric pressure.

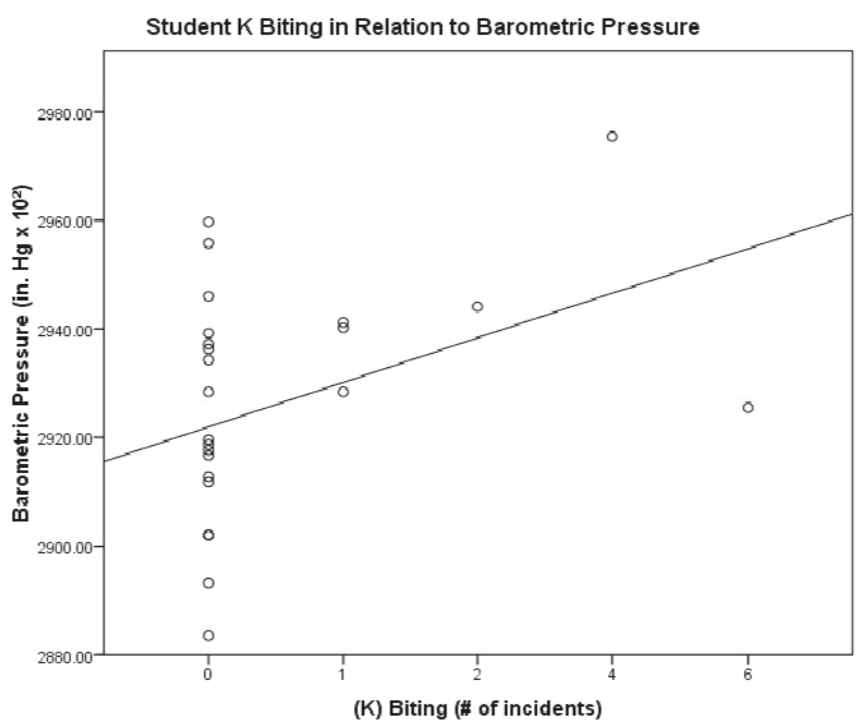

Figure 16.

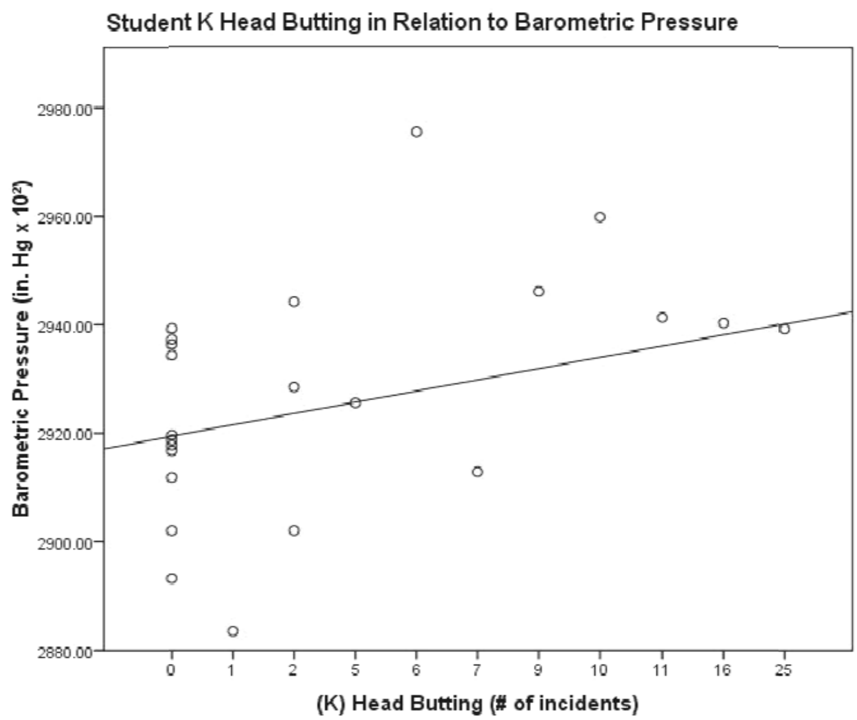

Figure 17.

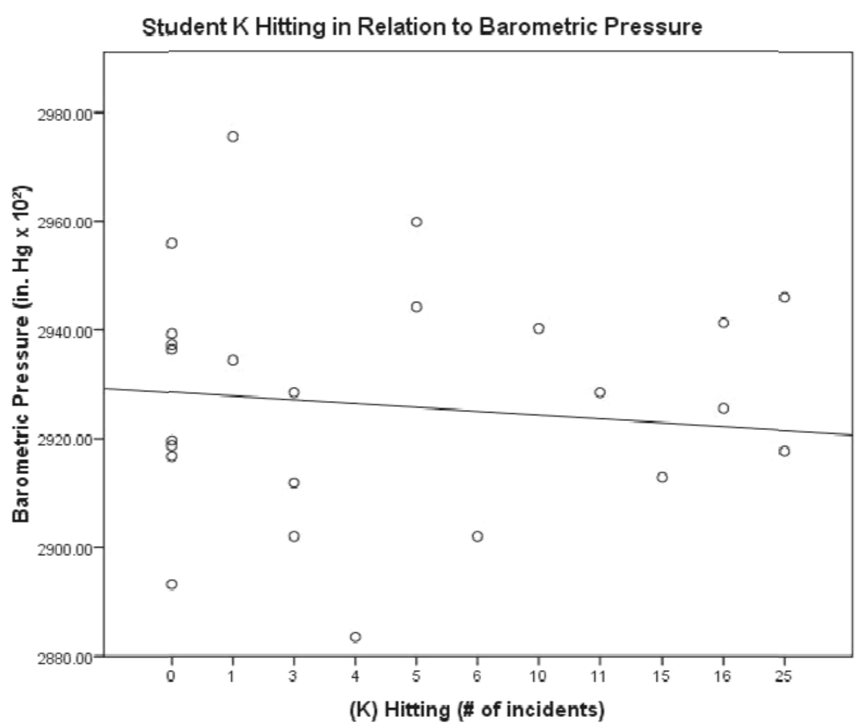

Figure 18.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The scatter plots and best-fit lines for all three visually indicate a weak positive relationship as they move from the lower left to upper right quadrant. The scatter plot for biting and barometric pressure appears to show the greatest relationship, although it is still a weak relationship. This indicates that as the barometric pressure rises student K tends to engage in more biting at school. While the best-fit line for biting may visually indicate a positive relationship, the majority of points are arranged in a straight vertical line, again suggesting little to no relationship between the variables. These results indicate that there is little relationship between student K's behaviors of hitting and head-butting in relation to barometric pressure, and a weak positive relationship between biting and barometric pressure.

Humidity.

Q1b: What is the relationship between humidity and academic performance and classroom behaviors of students with ASD??

Student E. Figures 19 - 21 present the scatter plots of academic performance in relation to humidity for student E.

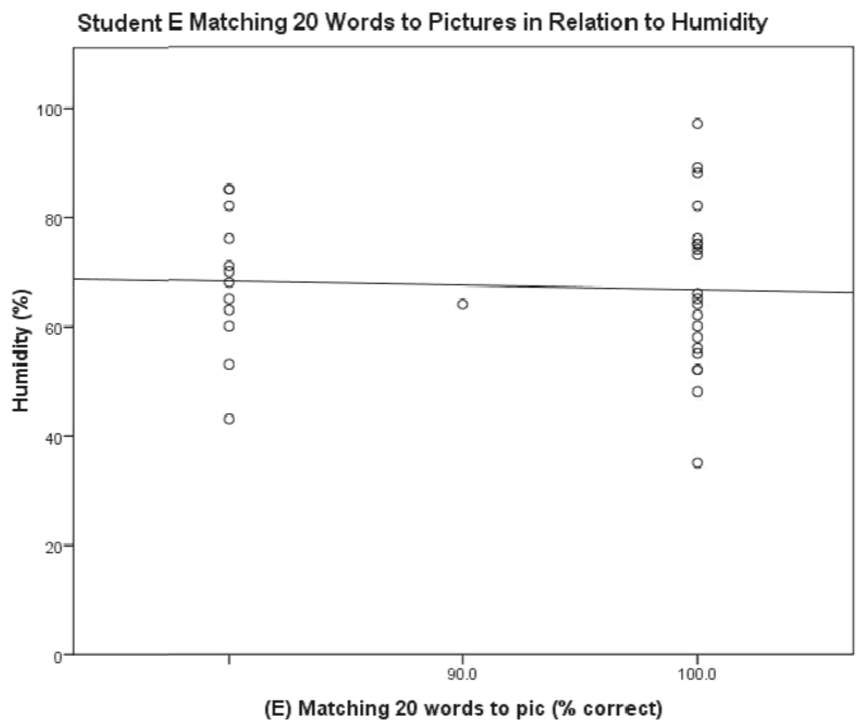

Figure 19. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

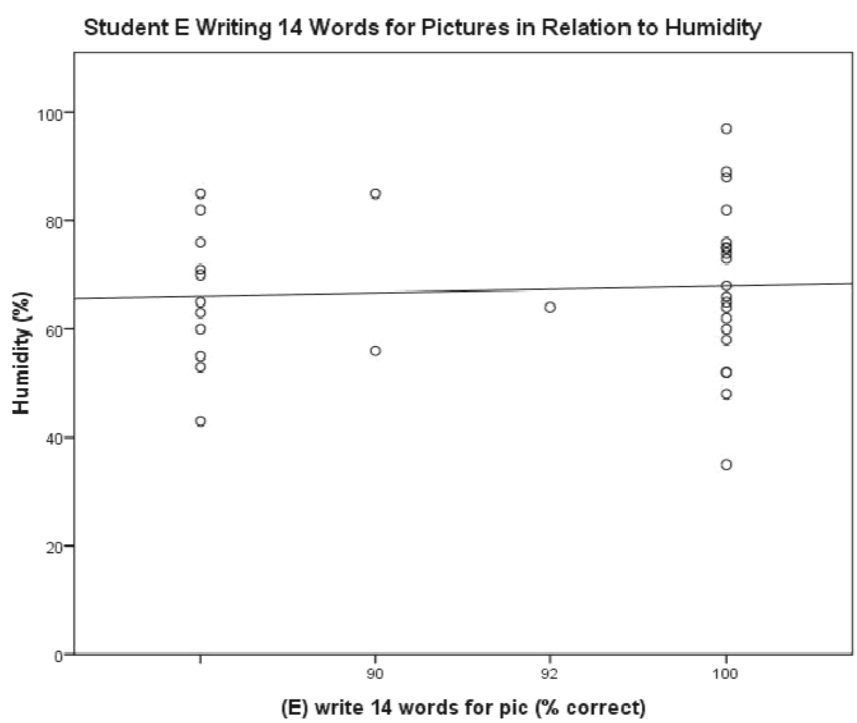

Figure 20. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

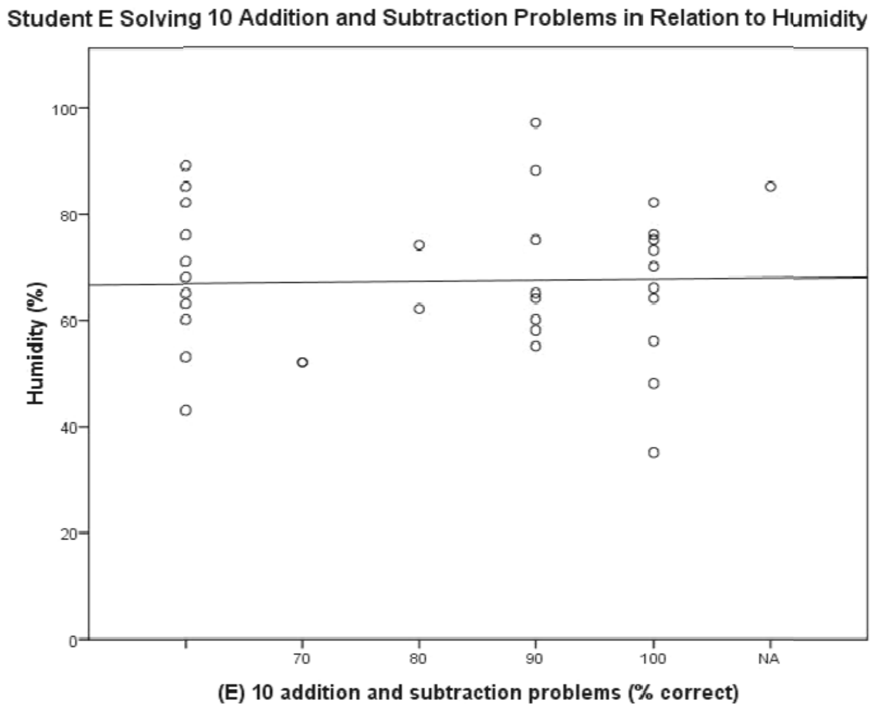

Figure 21. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

Minimal variability was observed in student E's academic performance data. The mean for student E's matching 20 words to pictures was 100%. The mean for writing 14 words for pictures was 99% and solving addition and subtraction problems 92. In addition, student E had observation periods where he would not comply with academic tasks. Those instances are shown on the far left of the scatter plot. The points on each scatter plot are in no way tightly arranged. Therefore, it may be inferred that there is little to no relationship between the variables. Additionally, the best-fit line on all 3 scatter plots is relatively flat, indicating no directionality or relationship between the variables. The results for student E thus indicate no relationship between the academic performance variables and humidity.

Data on the frequency of elopement, kicking, and hitting were collected for student E and compared to humidity data to determine the relationship between humidity and observable classroom behaviors. The daily mean for hitting was 3.09 incidents with a range of 0 to 27. Student E's kicking behavior had a mean of 1.19 with a range of 0 to 7 instances. Elopement had a mean of 2 and a range of 0 to 10. Figures 22-24 show the scatter plots for each behavior in relation to humidity.

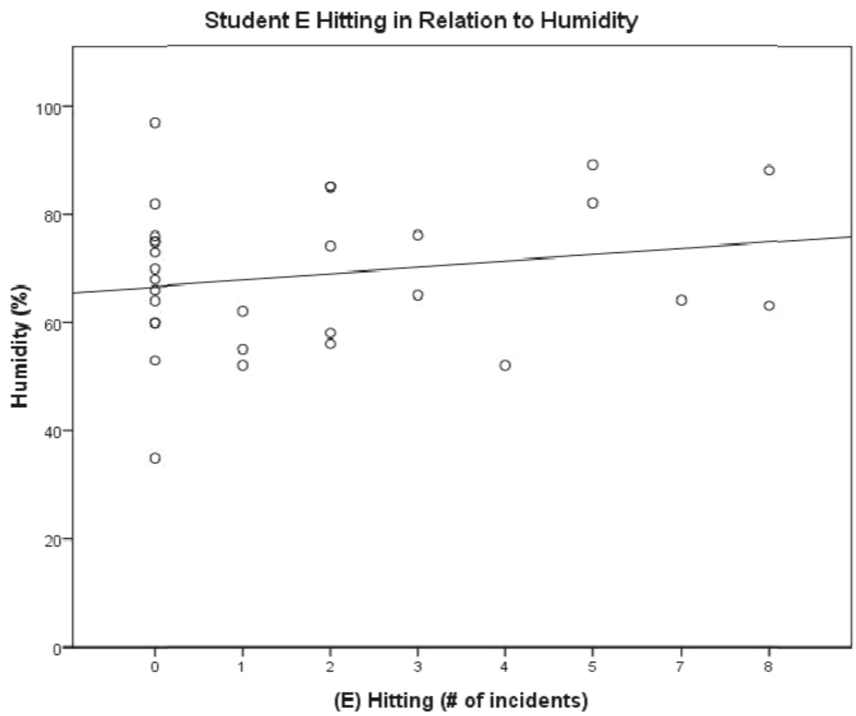

Figure 22.

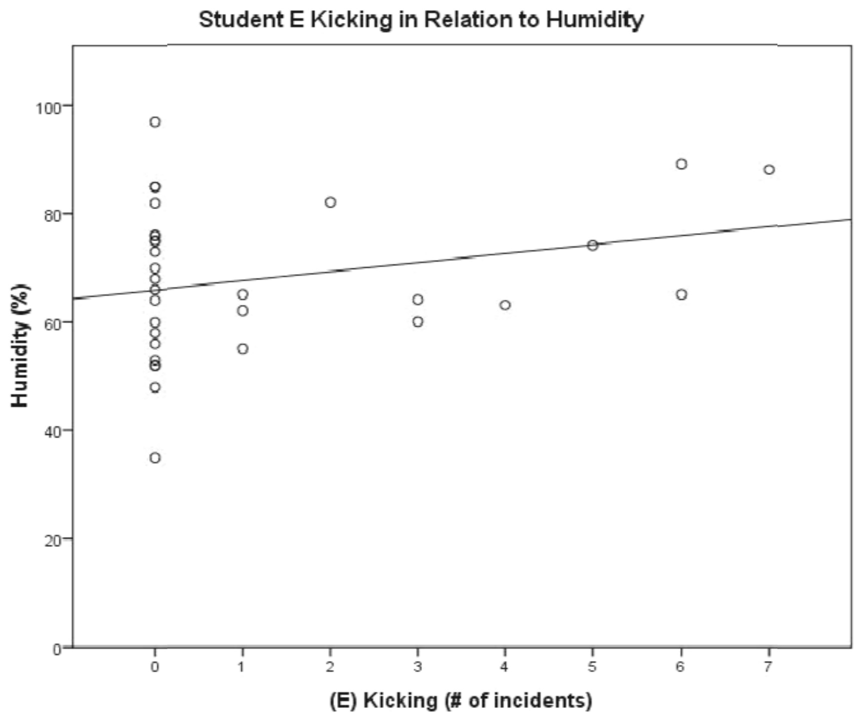

Figure 23.

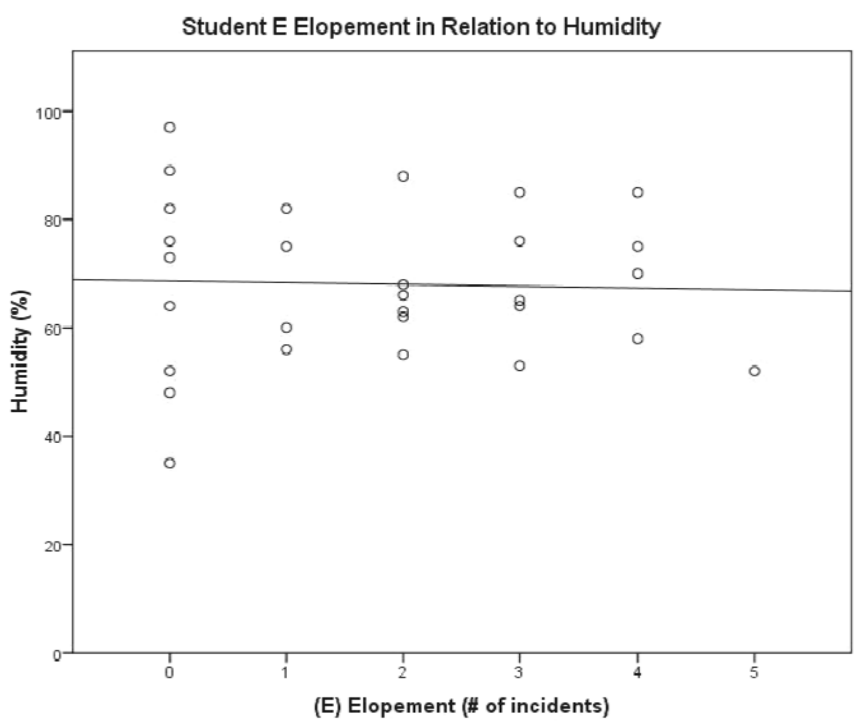

Figure 24.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The direction of the best-fit line is relatively flat for scatter plots for elopement and hitting. These results indicate that there is little relationship between elopement and humidity as well as hitting and humidity. The data points for kicking and humidity are more closely arranged to each other and the best-fit line indicates a weak positive direction moving from lower left to upper right on the scatter plot. These results suggest that there is a weak positive relationship between kicking and humidity. That is, as humidity rises Subject E was more inclined to kick at school.

Student S. Figures 25-28 present the scatter plots of academic performance in relation to humidity for student S.

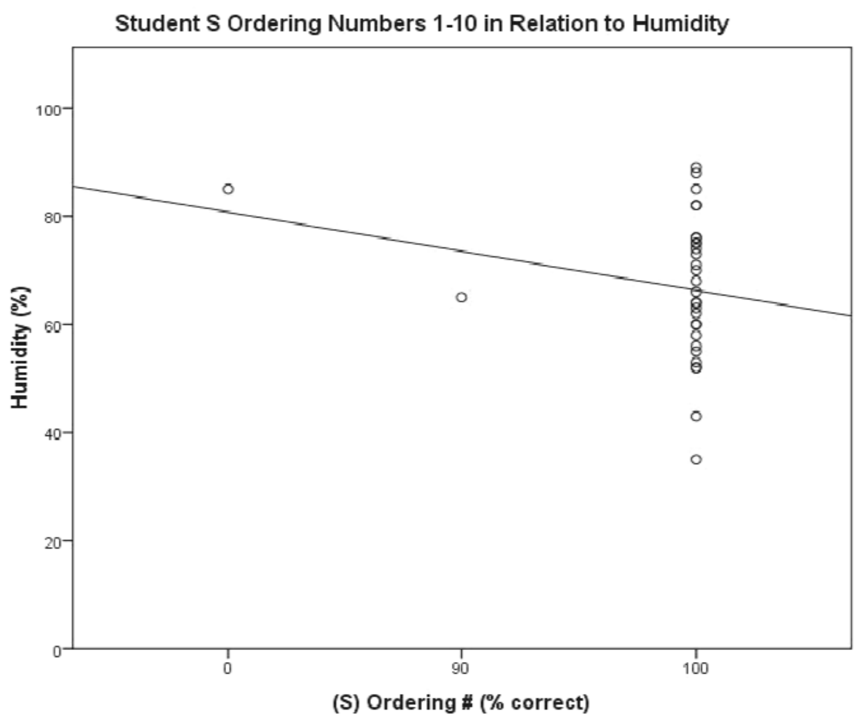

Figure 25.

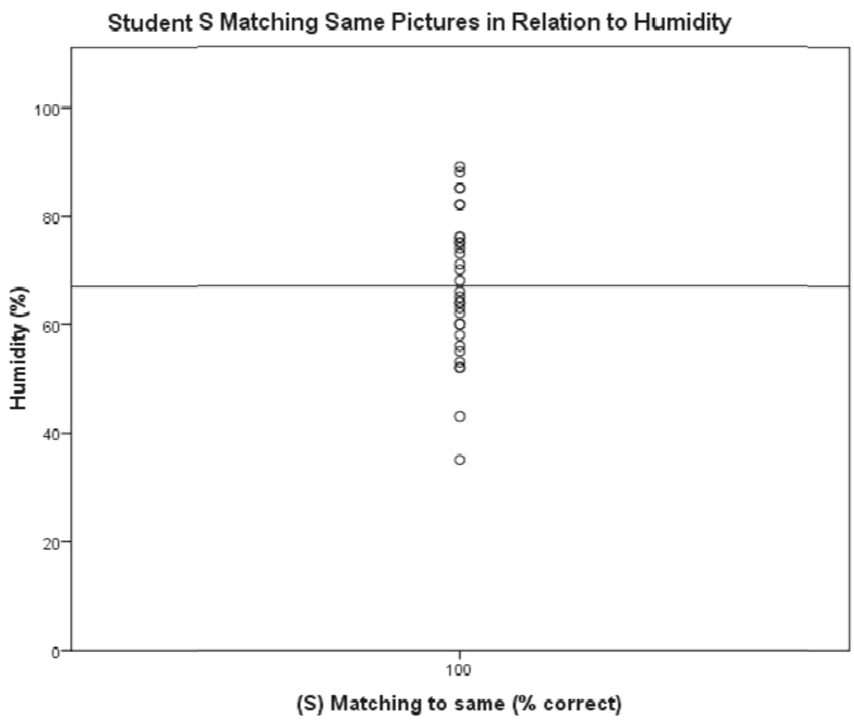

Figure 26.

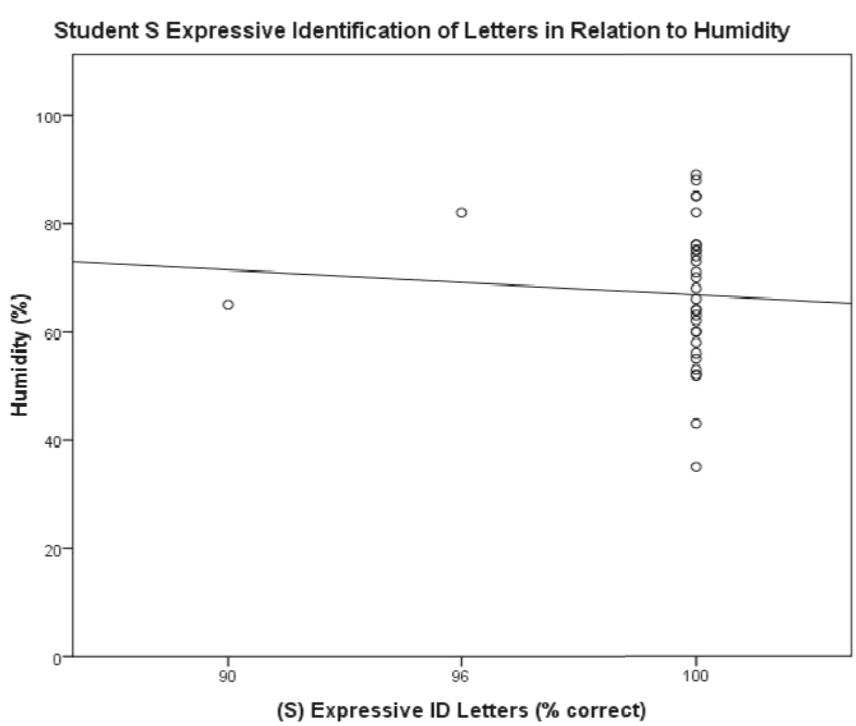

Figure 27.

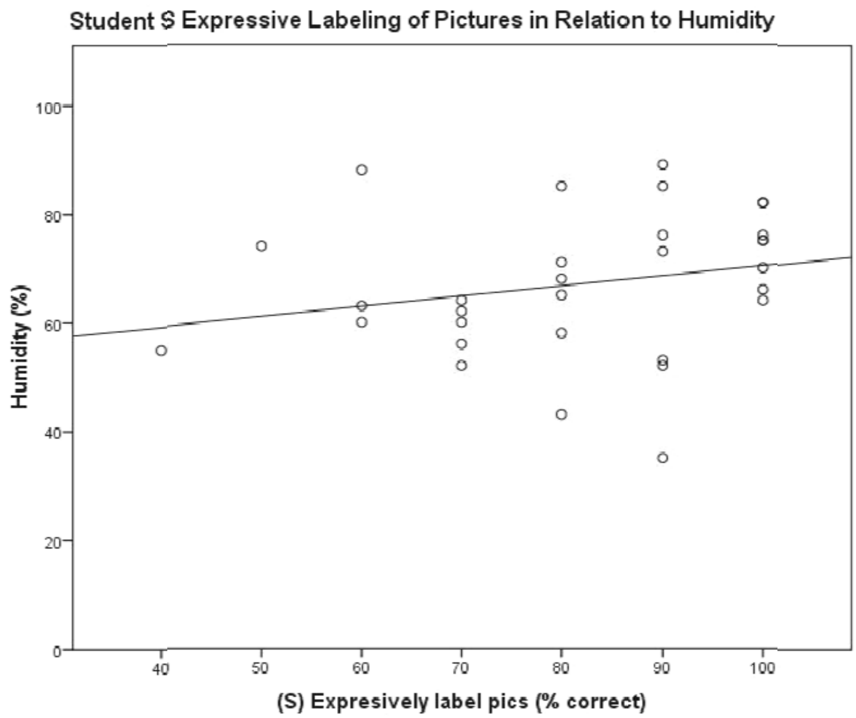

Figure 28.

Minimal variability was observed in student S's academic performance data, which was measured as percent correct. The mean for student S's ordering numbers 1 through 10 was 96.56. The mean for matching same pictures was 100. The academic performance data for expressively identifying letters had a mean of 99.56 and expressively labeling pictures of common objects had a mean of 82.19. The scatter plots for ordering numbers, matching same pictures and expressively identifying letters compared to humidity reflect relatively flat best-fit lines with the majority of data points creating a straight vertical line showing very limited variability in scores. While the scatter plot for expressively labeling pictures shows more variability, the best-fit line remains relatively flat indicating no directionality or relationship between the variables. Therefore, the inference is that there is little to no relationship between the variables. The results for student S thus indicate no relationship between the academic performance variables and humidity.

Data on the frequency of screaming and falling to the floor were collected for student S and compared to humidity data to determine the relationship between humidity and observable classroom behaviors. The daily mean for screaming was 5.39 with a range of 0 to 22 instances. Student S's falling to the floor behavior had a mean of 1.09 with a range of 0 to 8 instances. Figures 29 and 30 show the scatter plots for each behavior in relation to humidity.

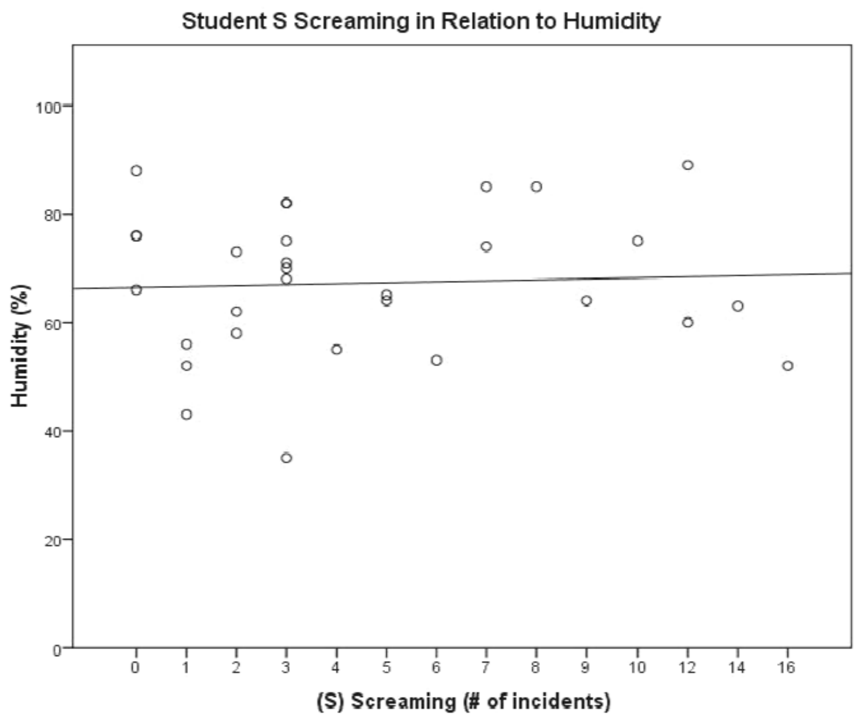

Figure 29.

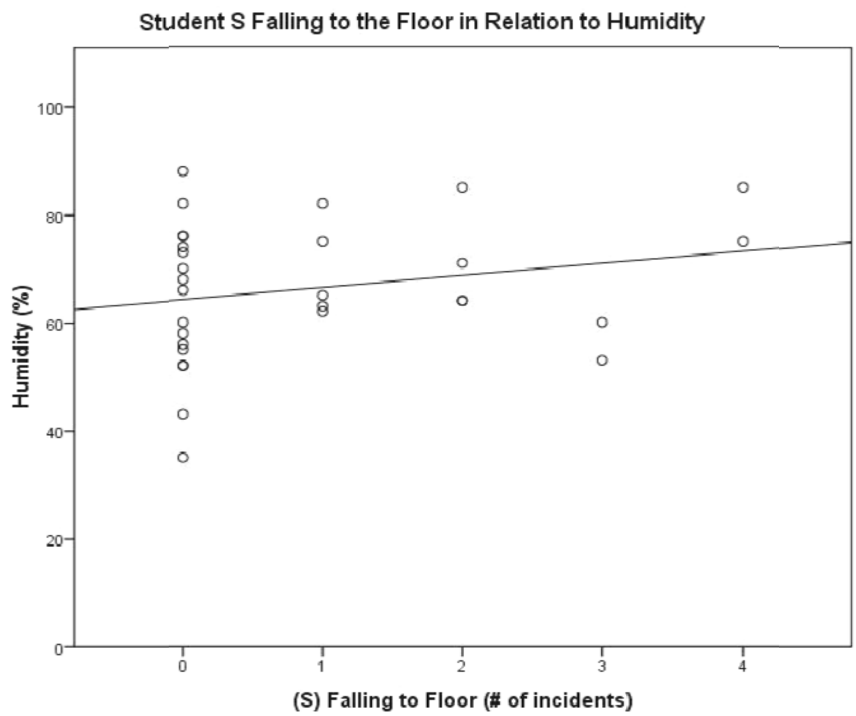

Figure 30.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The direction of the best-fit line is relatively flat for scatter plot for screaming and falling to the floor. These results indicate that there is little relationship between student S's behaviors of screaming and falling to the floor and humidity.

Student K. Figures 31-33 present the scatter plots of academic performance in relation to humidity for student K.

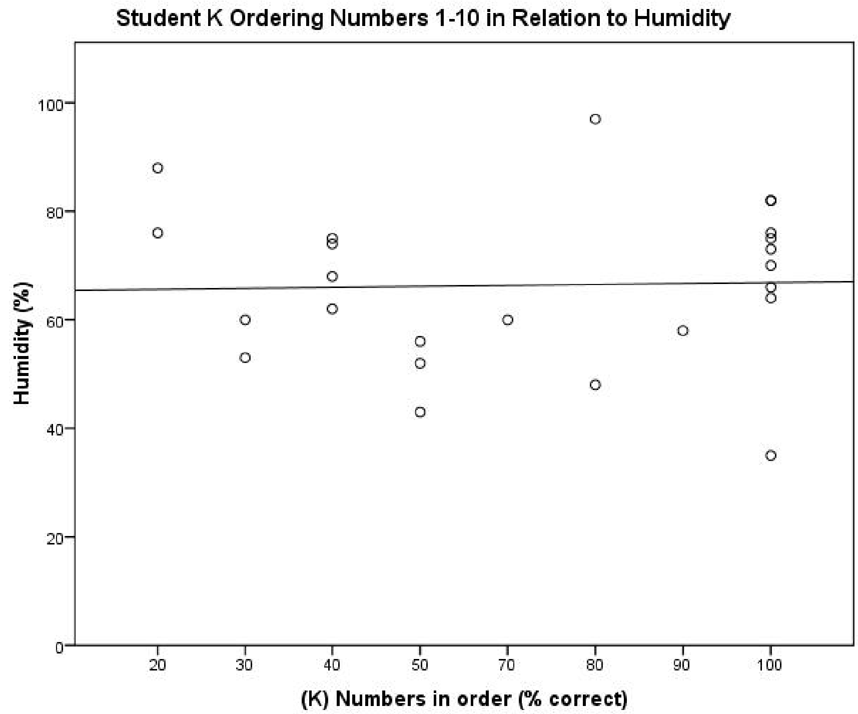

Figure 31.

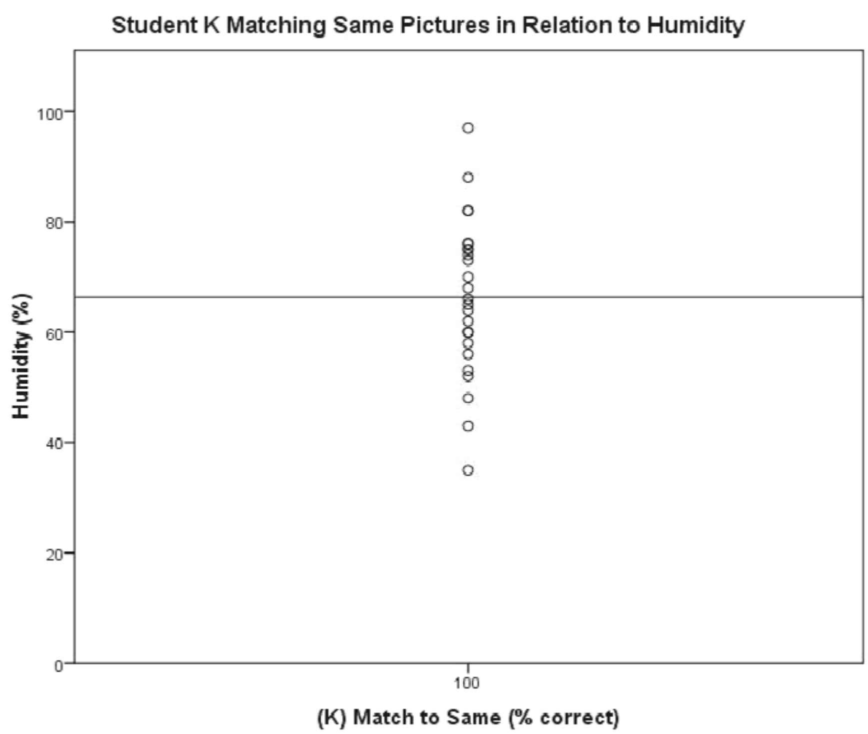

Figure 32.

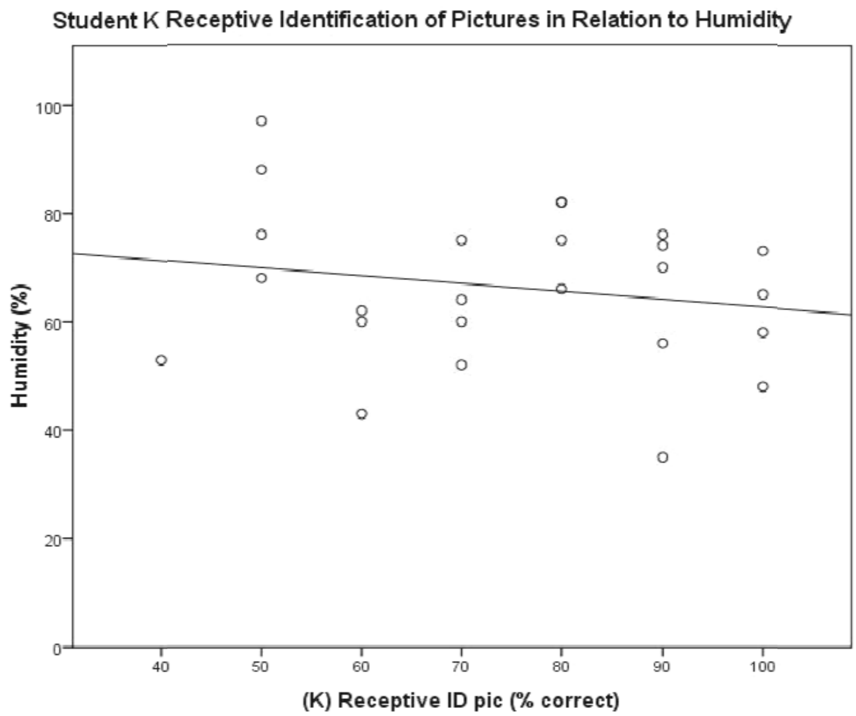

Figure 33.

Minimal variability was observed in student K's academic performance data for matching same pictures, which was measured in percent correct. His academic performance tasks of ordering numbers and receptively identifying pictures of common objects display more variability. The mean for student K's ordering numbers 1 through 10 was 69%, with a range of 20 to 100 % correct. The mean for matching same pictures was 100%. The academic performance data for receptively identifying pictures of common objects has a mean of 75 with a range from 40 to 100 % correct. The scatter plot for matching same pictures compared to humidity reflects a relatively flat best-fit line with the majority of data points creating a straight vertical line reflecting very low variability in scores. While the scatter plots for ordering numbers 1 through 10 and receptively identifying pictures of common objects show more variability, the best-fit line for both remains relatively flat. This pattern indicates no directionality or relationship between the variables. Therefore, the inference is that there is little to no relationship between student K's academic performance and humidity.

Data on the frequency of biting, head-butting, and hitting were collected for student K and compared to humidity data to determine the relationship between humidity and observable classroom behaviors. The daily mean for biting was 1.04 with a range of 0 to 13 instances. Student K's hitting behavior had a mean of 8 with a range of 0 to 56 instances. Head-butting behavior had a mean of 7.33 with a range from 0 to 48. Figures 34-36 show the scatter plots for each behavior in relation to humidity.

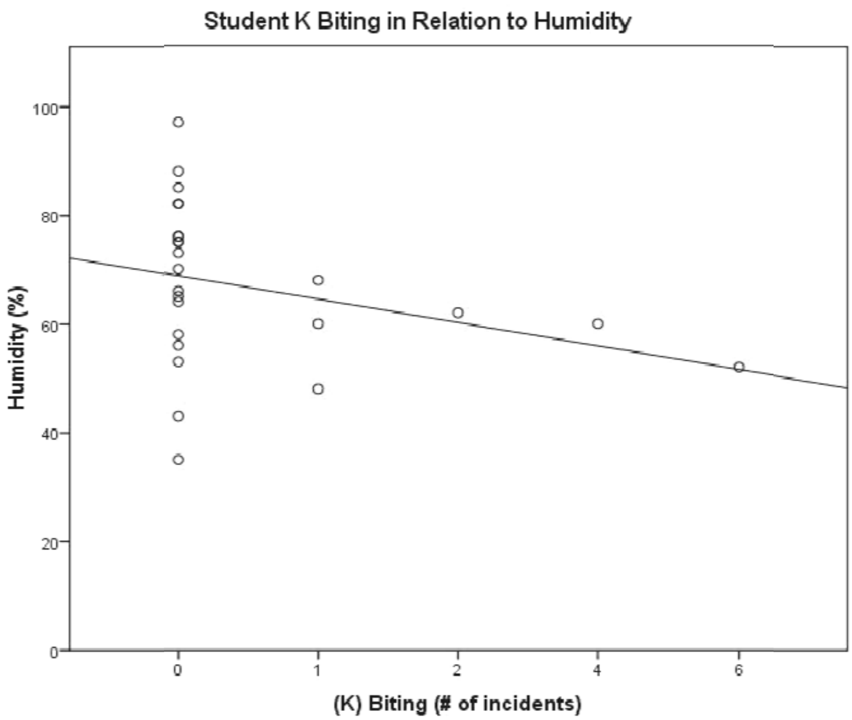

Figure 34.

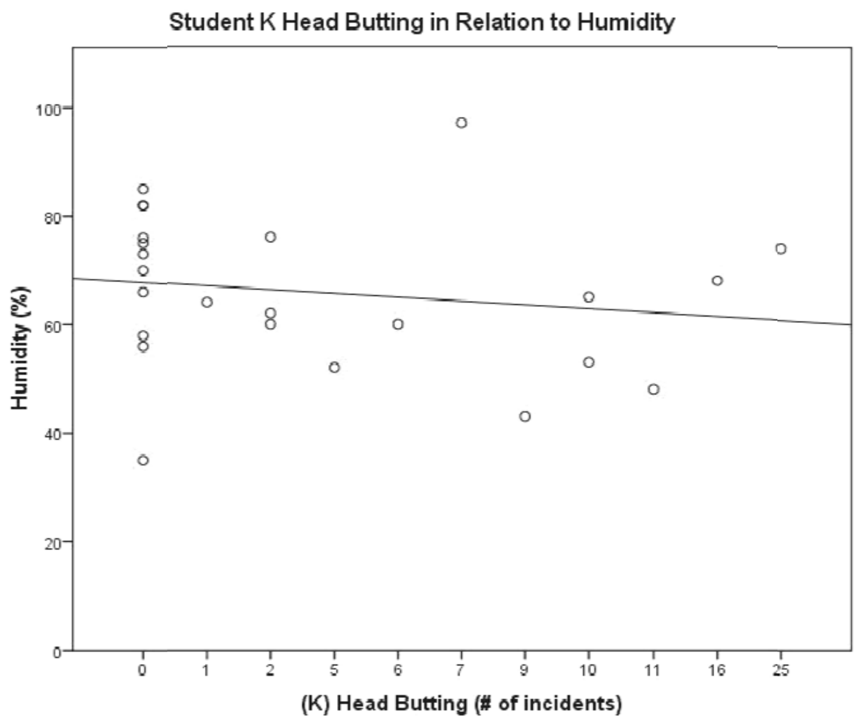

Figure 35.

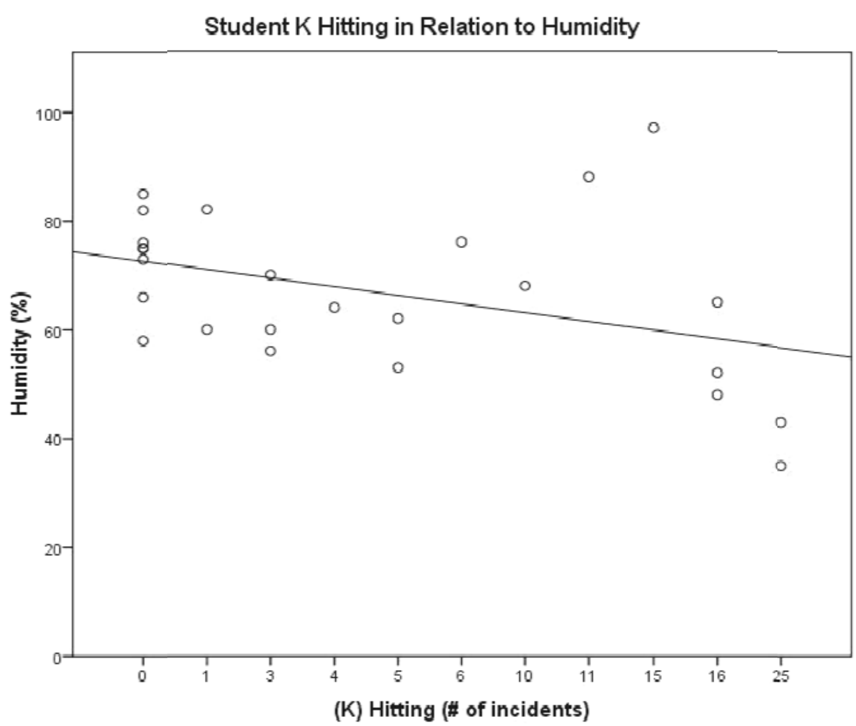

Figure 36.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The best-fit line is relatively flat for the scatter plot concerning head-butting, indicating there is no relationship between the variables. While the line of best fit for biting may visually indicate a weak negative relationship, the majority of points are arranged in a straight vertical line again suggesting no relationship between the variables. The points on the scatter plot for hitting shows the points more closely together with a best-fit line moving from the upper left to lower right of the graph. This indicates that a weak negative relationship may exist between student K's hitting behavior and humidity. That is, when the humidity increased, K was less inclined to hit at school. These results indicate that there is little relationship between student K's biting and head-butting in relation to humidity; and a weak negative relationship between hitting and humidity.

Moon Illumination.

Q1c: What is the relationship between moon illumination and academic performance and classroom behaviors of students with ASD?

Student E. Figures 37-39 present the scatter plots of academic performance in relation to moon illumination for student E.

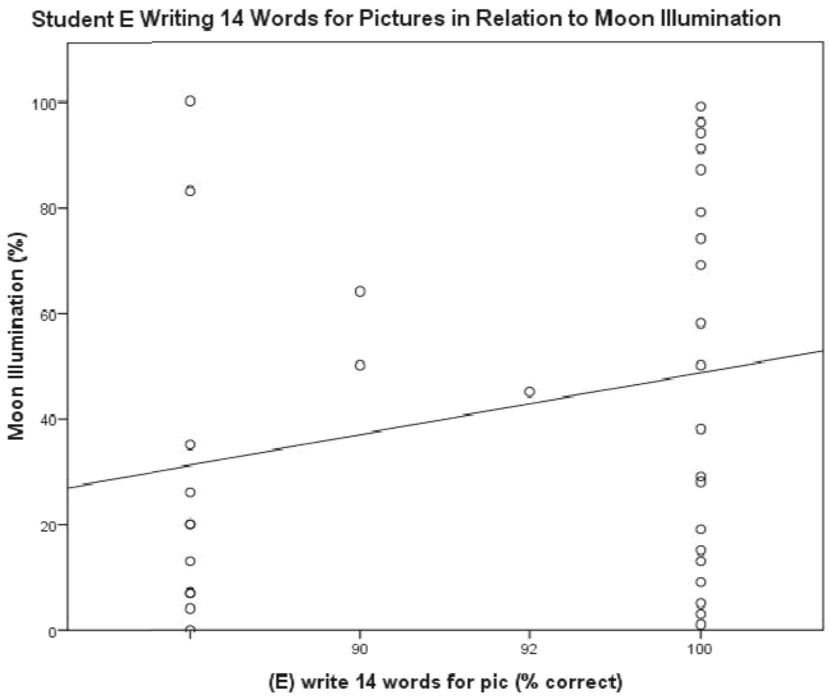

Figure 37. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

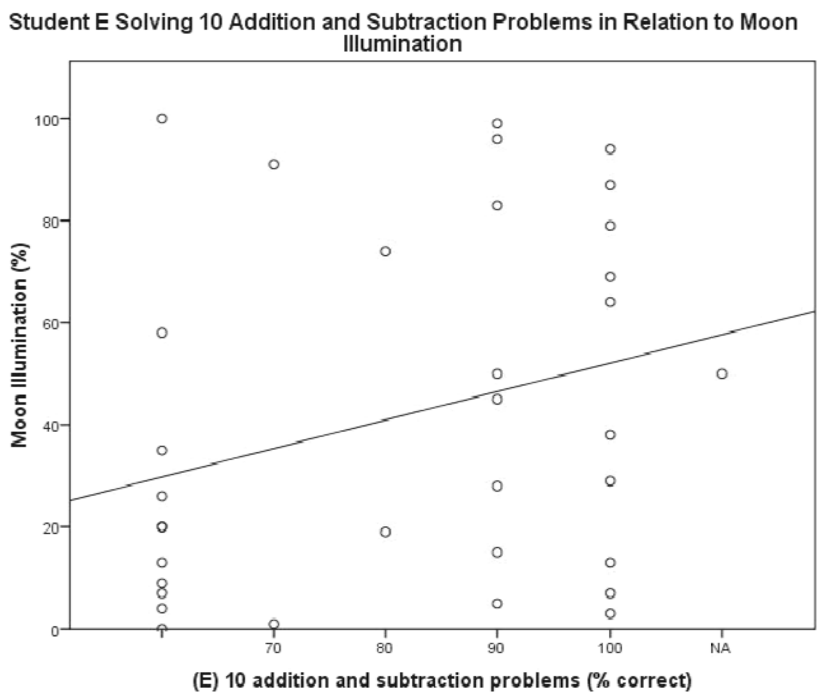

Figure 38. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

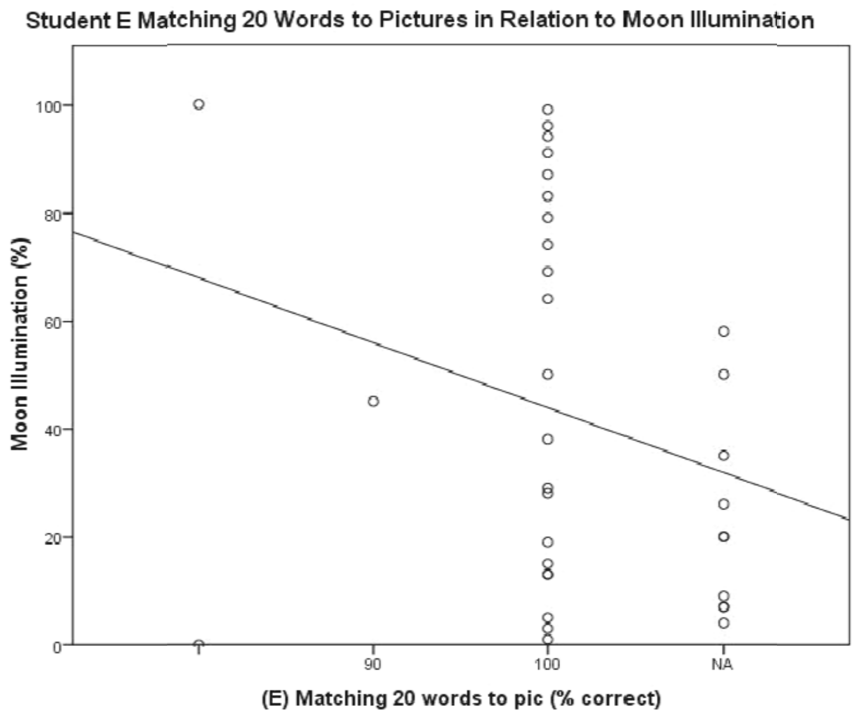

Figure 39. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

Minimal variability was observed in student E's academic performance data. The mean for student E's matching 20 words to pictures was 100%. The mean for writing 14 words for pictures was 99% and solving addition and subtraction problems 92%. In addition, student E had observation periods where he would not comply with academic tasks. Those instances are to the far left on the scatter plot. The points on each scatter plot are in no way tightly arranged. Therefore the inference is that there is little to no relationship between the variables. Additionally, the best-fit line on all 3 scatter plots moves from the lower left to the upper right, suggesting a weak positive relationship between the variables. There were instances where E had periods of non-compliance. At these times he would not complete the academic activities. Those instances are the points to the far left that make a vertical line. It appears that the instances have an effect on the best-fit line. That is, the points in the bottom left quadrant cause the line to be pulled down in that direction, causing the line to visually show a positive relationship and have an effect on these scatter plots influencing the line of best fit. However, noncompliance was not directly measured, making inferences concerning these data unfounded. These results indicate a weak positive relationship between performance on addition and subtraction problems and matching words to pictures when compared to moon illumination. This indicates that as the moon illumination increases toward a full moon status, E's accuracy on solving addition and subtraction problems and matching words to pictures tended to increase.

Data on the frequency of elopement, kicking, and hitting were collected for student E and compared to percent moon illumination data to determine the relationship between moon illumination and observable classroom behaviors. The daily mean for hitting was 3.09 with a range of 0 to 27 instances. Student E's kicking behavior had a mean of 1.19 with a range of 0 to 7 instances. Elopement had a mean of 2 and a range of 0 to 10. Figures 40-42 show the scatter plots for each behavior in relation to moon illumination.

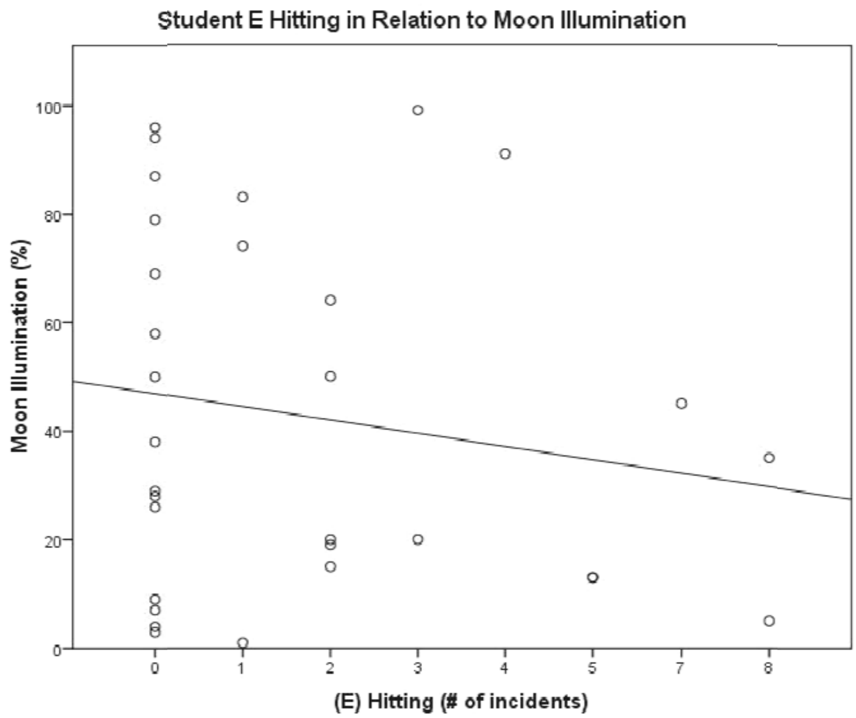

Figure 40.

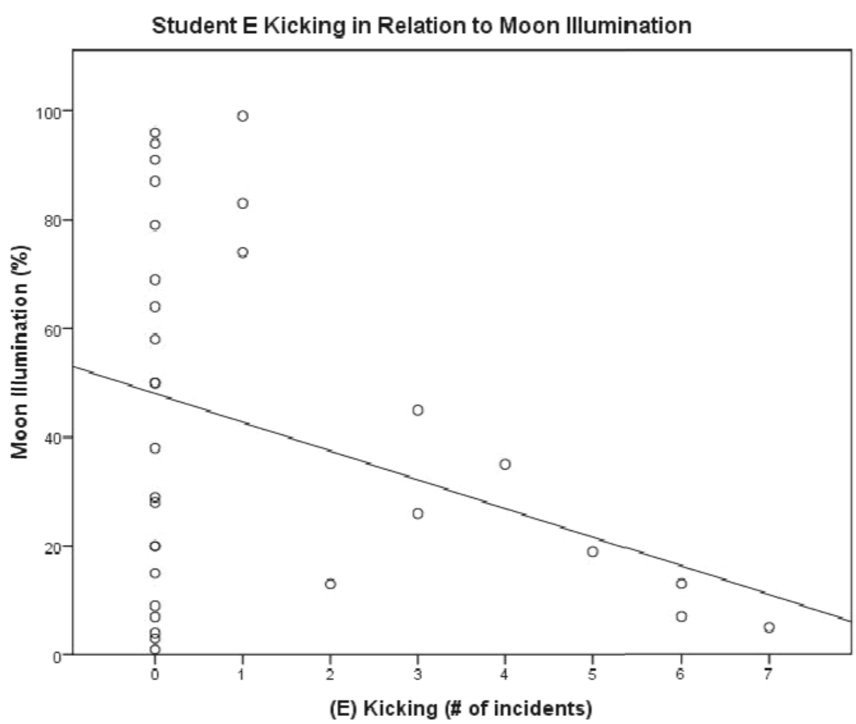

Figure 41.

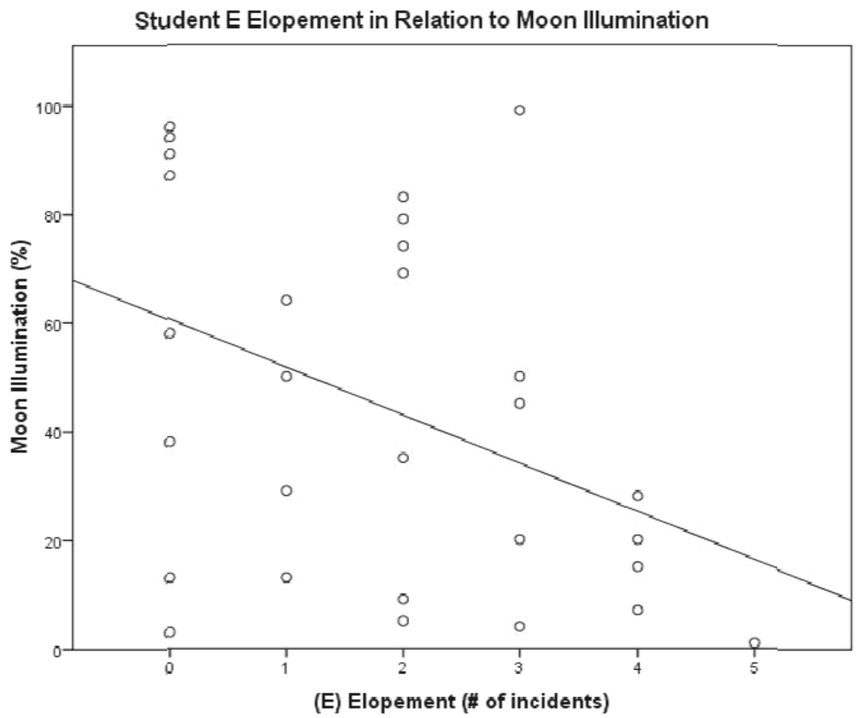

Figure 42.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The direction of the best-fit line is relatively flat for scatter plot for hitting in relation to moon illumination. These results indicate that there is little relationship between hitting and moon illumination. The data points for kicking and elopement compared to moon illumination show best-fit lines indicating a weak negative direction moving from upper left to lower right on the scatter plot. This suggests that as the moon illumination increases, E tends to engage in less frequent kicking and elopement behaviors at school. Likewise, as the moon illumination decreases, E tends to engage more frequently in kicking and elopement behaviors.

Student S. Figures 43-46 present the scatter plots of academic performance in relation to moon illumination for student S.

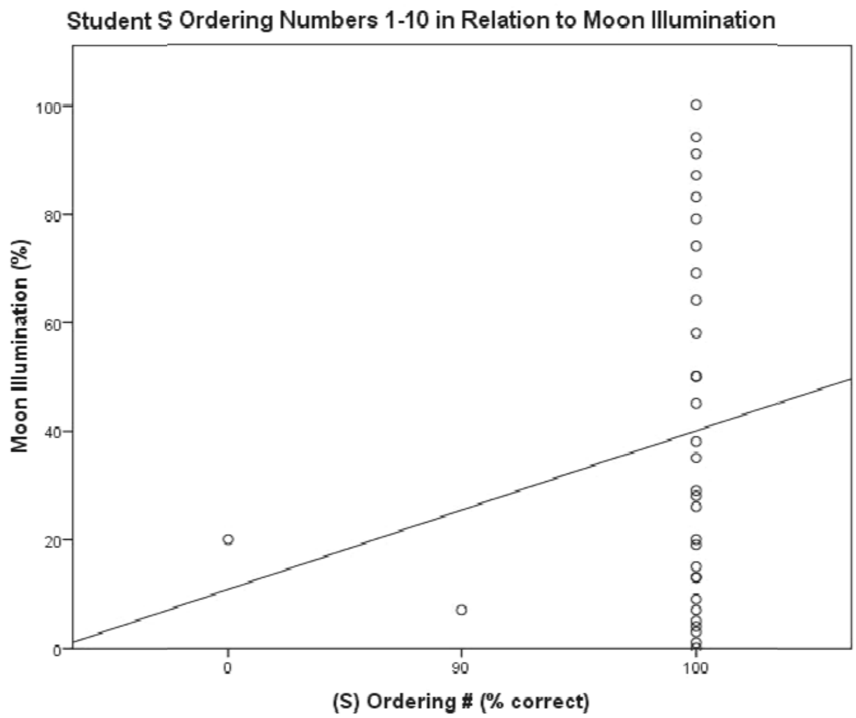

Figure 43.

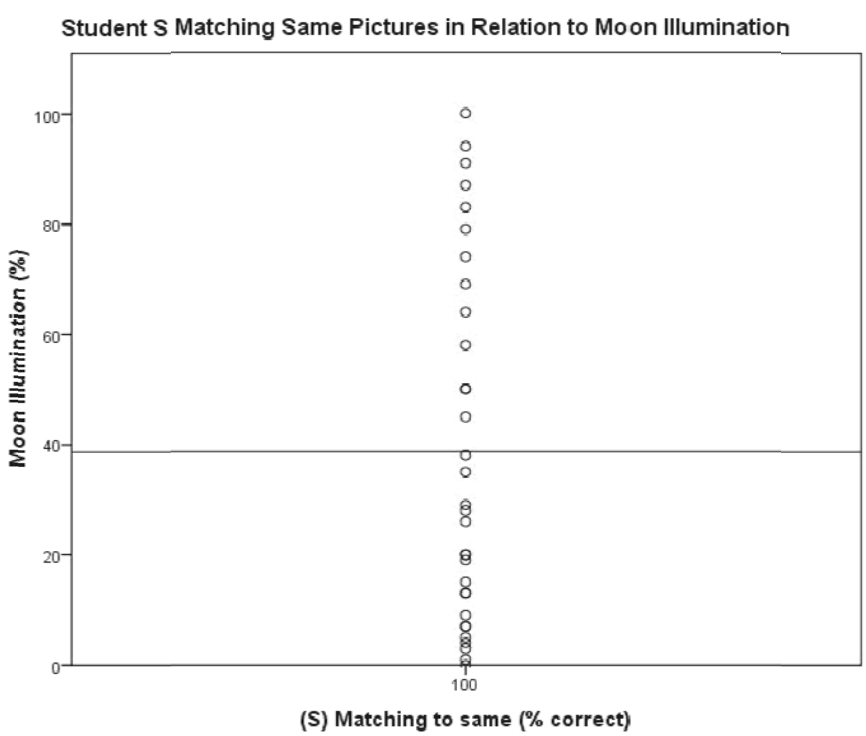

Figure 44.

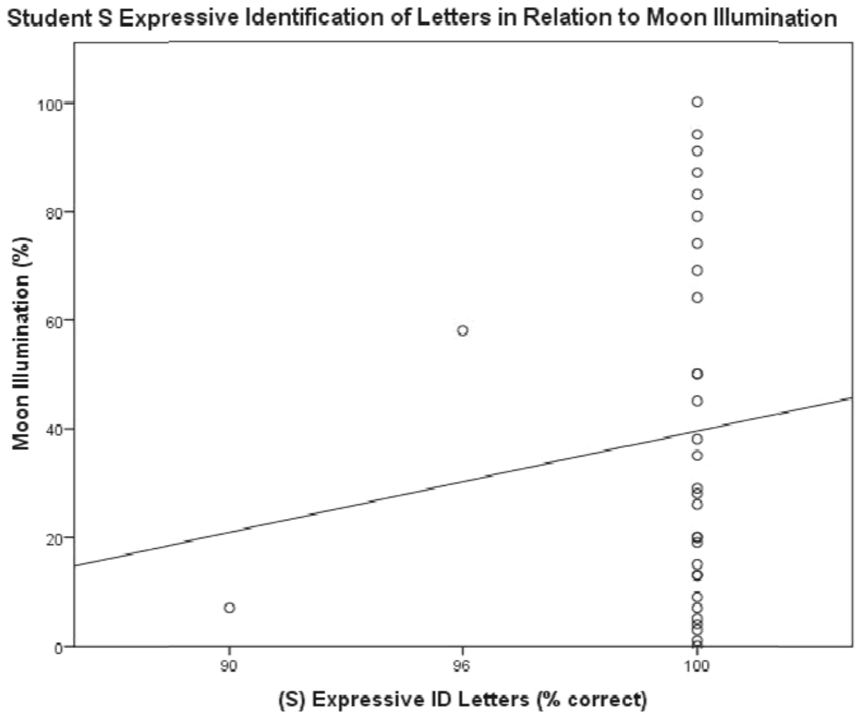

Figure 45.

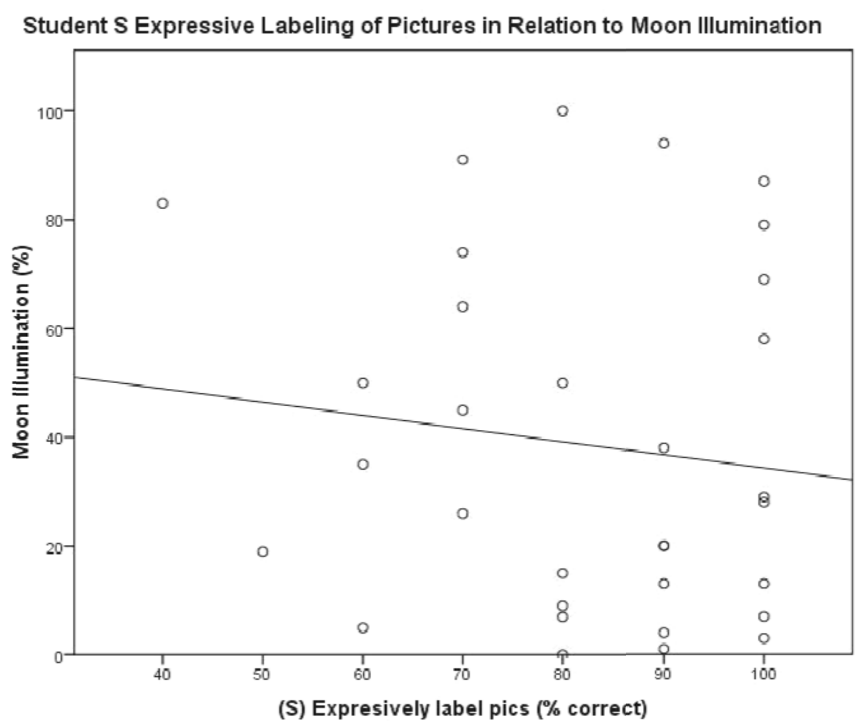

Figure 46.

Minimal variability was observed in student S's academic performance data, which was measured in percent correct. The mean for student S's ordering numbers 1 through 10 was 96.56. The mean for matching same pictures was 100. The academic performance data for expressively identifying letters had a mean of 99.56 and expressively labeling pictures of common objects had a mean of 82.19. The scatter plots for ordering numbers and expressively identifying letters show lines of best fit that are affected by extreme scores. Therefore, even though the directionality of the best-fit line might suggest a relationship, it is concluded that there is no relationship between ordering numbers and expressively identifying letters. The scatter plots for matching same pictures and expressively identifying pictures of common objects show relatively flat best-fit lines which also indicate no relationship between variables. The results for student S thus indicate no relationship between the academic performance variables and moon illumination.

Data on the frequency of screaming and falling to the floor were collected for student S and compared to percent moon illumination data to determine the relationship between moon illumination and observable classroom behaviors. The mean for screaming was 5.39 with a range of 0 to 22 instances. Student S's falling to the floor behavior had a mean of 1.09 with a range of 0 to 8 instances. Figures 47 and 48 show the scatter plots for each behavior in relation to moon illumination.

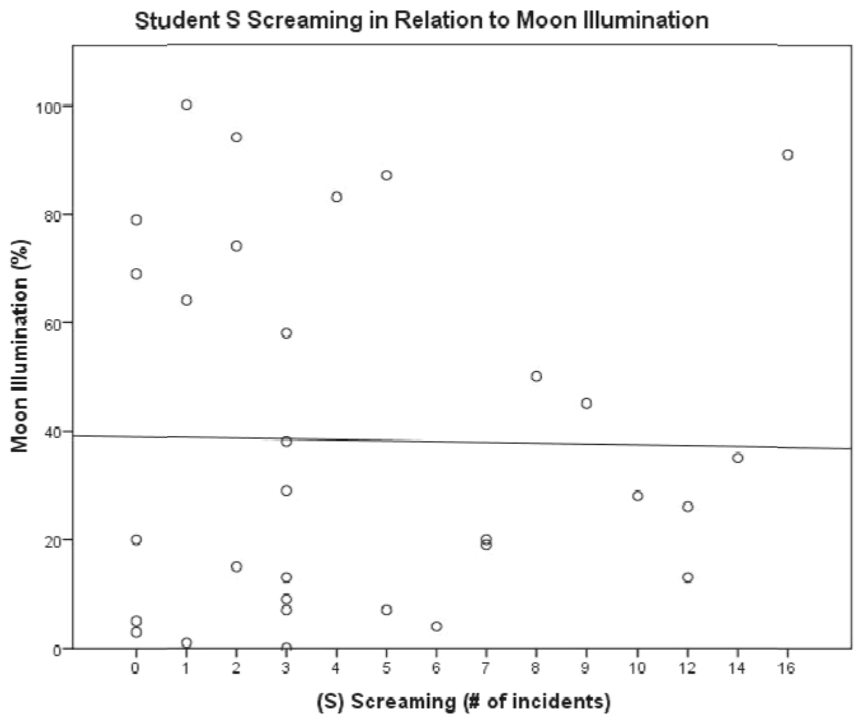

Figure 47.

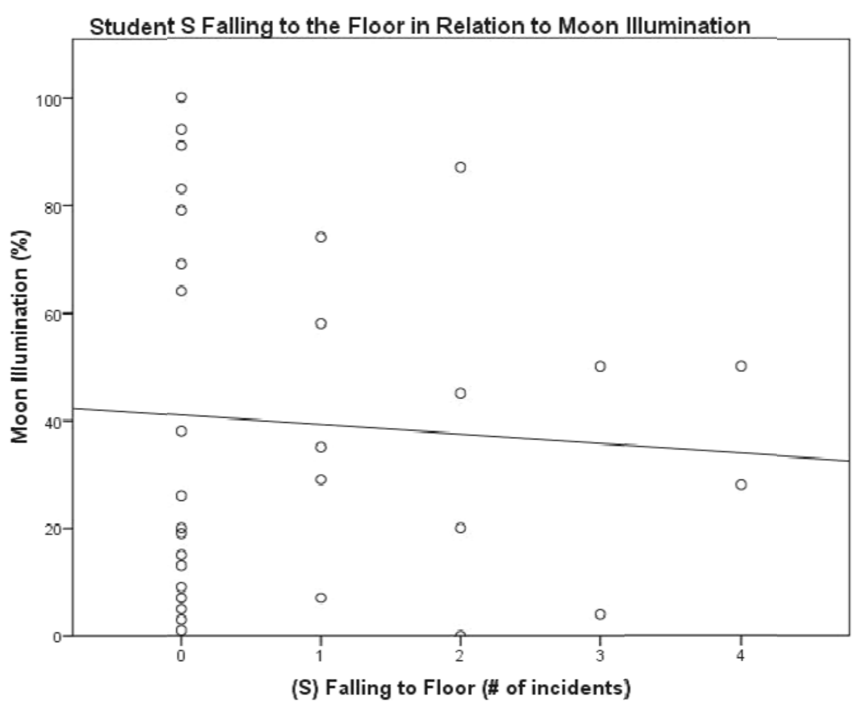

Figure 48.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The direction of the best-fit line is relatively flat for scatter plots for screaming and falling to the floor. These results indicate that there is little relationship between student S's behaviors of screaming and falling to the floor and moon illumination.

Student K.

Figures 49-51 present the scatter plots of academic performance in relation to moon illumination for student K.

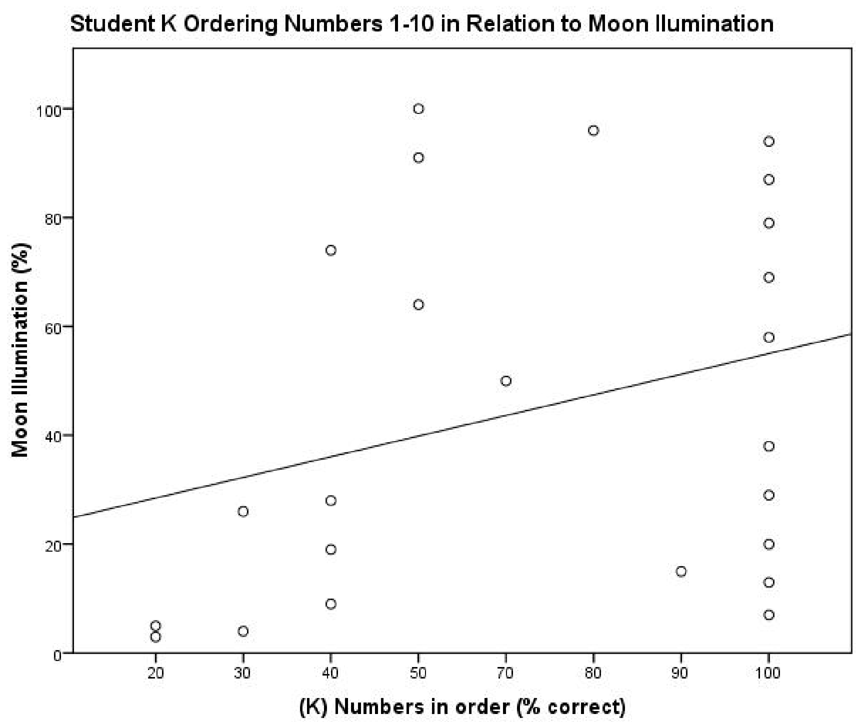

Figure 49.

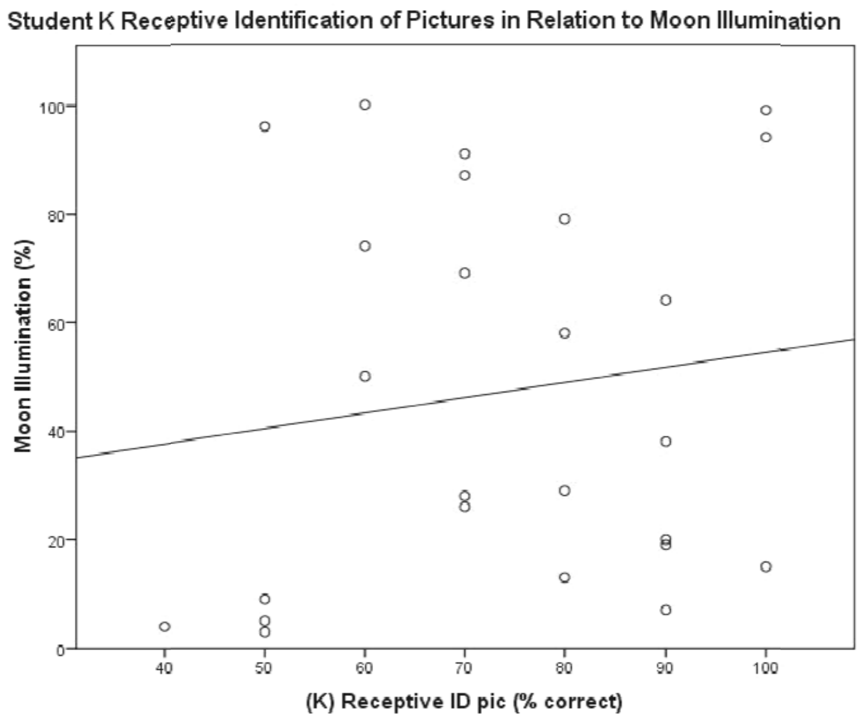

Figure 50.

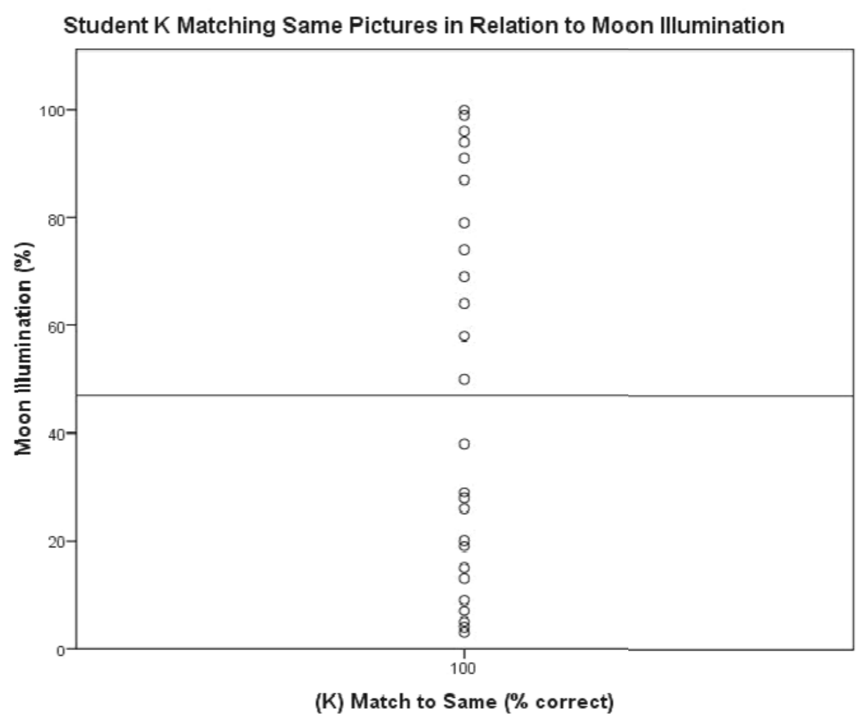

Figure 51.

Minimal variability was observed in student K's academic performance data for matching same pictures, which was measured in percent correct. His academic performance tasks of ordering numbers and receptively identifying pictures of common objects display more variability. The mean for student K's ordering numbers 1 through 10 was 69%, with a range of 20 to 100 % correct. The mean for matching same pictures was 100%. The academic performance data for receptively identifying pictures of common objects had a mean of 75% with a range from 40 to 100 % correct. The scatter plot for matching same pictures compared to moon illumination shows a relatively flat best-fit line with the data points creating a straight vertical line reflecting no variability in scores; therefore no relationship exists between these variables. While the scatter plots for ordering numbers 1 through 10 and receptively identifying pictures of common objects show more variability, the best-fit lines indicate a relationship existed. The best-fit line for ordering numbers indicates a positive relationship between moon illumination and ordering numbers. That is, as the moon illumination increases, student K's accuracy for ordering numbers tends to increase. The best-fit line for identifying pictures of common objects is relatively flat, indicating no relationship between identifying pictures of common objects and moon illumination. Therefore, the inference is that there is little to no relationship between the variables of identifying pictures and matching pictures and moon illumination. There is a weak positive relationship between ordering numbers and moon illumination for student K's academic performance.

Data on the frequency of biting, head-butting and hitting were collected for student K and compared to percent moon illumination data to determine the relationship between percent moon illumination and observable classroom behaviors. The daily mean for biting was 1.04 with a range of 0 to 13 instances. Student K's hitting behavior had a mean of 8 with a range of 0 to 56 instances. Head-butting behavior had a mean of 7.33 with a range from 0 to 48. Figures 52-54 show the scatter plots for each behavior in relation to moon illumination.

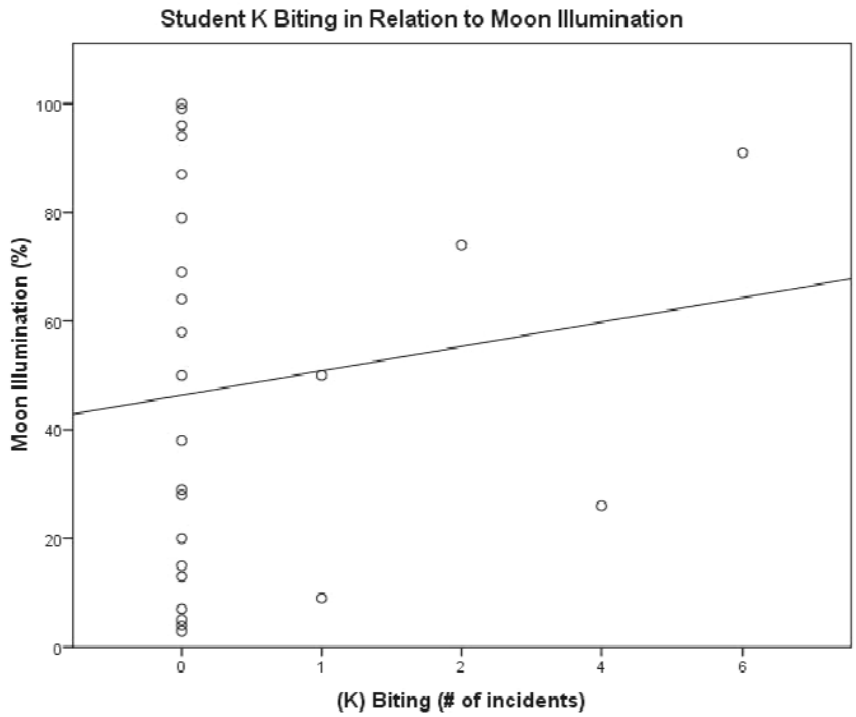

Figure 52.

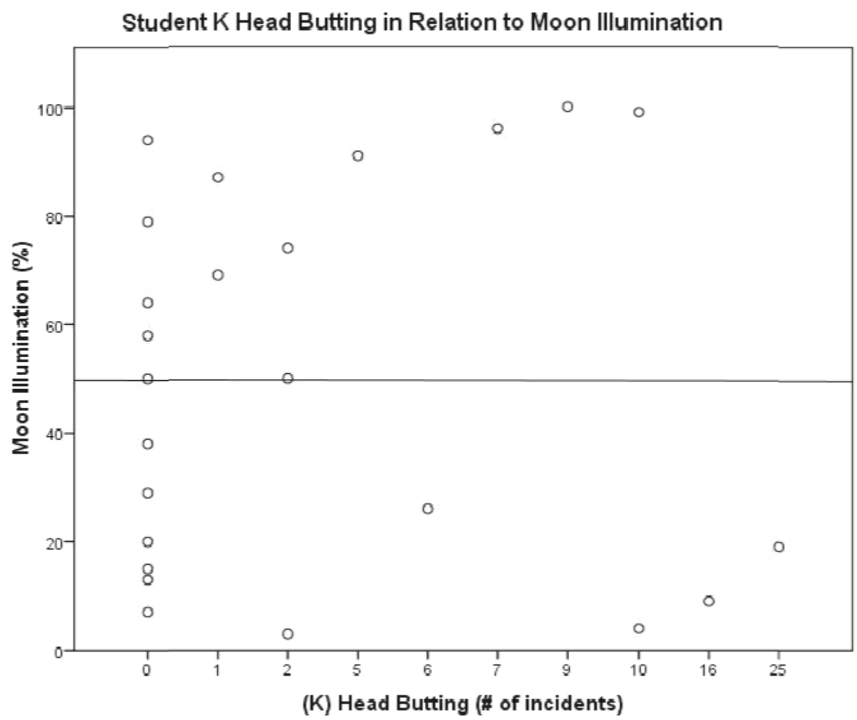

Figure 53.

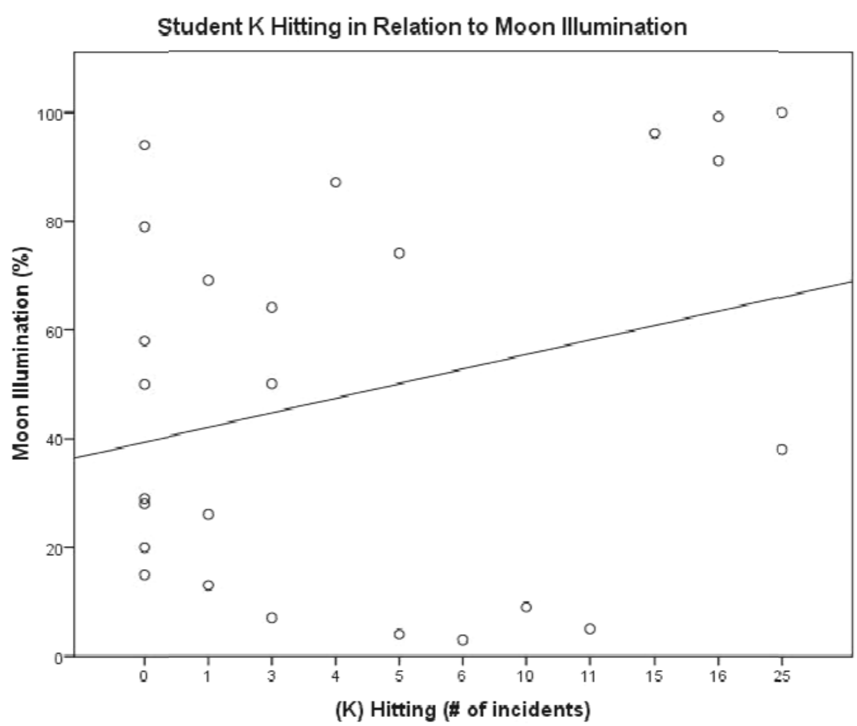

Figure 54.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The best-fit line is relatively flat for the scatter plots concerning head-butting and biting, indicating there is no relationship between the variables. The scatter plot for hitting shows more variability in the behavior and has a fit line that indicates a weak positive relationship between hitting and moon illumination. Thus, as moon illumination is higher student K tends to engage in more hitting behaviors at school. These results for student K suggest no relationship between biting and head-butting when compared to moon illumination and a week positive relationship between hitting and moon illumination.

Temperature.

Q1d: What is the relationship between temperature and academic performance and classroom behaviors of students with ASD?

Student E. Figures 55-57 present the scatter plots of academic performance in relation to temperature for student E.

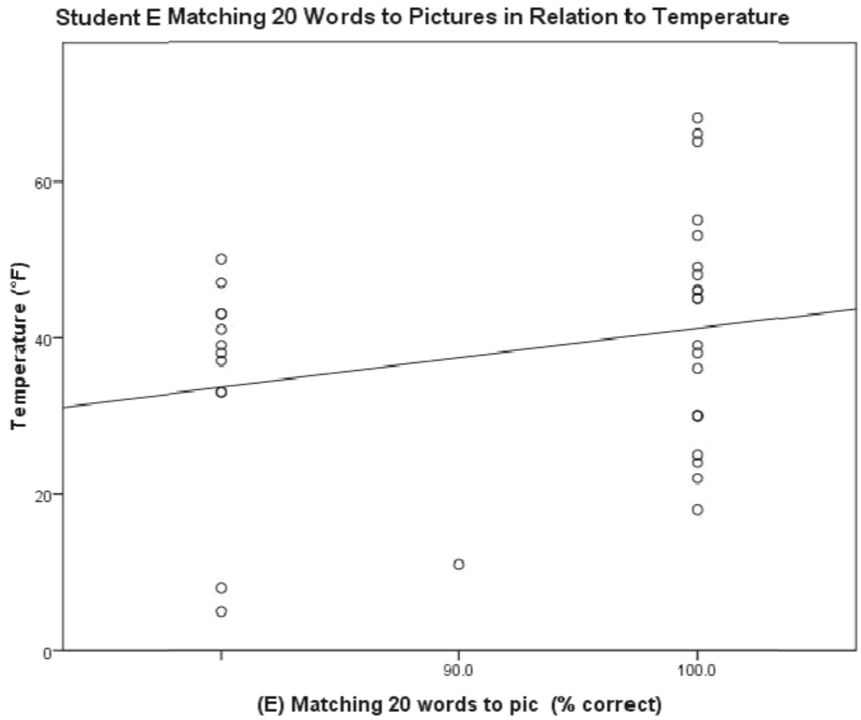

Figure 55. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

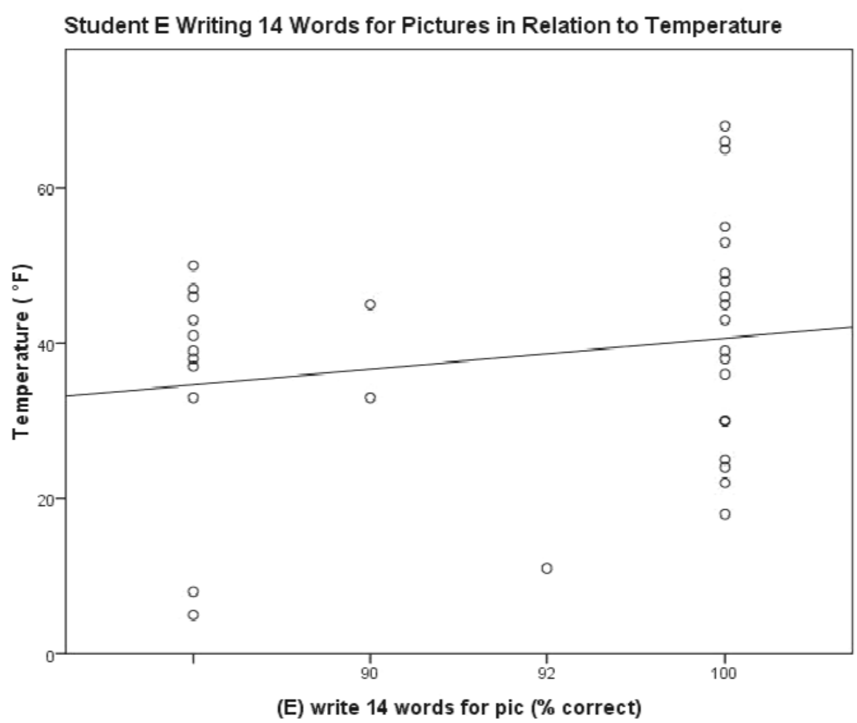

Figure 56. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

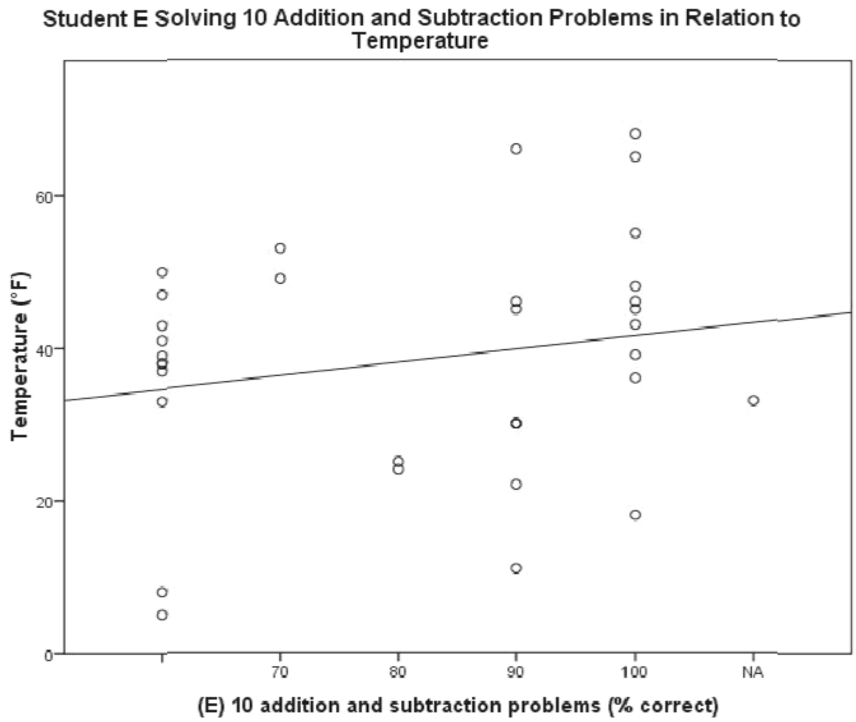

Figure 57. Points on far left are barometric pressures during observation periods during which student did not comply with academic tasks

Minimal variability was observed in student E's academic performance data. The mean for student E's matching 20 words to pictures was 100%. The mean for writing 14 words for pictures was 99% and solving addition and subtraction problems 92%. In addition, student E had observation periods where he would not comply with academic tasks. Those instances are shown on the far left of the scatter plot graph. The points on scatter plots for matching words and writing words are not tightly arranged, but tend to form vertical lines at the high and low ends of the x-axis. The scatter plot for addition and subtraction facts shows relatively more variability. The lines of best fit for each of the 3 scatter plots are relatively flat. These results suggest that there is no relationship between academic performance and temperature for student E.

Data on the frequency of elopement, kicking, and hitting were collected for student E and compared to temperature data to determine the relationship between temperature and observable classroom behaviors. The daily mean for hitting was 3.09 with a range of 0 to 27 instances. Student E's kicking behavior had a mean of 1.19 with a range of 0 to 7 instances. Elopement had a mean of 2 and a range of 0 to 10. Figures 58-60 show the scatter plots for each behavior in relation to temperature.

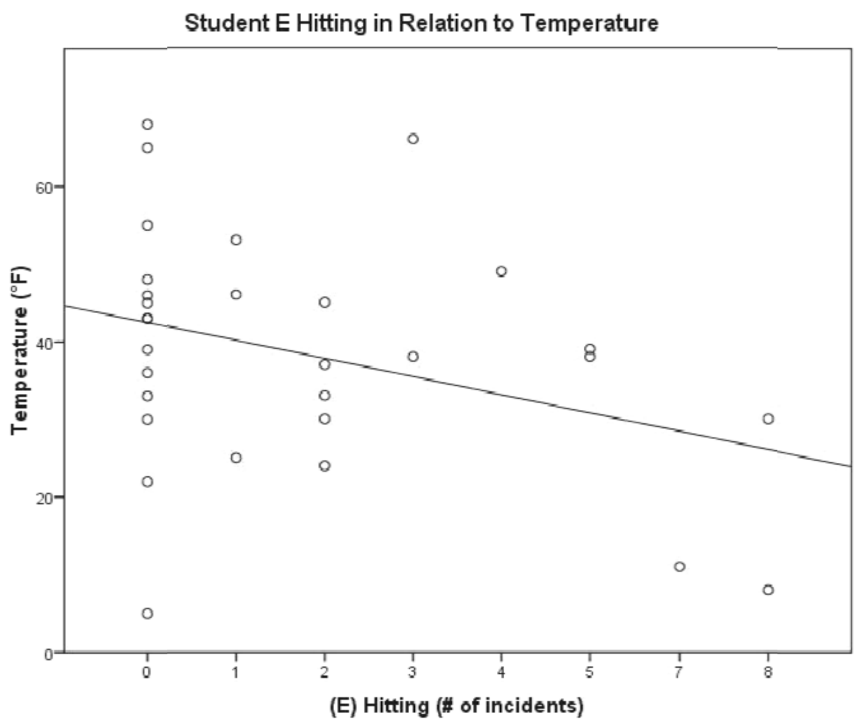

Figure 58.

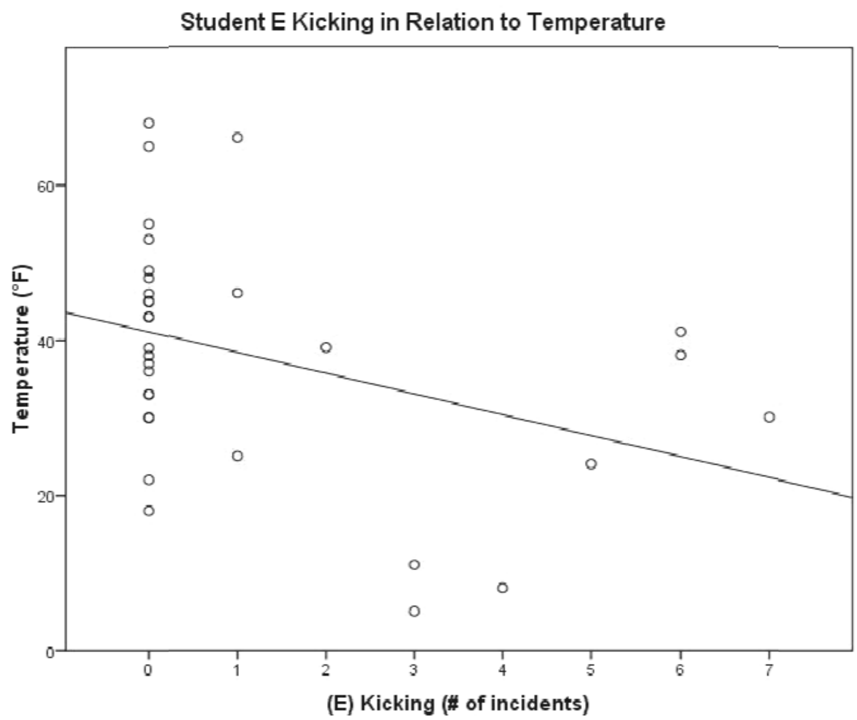

Figure 59.

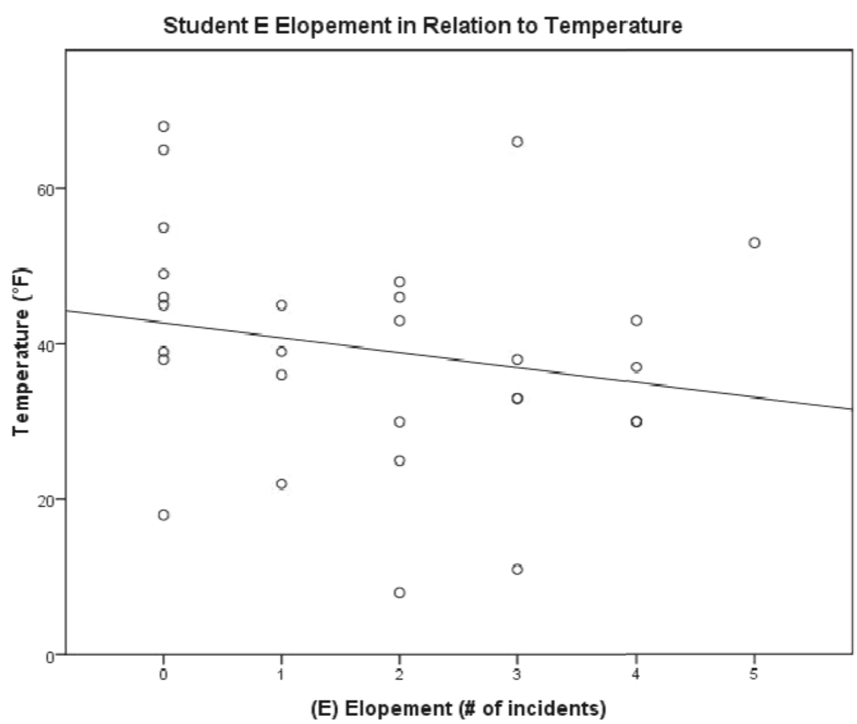

Figure 60.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The scatter plot for elopement has a relatively flat line indicating no relationship between elopement and temperature. The direction of the best-fit line for hitting and kicking scatter plots move from the upper left to lower right quadrant of each graph indicates a negative relationship for these variables relative to temperature. These results indicate a weak relationship. Thus, the trend of this relationship suggests that as the temperature increases student E's frequency of hitting and kicking behaviors tends to decrease at school. There appears to be no relationship between temperature and elopement.

Student S. Figures 61-64 present the scatter plots for academic performance in relation to temperature for student S.

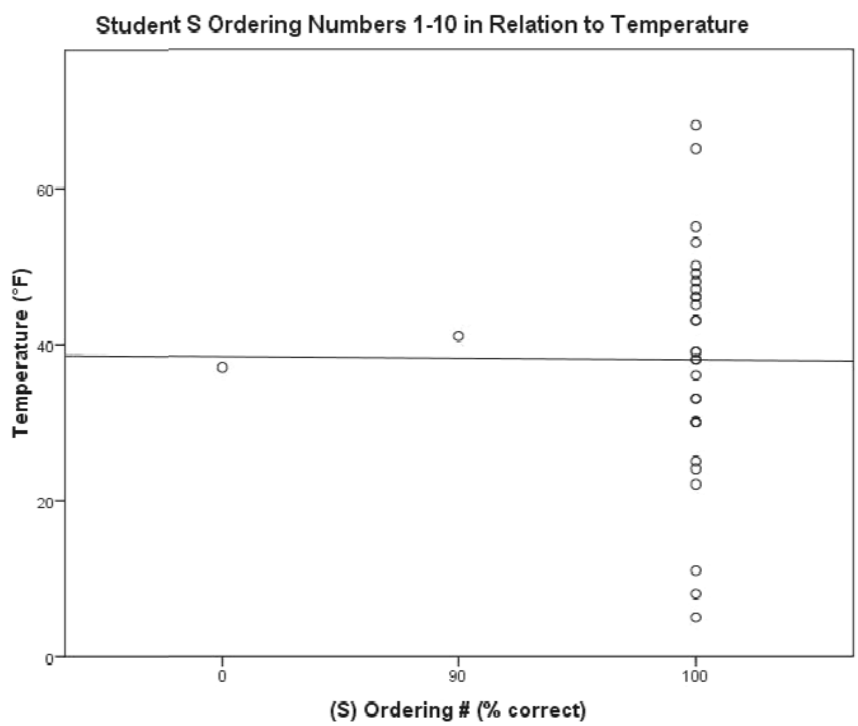

Figure 61.

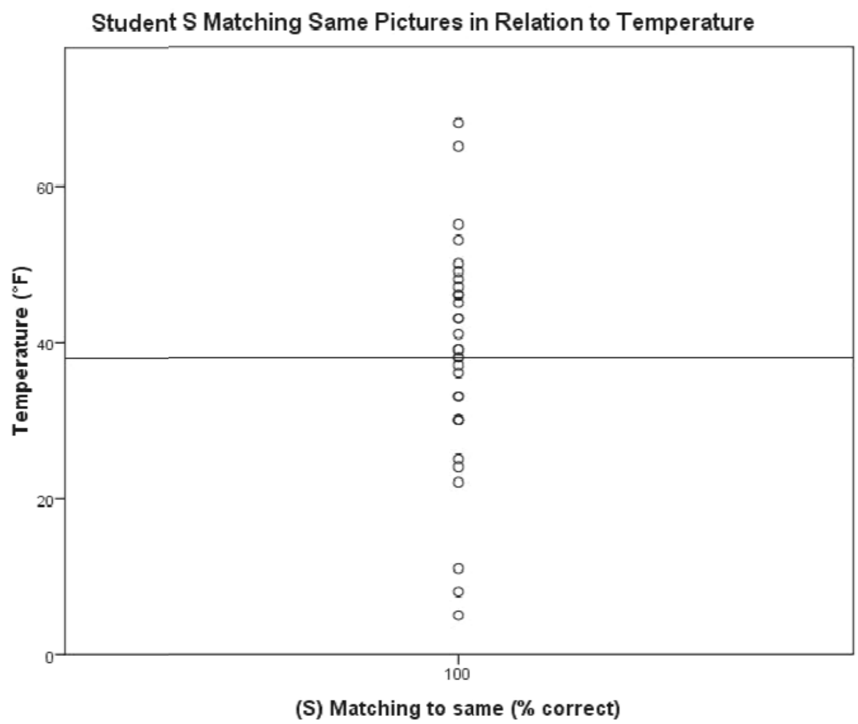

Figure 62.

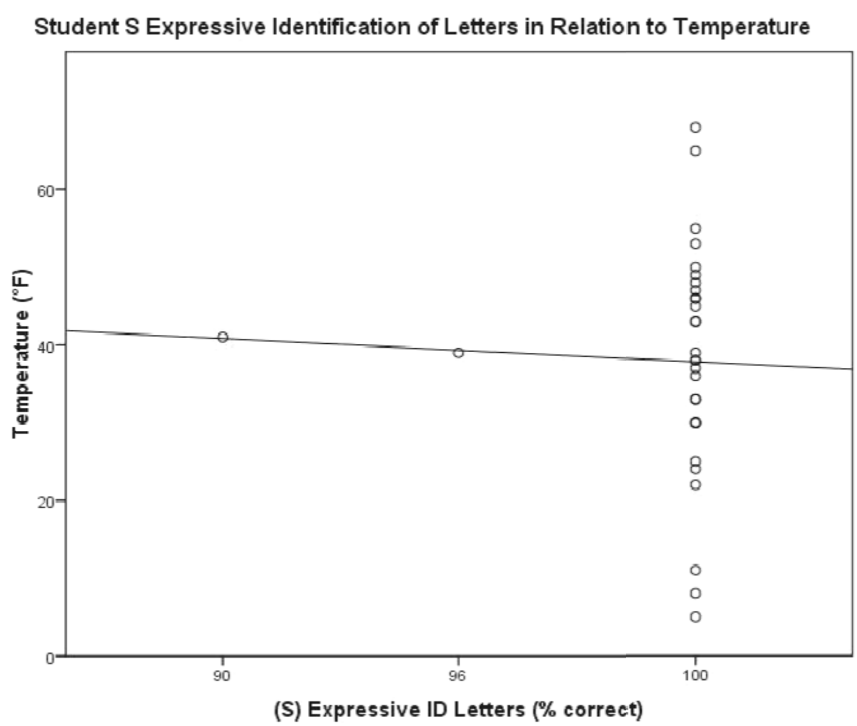

Figure 63.

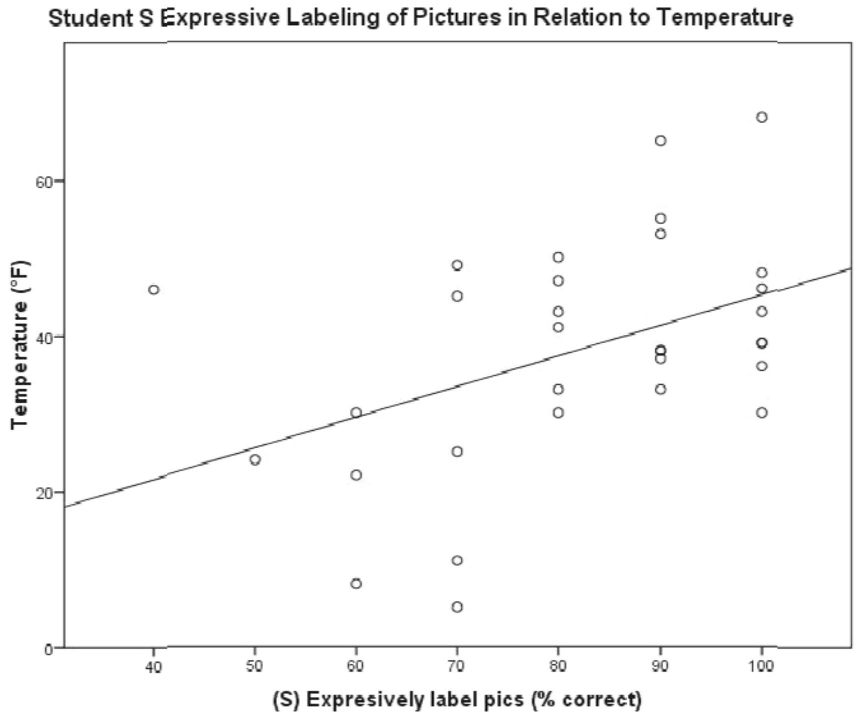

Figure 64.

Minimal variability was observed in student S's academic performance data, which was measured as percent correct. The mean for student S's ordering numbers 1 through 10 was 96.56%. The mean for matching same pictures was 100%. The academic performance data for expressively identifying letters had a mean of 99.56% while expressively labeling pictures of common objects had a mean of 82.19%. The scatter plots for ordering numbers, expressively identifying letters, and matching same pictures show data points forming straight vertical lines reflective of low variability in scores, with relatively flat lines of best fit. These trends indicate that there is no relationship between student S's performance on these tasks and outside temperature. The scatter plot for expressively identifying pictures of common objects shows a best-fit line which moves from the lower left to upper right quadrant of the graph, suggesting a positive relationship. This trend would suggest that as temperature rises student S's accuracy in expressively identifying pictures tends to increase. The results for student S thus indicate no relationship between ordering numbers and expressively identifying letters and temperature and a weak positive relationship between expressively labeling pictures of common objects and temperature.

Data on the frequency of screaming and falling to the floor were collected for student S and compared to temperature data to determine the relationship between temperature and observable classroom behaviors. The mean for screaming was 5.39 with a range of 0 to 22 instances. Student S's falling to the floor behavior had a mean of 1.09 with a range of 0 to 8 instances. Figures 65 and 66 show the scatter plots for each behavior in relation to temperature.

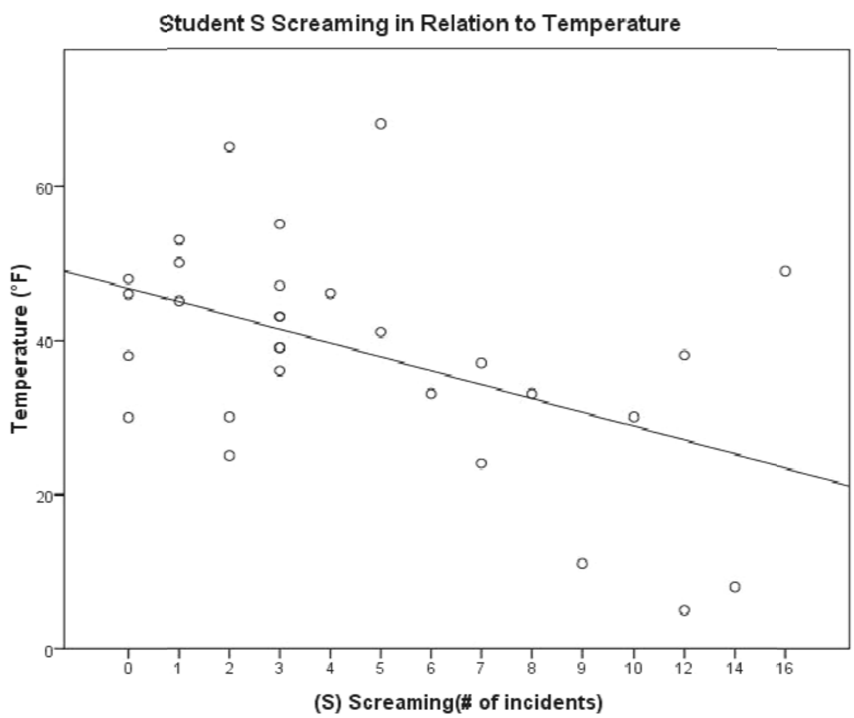

Figure 65.

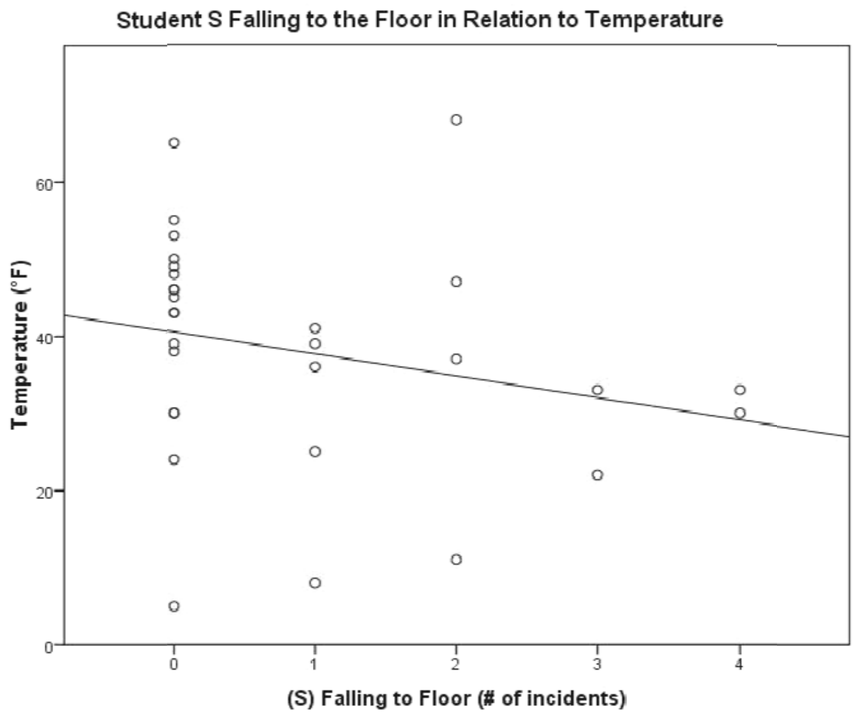

Figure 66.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The direction of the best-fit line is relatively flat for the falling to the floor scatter plot. These results indicate that there is little relationship between student S's falling to the floor and temperature. The scatter plot for screaming shows a best-fit line that indicates a weak negative relationship between falling to the floor and temperature. This indicates that as the temperature increases student S's screaming behavior at school tends to decrease. The results for student S show no relationship between falling to the floor and temperature and a weak negative relationship between screaming and temperature.

Student K. Figures 67-69 present the scatter plots for academic performance in relation to temperature for student K.

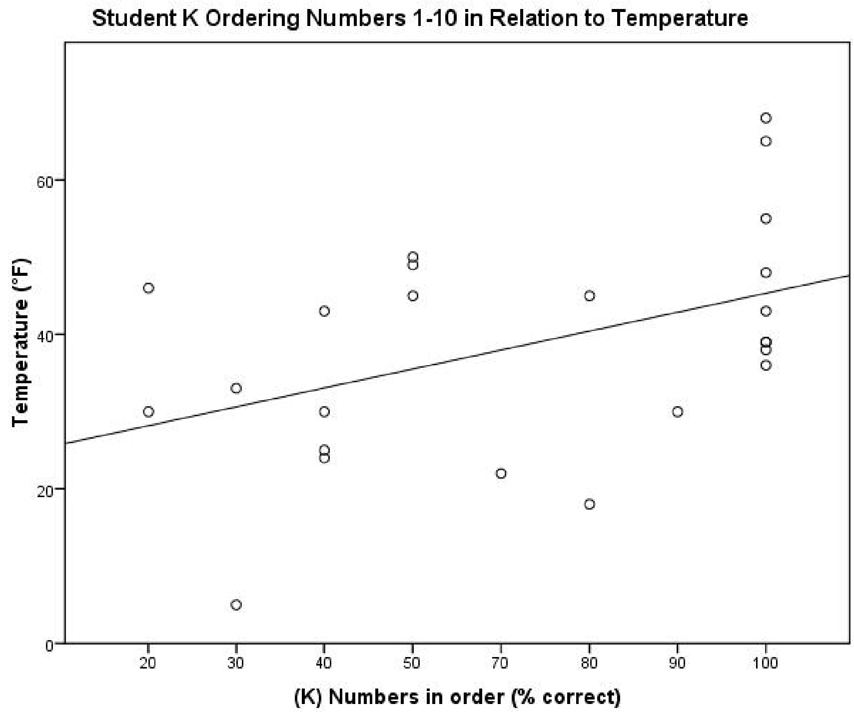

Figure 67.

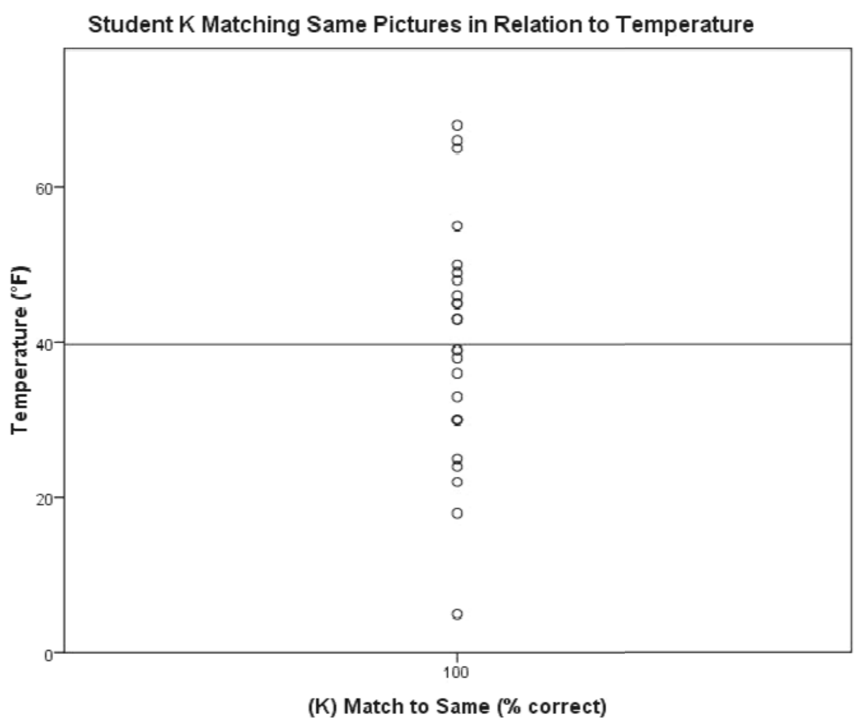

Figure 68.

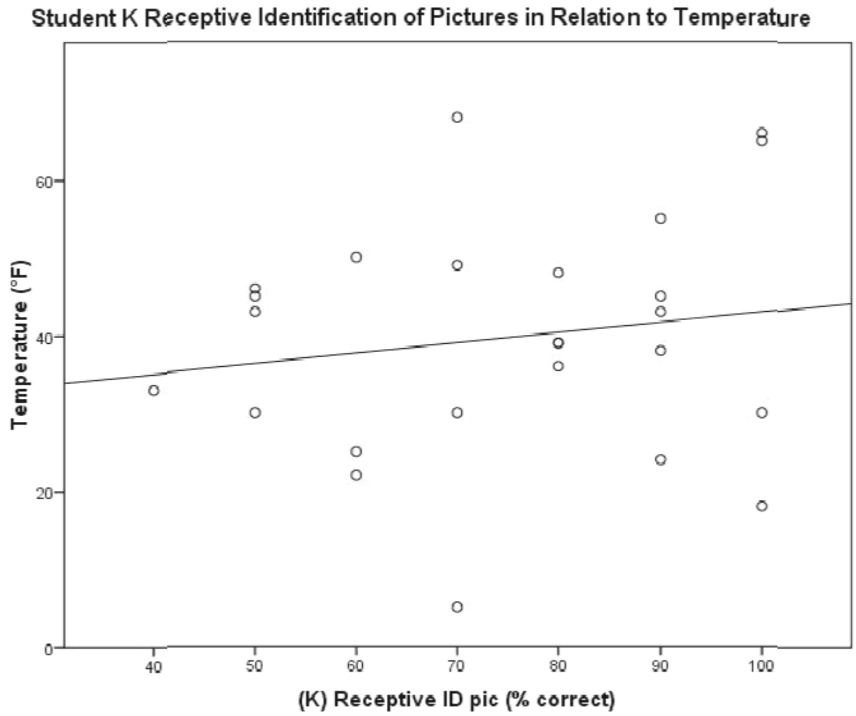

Figure 69.

Minimal variability was observed in student K's academic performance data for matching same pictures, which was measured as percent correct. The graphs of his academic performance tasks of ordering numbers and receptively identifying pictures of common objects display more variability. The mean for student K's ordering numbers 1 through 10 was 69%, with a range of 20 to 100 % correct. The mean for matching same pictures was 100%. The academic performance data for receptively identifying pictures of common objects had a mean of 75% with a range from 40% to 100% correct. The scatter plot for matching same pictures compared to temperature reflects a flat best-fit line with the points creating a straight vertical line. While the scatter plots for receptively identifying pictures of common objects show more variability, the best-fit line for this relationship remains relatively flat indicating no directionality or relationship between the variables. The scatter plot for ordering numbers shows a best-fit line that moves from the lower left to upper right quadrant of the graph indicating a weak positive relationship between ordering numbers and temperature. As the temperature increases student K's accuracy in ordering numbers tends to increase. The results for student K indicate that there is little to no relationship between identifying pictures and receptively identifying pictures of common objects when compared to temperature and a weak positive relationship between ordering numbers and temperature.

Data on the frequency of biting, head-butting, and hitting were collected for student K and compared to temperature data to determine the relationship between temperature and observable classroom behaviors. The mean for biting was 1.04 with a range of 0 to 13 instances. Student K's frequency of hitting had a mean of 8 with a range of 0 to 56 instances. Head-butting had a mean of 7.33 with a range from 0 to 48. Figures 70-72 show the scatter plots for each behavior in relation to temperature.

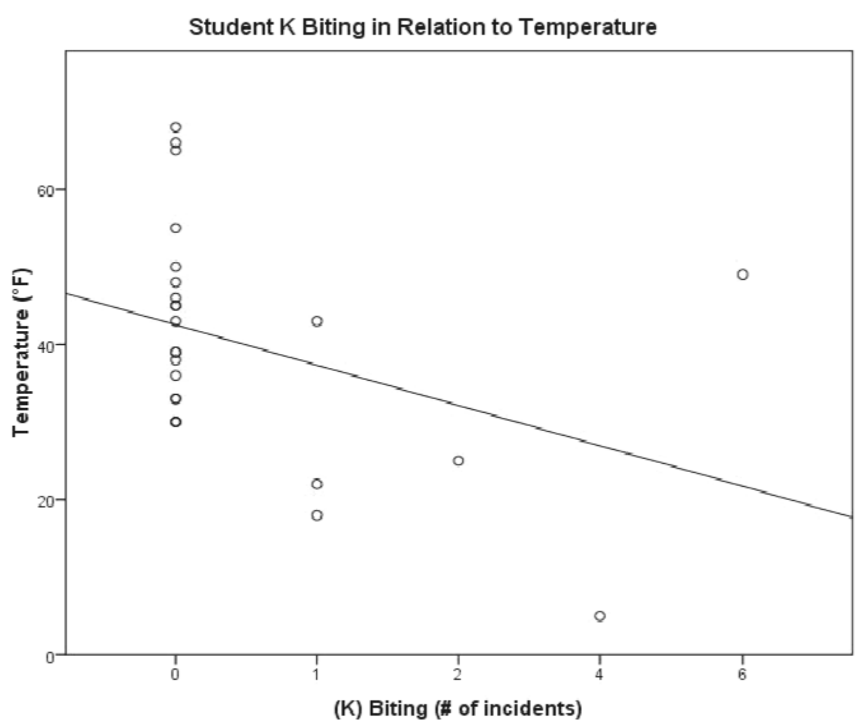

Figure 70.

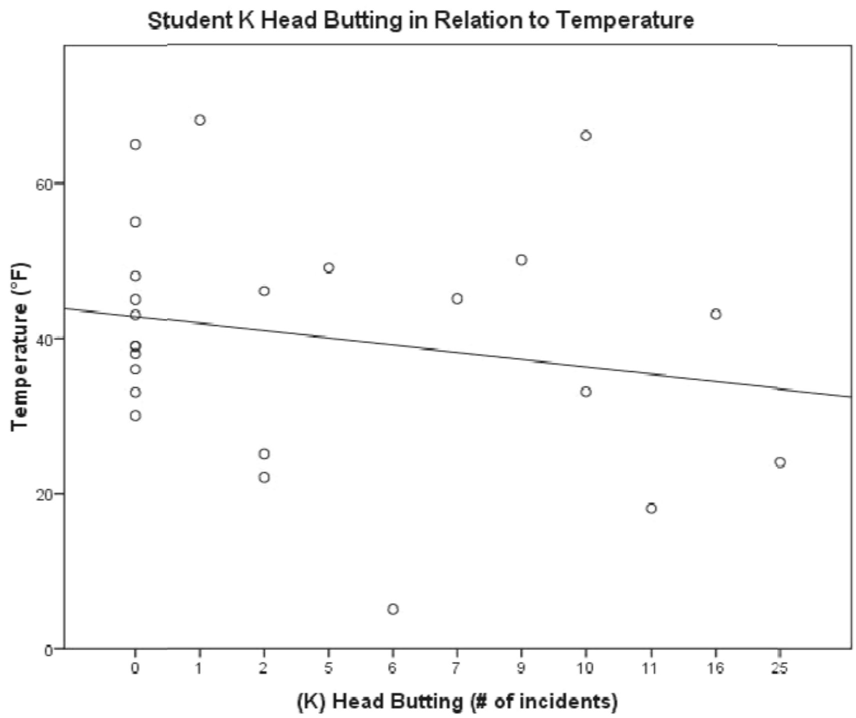

Figure 71.

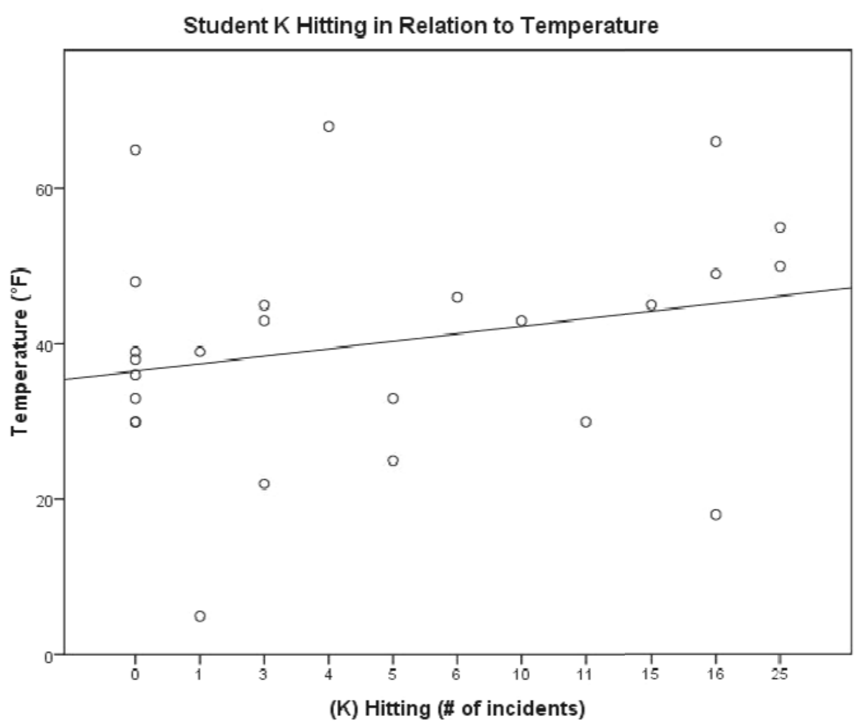

Figure 72.

The points on each scatter plot are not closely arranged, suggesting that any relationship is weak. The best-fit line is relatively flat for the scatter plots, indicating there is no relationship between head-butting and hitting and outside temperature. The scatter plot for biting shows little variability in the behavior, but has a fit line that indicates a weak negative relationship between biting and temperature. Thus, as temperature increases student K's biting behaviors tend to decrease at school. These results for student K suggest no relationship between hitting and head-butting when compared to temperature and a weak negative relationship between biting and temperature.

Summaries for each meteorological variable.

This study sought to answer the following research questions. What is the relationship between meteorological conditions, including barometric pressure, humidity, moon illumination, and temperature, and daily academic and behavioral performance of students with ASD? Four specific sub-questions were addressed. What is the relationship between barometric pressure and academic performance and classroom behaviors of students with ASD? What is the relationship between humidity and academic performance and classroom behaviors of students with ASD? What is the relationship between moon illumination and academic performance and classroom behaviors of students with ASD? What is the relationship between temperature and academic performance and classroom behaviors of students with ASD?

Overall, any relationships between these variables are weak at best. None of the resulting scatter plots indicated strong relationships between variables. However, some variables were found to have weak relationships. These relationship findings are summarized below.

Barometric Pressure.

There were eight weak relationships found between barometric pressure and student variables. Student S's screaming and student K's biting behaviors were both shown to have a weak positive relationship with barometric pressure. Within the area of academic performance three variables had weak positive relationships and three variables had weak negative relationships. Student S's expressive labeling of pictures along with student K's ordering numbers and receptive identification of pictures had weak negative relationships to barometric pressure. Student E's academic performance was found to have a weak negative relationship with barometric pressure; accuracy tended to increase as barometric pressure increased.

Humidity.

Two weak relationships were found between student variables and humidity. Student K's biting and hitting were found to have a weak negative relationship with humidity. This indicated that as the humidity increased student K's biting and hitting tended to decrease.

Moon Illumination.

The investigation of the relationship of student variables to moon illumination yielded six weak relationships. There was a weak positive relationship between student K's hitting behaviors, ordering numbers performance and moon illumination. A weak negative relationship was indicated for student E's kicking and hitting behaviors. Student E was the only student with academic performance showing a weak relationship with moon illumination. His academic performance on solving addition and subtraction problems and matching words to pictures showed a weak positive relationship to moon illumination. Additionally, results indicate that non-compliance behaviors may have had an influence on the best-fit line of E's scatter plots for academic performance and moon illumination. Although non-compliance instances occurred when comparing academic performance and temperature, barometric pressure, and humidity, those scatter plots did not show indication of the non-compliance itself affecting the best-fit lines. Although this is noted, non-compliance was not directly measured during this study; therefore any inferences based on this anecdotal observation are unfounded.

Temperature.

Temperature compared with student variables revealed six weak relationships. Four weak negative relationships were found between student behaviors and temperature indicating that as temperature increases, target behaviors tended to decrease. Those relationships were between temperature and student S's screaming, student K's biting, and student E's hitting and kicking. Two weak positive relationships were revealed for student S's expressive labeling of pictures of common objects and student K's ordering numbers 1-10.

Overall Summary.

Although some weak relationships were identified, there was significant variability in the direction of relationships. Student behavioral relationships to meteorological variables tended to be negative in nature; however this was not a consistent pattern, making relationship inferences difficult. Likewise, relationships between meteorological variables and academic performance, when they were arguably present, tended to be positive. On the other hand, once again, these relationships were either so weak or variable that it is impossible to make a case for significant relationships based on the present data.

Chapter 5

Summary and Discussion

The purpose of this study was to determine if relationships exist between various meteorological factors and the academic and behavioral performances of students with autism spectrum disorders (ASD). The factors that were studied included barometric pressure, temperature, moon phase, and humidity. Related to this purpose this chapter includes the following: (a) a summary and conclusion of the study, (b) a discussion of the findings and how the present data aligns with the extant literature on meteorological factors and the academic and behavioral performance of students with autism spectrum disorders and other individuals, (c) limitations of the present study, (d) implications of the study for practitioners and other stakeholders, and (e) recommendations for future research.

Summary and Conclusions

The purpose of this study was to investigate the relationship between various meteorological factors and academic and behavioral performances of students with autism spectrum disorders (ASD). The meteorological factors that were studied were barometric pressure, temperature, moon phase, and humidity. Three participants were included in this study. Each participant had a medical and educational diagnosis of autism. Student E was an 8-year-old male with observable classroom behaviors of hitting, kicking, and elopement that impeded his learning and the learning of others. Student S was a 5-year-old female with observable behaviors of screaming and falling to the floor, which impeded her learning as well as the learning of her peers. Student K was a 5-year-old who presented with significant disruptive classroom behaviors, including hitting, biting, and head butting. Each student also had academic performance tasks that were targeted for data collection. These tasks were previously mastered.

Previously mastered tasks were monitored in order to eliminate the variability associated with introducing new tasks.

Daily data were collected on each student's target behaviors and academic performance. These data were compared to meteorological variables that existed during one hour observational periods. Data were displayed using individual scatter plots for each behavioral variable and academic performance variable to show graphical representation and directionality of relationships to meteorological variables. Lines of best fit were added to each scatter plot to accentuate the directionality of these relationships.

Some weak relationships between subjects' behavioral and academic performances were identified relative to meteorological variables. Weak relationships were considered to be relationships that resulted in scatter plots with best-fit lines with some slope. These lines would slope from one quadrant of the scatter plot to the opposite quadrant, representing positive or negative relationships relative to their direction. For example, best-fit lines representing negative relationships would extend from the upper left quadrant to the lower right quadrant of a scatter plot. Positive relationships were represented by best-fit lines that extended from the bottom left quadrant to the upper right quadrant of a scatter plot. Barometric pressure seemed to have the highest incidence of notable slope with eight of these weak relationships revealed. In particular, Student S and student K's behavioral data indicated weak positive relationships with barometric pressure. Likewise, student S and student K had weak negative relationships between their academic performance tasks and barometric pressure. Student E's behavioral data did not show a relationship with barometric pressure, however there was a weak negative relationship between his academic performance and barometric pressure. Humidity seemed to have the least relationship with students' data. Student K was the only student who had a weak negative relationship with his behavior (hitting and biting) and humidity. All students appeared to have at least one weak negative relationship between a target behavior and temperature. Students S and K displayed weak positive relationships between one their academic performance tasks and temperature. Student E's academic performance tasks did not appear to vary in accordance with the outside air temperature.

For students E and K moon illumination appeared to have weak relationships with six behavior and academic targets. Student K's hitting behavior had a weak positive relationship with moon illumination. Student E's kicking and elopement had a weak negative relationship to moon illumination. Both students E and K had weak positive relationships between academic performance and moon illumination. No relationships between behavioral and academic performance and moon illumination were found for Student S.

Although some weak relationships were identified, there was significant variability in the direction of these possible associations. Student behavioral relationships to meteorological variables tended to be negative in nature. That is, as one variable increased the second variable decreased. However this was not a consistent pattern, making relationship inferences difficult to justify. Likewise, relationships between meteorological variables and academic performance, when they were arguably present, tended to be positive (i.e., as one variable increased the second variable tended to increase as well). Once again, however, these possible relationships were either so weak or variable that it is impossible to make a case for an empirical cause-effect association between students' behavior and academic performances and meteorological conditions.

Discussion

This study identified some weak relationships between meteorological variables and the behaviors and academic performances of elementary school-age students with ASD. These relationships were so weak that it is impossible to infer any level of logical statistical significance or cause-effect association. However, the tentative trends identified are the basis for some introductory inferences about relationships that may or may not exist between meteorological factors and the functioning of students with ASD at school. For example, relative to the weak relationships between humidity, temperature, and moon phase and students' behaviors and academic performances, the majority of the relationships were negative in nature. As humidity and temperature increased target student behaviors tended to decrease. The temperature range throughout this study was 5˚F to 68˚F and the study was conducted during winter months in a Midwestern city. Considering this study was conducted in the months of January through March in a temperate climate with rather cold temperatures, problem behaviors could have decreased as the temperature increased due to the participants being more comfortable in warmer temperatures. It is quite possible that temperature could have a positive relationship with student behaviors if the range of temperature were higher. Likewise, it is also possible that humidity could have a different effect and type of relationship to student variables if this study were conducted during a different season with distinctively different weather patterns.

Additionally, in the weak relationships identified, as the moon illumination increased toward a full moon, student behaviors tended to decrease. Barometric pressure and student behavior had a positive weak relationship, when there appeared to be an association. That is, behaviors tended to increase as barometric pressure increased. Additionally, student K was the only student with at least one weak relationship between his behaviors and each meteorological variable. Student S did not appear to have relationships between her falling to the floor behavior with any weather variables and only relationships with barometric pressure and temperature for her screaming behaviors. Student E's data only indicated relationships between behaviors and temperature and moon illumination.

The majority of the possible weak relationships between meteorological factors and academic performance were positive in nature. Barometric pressure relationships presented an interesting trend as two students' data revealed weak negative relationships, while the third student had weak positive relationships between all of his academic performance tasks and barometric pressure. This would seem to be preliminary and arguably tentative evidence that students with ASD could be affected differently by various weather variables. Additionally, two of the three students (student K and S) had weak positive relationships between temperature and academic performance while students K and E had weak positive relationships between moon illumination and academic performance tasks. None of the students' data indicated relationships between academic performance and humidity. The meteorological variable with the most relationships to academic performance was barometric pressure.

Comparison of the current study results to existing research concerning relationships between behavior and meteorological factors presents contradictory conclusions. The weak relationships found between behavior variables and temperatures were negative in nature, suggesting that as the temperature increased student behaviors decreased. This effect is the opposite of those reported in previous studies where aggression and temperature increased together (Bell, 1992; Cohn, 1990a, 1990b). Previous research studies focused on adults and aggression, specifically violence, and determined that there is a positive relationship between the two up to temperatures at which the level of discomfort outweighed individuals' tendency to aggress (Bell, 1992). The point where the person is more concerned with escaping discomfort from temperature than aggressing was found to be about 85˚F (Bell, 1992). The outdoor temperature data collected in the current study had a maximum recorded of only 68˚F, well below the 85˚F threshold. The current study found weak negative relationships between student behaviors and temperature, however, results concurrent with previous research might be gained with studies where the temperature exceeds 70˚F and passes the 85˚F threshold. Of course, it is also significant to remember that data were collected insideclassrooms that were relatively unaffected by variations in outside air temperature.

Although mood state was not directly measured in this study, it would seem students would be experiencing more positive moods when displays of problem behaviors are lower. Generally, student problem behaviors decreased when humidity and temperature increased. During the study staff offered some anecdotal observations of student behavior and possible moods. On days when the temperature was extremely cold (15˚F or below) it was difficult to maintain student engagement in activities, and when the students became agitated, it was more difficult than usual to sooth them. This trend differs from findings of Whitton et al. (1984) where a link between lower humidity, barometric pressure, and temperature and positive moods was identified. However, Sanders and Brizzolara (1982) found that positive affect was associated with higher humidity, barometric pressure, and temperature. Again, positive affect was not directly measured; however, it would seem that students would have a more positive affect when not displaying problem behaviors. Therefore, the results of this study align with the results of Sanders and Brizzolara (1982) in that the problem behaviors decreased as the humidity and temperature increased. In the area of barometric pressure problem behaviors increased with barometric pressure which is inconsistent with previous research (Brizzolara, 1982).

The results of the current study indicate that humidity had the least weak relationships between variables targeted, suggesting that humidity does not have the same potential for relationships as other meteorological variables might when examining student behaviors and academic performance. Research by Howarth and Hoffman (1984) found humidity to be the most important predictor variable when measuring concentration. While concentration was not specifically measured in the current study, data concerning academic performance were at or above 90% accuracy with minimal variability. Humidity had no relationship with academic performance requiring concentration in order to complete at the high level of accuracy (90% or above) observed in the current study. This might lead to the inference that the current study does not support previous research that humidity is the most important predictor variable in concentration from the limited data collected. These same researchers did not specifically measure aggression, but data indicated that aggressive feelings were positively related to colder temperatures, which would be counterintuitive to the results of the current study. The current study found that as temperatures increased, problem behaviors tended to decrease. The temperature range throughout this study was from 5˚F to 68˚F and the study was conducted during winter months in a Midwestern city. Considering this study was conducted in the months of January through March in a temperate climate with rather cold temperatures, problem behaviors could have decreased as the temperature increased due to the participants being more comfortable in warmer temperatures. It is quite possible that temperature could have a positive relationship with student behaviors if the range of temperature were higher.

Thus far, discussion has been focused on results of the current study in comparison to existing research with adult subjects. The most appropriate connections between the current study results and previous research can be found in studies conducted with children. The current study revealed two possible weak negative relationships between humidity and problem behaviors, where problem behaviors tended to decrease as humidity increased. These results are the opposite of those found by Lagacé-Séguin and d'Entremont (2005) in which a positive relationship was found between humidity and externalizing problems, as well as findings that higher humidity is associated with higher levels of irritability (Lagacé-Séguin & Coplan, 2001). The weak negative relationships between humidity and student problem behaviors found in the current study is also in conflict with previous research findings that humidity has a positive relationship with frustration, sadness, and aggression (Ciucci et al., 2011).

The results of the current study do not appear to be consistent with the limited existing research on the relationships between meteorological variables and human behavior. In fact, the few weak relationships found in the current study are the opposite of findings of other researchers. The methodology of the current study is not identical to that used in previous research, which may explain the disparity in comparisons. The current study focused on a one hour observational period with explicit data collection of behavioral instances and percentage correct on academic performance. Some previous researchers collected data on student referral to a quiet room following confrontations with staff compared to wind speed and direction, maximum and minimum temperature, and rainfall (Badger & O’Hare, 1989). In this specific study, the numbers of referrals across a school day were compared with meteorological variables collected at a set time during the day. In this instance, the time of the referral to the quiet room was not specifically connected to the collection time for meteorological variables.

Previous research generally took into account an entire school day with teachers and staff rating student behavior or moods at the end of the day (Ciucci et al., 2011; Lagacé-Séguin & d'Entremont, 2005). This research may have been able to capture changes in student behavior as an overall measure of student behavior, but not specific behavior instances that may be directly related to changes in meteorological variables. Additionally, ratings provided by teachers may not be as exact as recording behavioral events. The current study could not have captured effects of changing meteorological variables as the observational period was at a static time of day and measurements for the meteorological variables were collected at a set time during that observational period.

The current study also did not specifically measure changing meteorological factors as did previous research. Essa and colleagues (1990) compared student behavioral observations with four weather categories: stable, moving from stable to unstable, moving from unstable to stable, and unstable. This study most resembles the current study methodology in the way that behavioral data were directly observed and collected. However, this study rated children's behaviors on 10 behavior categories instead of recording the frequency of distinct behaviors. Relationships were identified with student interaction with adults, peers, and materials. These behaviors were not measured and weather categories were not used in the current study. Finally, all previous research included a sample of at least 35 students. This larger sample size allowed for the use of statistical applications, making reports of correlations possible; the current study was unable to use these statistical methods. It may be that comparisons between the current study and previous studies are difficult to make due to differences in methodology or these comparisons may provide some initial evidence that individuals with ASD respond differently to meteorological variables when compared to their neurotypical counterparts.

The literature base concerning the atypical sensory processing of individuals with ASD was part of the foundation and rationale for this investigation into the relationships between student behavior and performance and meteorological variables. Considering that individuals with ASD present with difficulties in properly processing sensory stimuli in their environment, it is logical to speculate that meteorological variables are sensory stimuli that can affect student's behavior and functioning. Children with ASD exhibit behaviors that can be attributed to an imbalance or poor modulation in the central nervous system (Berkson, 1996; Guess & Carr, 1991). Individuals with ASD can react too quickly to sensory stimuli or seem unaware of sensory stimuli (Dunn, 2008). Modulation balances the level of excitation and inhibition (Berkson, 1996; Guess & Carr, 1991), which allows an individual to recognize what sensory stimuli to attend to and which stimuli can be safely ignored (Dunn, 1997b). It could be inferred that individuals with ASD may have difficulty determining which meteorological variables to attend to and which can be ignored, resulting in observable problem behaviors. Children with ASD often have a disrupted balance between arousal/alerting and discriminating/mapping functions which precipitates unusual behaviors as they try to respond appropriately using only distorted information (Royeen & Lane, 1991). Furthermore, Baker et al. (2007) found that poor sensory processing ability was associated with higher levels of behavioral and/or emotional problems for students with ASD.

The weak negative relationships identified between temperature and student behaviors in all three participants could provide more insight into the sensory processing of individuals with ASD. In the current study, as temperature increased students' observable problem behaviors decreased. Conversely, when temperatures were lower, student problem behaviors tended to increase. Considering this study was completed during winter months, it is possible that the increased frequency of student behaviors are a result of student difficulty in processing sensory stimuli associated with colder temperatures. A decrease in student behaviors as the temperature increased could be attributed to student comfort level increasing and therefore less difficulty processing temperature stimuli.

Additionally, some weak relationships were found between barometric pressure and student performance on academic tasks. Considering that there was very little variability in academic performance these weak relationships could be attributed to student difficulty processing sensory information that may accompany a change in barometric pressure. Additionally, these weak relationships were not consistent in directionality across participants. Two participants had negative relationships between academic tasks and barometric pressure, while one participant had positive relationships between his academic tasks and barometric pressure. Again, this finding suggests that meteorological variables affect students with ASD differently. These data are comparable to research findings that suggest that individuals process sensory stimuli in varied ways (Lane et al., 2010).

Limitations

This study was limited in several ways. First, the sample for this study was small (n=3). Therefore, findings should not be generalized to other students with ASD. This small n also makes it impossible to perform actual correlations with the collected data. A larger sample would provide the number of independent observations needed to use correlational statistics instead of simple visual inspection of scatter plot data for analysis. Correlational statistics would provide stronger support to any relationships found in the study.

Additionally, this study limited observational periods to one hour in the morning of each school day for an 8week period. Meteorological factors such as temperature, humidity, and barometric pressure often fluctuate throughout the day. It is possible that as meteorological factors fluctuated, the behavior of students also fluctuated, but these observations were not captured. Also the temperature and humidity inside the classroom was not measured, thus fluctuations of indoor conditions were not taken into account.

A limitation was discovered specifically for student E during the course of the study. Observable behaviors of hitting, kicking and elopement were chosen as the target behaviors for observation for this student prior to the start of the study. These behaviors had been routinely observed previously and considered most problematic by the school staff. As the observations began for academic performance it was noted that student E would at times engage in non-compliant behaviors by refusing to perform academic tasks. When a task was placed in front of him, student E would flip a straw in front of his eyes, avert his gaze from the task, turn his back to the task or lay on the floor. Staff attempts to engage him in the activity were met with continued non-compliance. There were instances where he was able to complete tasks later in the school day outside the designated observation period. In other instances, school staff was unable to elicit compliance or motivate the student to complete designated academic performance tasks during the entire day. It was apparent as this became a repeated occurrence that this behavior should have been included in the target behaviors for this student. It is possible that the non-compliant behaviors student E exhibited had a relationship to meteorological variables, but considering these were not recorded as a part of the study protocol any empirical inferences concerning student E's non-compliance and its relationship to meteorological variables are unknown.

Another limitation of this study is the variability of the academic performance scores for each student. While these tasks were mastered tasks, there was little to no variability in the scores each student received on these tasks. This minimal variability made any comparison to meteorological factors difficult. Results would be strengthened by measuring tasks that showed greater variability in the academic performance task data.

Finally, this study examined behaviors exhibited by students that impeded their learning and/or that of others. Commonly, these behaviors are disruptive to the classroom and daily activities. School staff in this setting continually worked to extinguish these behaviors using a variety of interventions. Although no changes were made relative to how staff dealt with these behaviors during the study, it is possible that interventions employed by the staff had an effect on the target behaviors. These interventions thus may have mitigated the relationship between behaviors and meteorological factors. Due to the complexity of ASD characteristics displayed by each participant, it is also possible that factors neither identified nor controlled for in this study affected student behavior and academic performance.

Implications for Practitioners and Other Stakeholders

Autism spectrum disorders are the fastest growing diagnoses of childhood (Simpson & Myles, 2008). Practitioners, parents, and other professionals are continually searching for information on this complex neurological disorder in order to provide appropriate social and educational services to individuals with ASD. The current study sought to investigate one area that could have an effect on student functioning. The current study resulted in identification of some possible and tentative weak relationships between meteorological variables and student variables. These relationships were not statistically significant and therefore it should not be inferred that they reflect scientifically valid and empirically supported associations between students' academic performances and behaviors and meteorological factors. Moreover, these speculative, indefinite, and unconfirmed data cannot be generalized to apply to other students with ASD. However, this study and results have some implications for individuals working or living with students with ASD. While individuals interacting with students with ASD should not alter service delivery or current interventions based on this research, it is important to indicate that meteorological factors may play a role in the behaviors of students in classroom settings. It is possible that student behaviors vary with changing weather patterns and it may be important to note weather conditions when fluctuations in behavior occur. For example, one of the students in this study exhibited an increase in a specific problem behavior one day. Educational staff observed that thunderstorms occurred the same day. Staff working with this student may note the atypical increase in problem behaviors as well as the fact that thunderstorms were present. This could assist staff in identifying any patterns in student behavior relative to changes in weather patterns associated with inclement weather.

Recommendations for Future Research

More comprehensive research is required to investigate the effects of meteorological variables on academic performance and classroom behaviors of students with ASD. Larger sample sizes with independent observations of variables are needed in order for correlational relationships to be calculated. The sample size should also include individuals from a broader age range, older students, and perhaps even adults with ASD. A broader range of observations should be investigated spanning an entire day and for a longer study duration. This would ensure that meteorological variations throughout a day would be captured and perhaps indicate relationships that may arise as weather conditions change instead of comparison of static measurements. Further research in this area should also include investigations in different seasons and various climates. This study took place in a Midwestern city from January through March. These weather conditions will of course differ greatly for other parts of the country and world. Additional research concerning academic performance should seek to investigate academic tasks with more variability in order to be able to see performance differences and make inferences concerning the relationships between performance and meteorological variables. Future research should also seek to replicate previous research conducted with neurotypical individuals to determine if individuals with ASD follow similar patterns in their reaction to meteorological variables or if there are anomalies due to the complex nature of their disability.

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APPENDIX A

Informed Parent Consent Form

Relationships Between Meteorological Variables and Academic Performance and Behavior in Children with Autism Spectrum Disorders

INTRODUCTION

The Department of Special Education at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study, it will not affect your relationship with the school, the services it may provide to you, or the University of Kansas.

PURPOSE OF THE STUDY

The purpose of the proposed study is to determine if Relationships exist between various meteorological factors and academic and behavioral performance of students with autism spectrum disorders. These factors include barometric pressure, temperature, moon illumination, and humidity.

PROCEDURES

Families that agree to participate in this study will receive information regarding detailed procedures and expectations. Data will be collected on participating students regarding academic performance on Individual Education Plan Goals and behaviors which impede participation in school activities. Participating students will be observed within daily activities to record behaviors which impede their participation in school.

RISKS

There are no potential physical or emotional harm for the participating student. Data concerning student performance and behaviors will be collected by individuals currently familiar to the learning environment. In addition, data that will be used for academic performance is already being collected in the student's environment and this procedure will not change. Collected data will be compared to weather variables present in participating student locations.

BENEFITS

This study has the potential to provide research information on the affects of meteorological variables on student performance and impeding behaviors. This study also has the potential to provide information regarding participating student's individual functioning when particular meteorological variables are present.

PAYMENT TO PARTICIPANTS

Your child's name will not be associated in any way with the information collected about your child or with the research findings with the study. The researcher will use a study number instead of your child's name. The researchers will not share information about your child unless required by law or unless you give written permission.

Permission granted on this date to use and disclose your information remains in effect indefinitely. By signing this form you give your permission for the use and disclosure of your child's information, excluding your child's name, for purposes of this study at any time in the future.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION

You are not required to sign this Consent and Authorization form and you may refuse to do so without affecting your right to any services you are receiving or may receive from the University of Kansas or to participate in any programs or events of the University of Kansas. However, if you refuse to sign, you cannot participate in this study.

CANCELLING THIS CONSENT AND AUTHORIZATION

You may withdraw your consent to participate in this study at any time. You also have the right to cancel your permission to use and disclose information collected about your child, in writing, at any time, by sending your written request to:

Sabrina VanBuskirk, M.S. Ed.,

1155 Cardinal Dr.

Liberty, MO 64068

If you cancel permission to use your information, the researchers will stop collecting additional information about your child. The researcher may use and disclose information that was gathered before she received your cancellation, as described above.

QUESTIONS ABOUT PARTICIPATION

Questions about procedures should be directed to the researcher listed at the end of this consent form.

PARTICIPANT CERTIFICATION:

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study and the use and disclosure of information about me for this study. I understand that if I have any additional questions about my rights as a research participant, I may call (785) 864-7429 or write the Human Subjects Committee Lawrence Campus (HSCL), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7563, email dhann@ku.edu.

I agree to take part in this study as a research participant. I further agree to the uses and disclosures of my information as described above. By my signature I affirm that I am at least 18 years old and that I have received a copy of this Consent and Authorization form.

_______________________________________ _______________________________________

Type/Print Parent's Name Child's Name **Parent's Signature** **Date**

Researcher Contact Information

Sabrina VanBuskirk, Student Investigator

1155 Cardinal Dr.

Liberty, MO 64068

(660) 988-2588

APPENDIX B

E will match 20 words to the correct picture.

Dates

Initials											
marbles											
sugar											
fire truck											
television											
CD player											
fan											
socks											
boots											
scarf											
sunglasses											
shirt											
gloves											
buttons											
tie											
coat											
hat											
robe											
stove											
oven											
VCR											
refrigerator											
Percent Correct											

+ Correct - Incorrect

E will write 14 words when show a picture and directed to write the words.

Dates

Initials											
Cow											
Book											
Car											
Cat											
Swing											
Straw											
Cup											
Duck											
Bug											
Pizza											
Movie											
Pop											

Dog											
Tree											
Percent Correct											

\+ Correct - Incorrect

E will write the answer to 10, 1-digit addition/subtraction problems on the same page.

Dates

Initials											
10 problems	/10	/10	/10	/10	/10		/10	/10	/10	/10	/10
Percent Correct											

\+ Correct - Incorrect

S will put numbers 1 through 10 in order.

Dates

Initials											
Number Correct	/10	/10	/10	/10	/10		/10	/10	/10	/10	/10
Percent Correct											

+ Correct - Incorrect

S will match same pictures.

Dates

Initials											
Number Correct	/10	/10	/10	/10	/10		/10	/10	/10	/10	/10
Percent Correct											

+ Correct - Incorrect

S will say the name of each letter.

Dates

Initials											
A											
B											
C											
D											
E											
F											
G											
H											
I											
J											
K											
L											
M											
N											
O											
P											
Q											
R											
S											
T											
U											
V											
W											
X											
Y											

Z											
Percent Correct											

+ Correct - Incorrect

S will say the name of each object in a picture.

Dates

Initials											
Doll											
Wagon											
Balloon											
Computer											
Cat											
Dog											
Shoes											
Pencil											
Cup											
Chair											
Percent Correct											

+ Correct - Incorrect

K will put numbers 1 through 10 in order.

Dates

Initials											
Number Correct	/10	/10	/10	/10	/10		/10	/10	/10	/10	/10
Percent Correct											

\+ Correct - Incorrect

K will match same pictures.

Dates

Initials											
Number Correct	/10	/10	/10	/10	/10		/10	/10	/10	/10	/10
Percent Correct											

\+ Correct - Incorrect

K will hand an adult the requested picture when presented in a field of 3.

Dates

Initials											
Ball											
Computer											
Goldfish Cracker											
Scissors											
DVD											
Wagon											
Shoes											
Hat											
Table											
Chair											
Percent Correct											

\+ Correct - Incorrect

APPENDIX C

S Behavioral Data Collection Protocol

Operational Definition:

- Screaming is defined as S making a sound that is indistinguishable as a word and can be heard from more than 3 feet away from her location.
- Falling to the floor is defined as S falling to her knees.

Date	Frequency (Tally mark for each occurrence)	
	Screaming	Falling to Floor

K Behavioral Data Protocol

Operational Definitions:

- Biting is defined as K moving toward a body part of another individual with his mouth open.
- Head butting is defined as K's head coming in contact with a body part of another person.
- Hitting is defined as K's hands striking a body part of another person.

Date	Frequency (Tally marks for each occurrence)		
	Biting	Head butting	Hitting

E Behavioral Data Protocol

Operational Definitions:

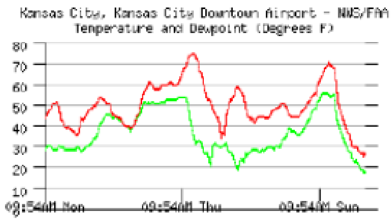
- Hitting is defined as E's closed fist coming in contact with a body part of another individual.
- Elopement is defined as E moving in the opposite direction from the activity or area where he has been instructed to go.

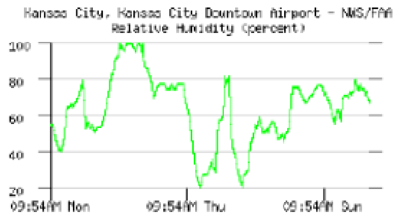
Date	Frequency (Tally mark for each occurrence)		
	Hitting	Kicking	Elopement

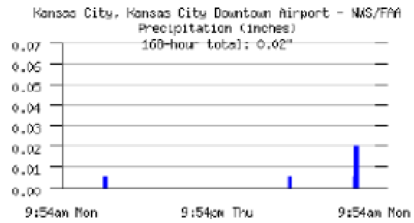
APPENDIX D

Close window Quick 7-Day View

Show 2 Days Show Raw Observations For Information Regarding the Accuracy of This Data: MesoWest Disclaimer







Weather Conditions for:

Kansas City, Kansas City Downtown Airport, MO (KMKC)

Elev: 758 ft; Latitude: 39.12083; Longitude: -94.59694

Current time: Mon, 21 Feb 10:06 am (CST)

Most Recent Observation: Mon, 21 Feb 9:54 am (CST)

Time (CST)	Temp. (f)	Dew Point (f)	Relative Humidity (%)	Wind Chill (f)	Wind Direction	Wind Speed (mph)	Visibility (miles)	WX	Clouds	Sea Level Pressure (mb)	Altimeter Setting (inches)	Station Pressure (inches)	Precip 1 hour (inches)	Precip 6 hour (inches)	Precip 24 hour (inches)	6 Hr Max Temp	6 Hr Min Temp	24 Hr Max Temp	24 Hr Min Temp	Quality Control
21 Feb 9:54 am	27	18	68	16	WNW	12G21	10.00		CLR	1012.6	29.89	29.089								OK
21 Feb 8:54 am	26	18	71	14	NW	16G21	10.00		SCT018 OVC055	1011.8	29.87	29.069								OK
21 Feb 8:45 am	27	19	74		NW	8	10.00		SCT018 BKN055		29.86	29.059								OK
21 Feb 8:32 am	27	19	74	16	WNW	12G17	10.00		BKN018		29.87	29.069								OK
21 Feb 7:54 am	27	19	72	18	NW	9	10.00		FEW018 SCT060 OVC095	1011.2	29.85	29.050								OK
21 Feb 6:54 am	28	21	75	19	WNW	10	10.00		FEW018 OVC100	1009.8	29.81	29.011								OK
21 Feb 5:54 am	29	22	75	20	NW	10	10.00		SCT019 BKN090 OVC100	1008.4	29.78	28.981		0.02	0.02	38	29			OK
21 Feb 4:54 am	30	24	78		WNW	8	10.00		BKN019 BKN095	1009.0	29.80	29.001								OK
21 Feb 4:22 am	30	23	74		N	8	10.00		SCT017 SCT110		29.75	28.952								OK
21 Feb 3:54 am	31	24	75	22	NNW	10	10.00		BKN017 OVC085	1007.4	29.76	28.952								OK
21 Feb 3:10 am	30	25	80	20	NW	13	10.00		BKN015 OVC090		29.73	28.932								OK
21 Feb 2:54 am	31	25	78	22	NNW	10G20	10.00		FEW015 BKN090 OVC110	1006.7	29.73	28.932	0.02							OK
21 Feb 2:29 am	32	27	80	23	NNW	12G22	9.00	UP	SCT016 OVC050		29.73	28.932	0.02							OK
21 Feb 1:54 am	34	28	79	25	W	12	9.00	-RA	OVC018	1007.6	29.76	28.962	T							OK
21 Feb 1:42 am	36	28	75		WNW	6	10.00		BKN018 OVC055		29.74	28.942								OK
21 Feb 12:54 am	37	29	72	30	NNW	10	10.00		BKN060 BKN095 OVC110	1006.4	29.72	28.923								OK
20 Feb 11:54 pm	38	30	73	31	NW	10	10.00		CLR	1006.2	29.71	28.913				68	38	71	38	OK
20 Feb 10:54 pm	42	33	70		WNW	7	10.00		FEW110	1006.2	29.72	28.923								OK
20 Feb 9:54 pm	45	36	71		NW	7	10.00		FEW120	1005.3	29.69	28.893								OK
20 Feb 8:54 pm	47	38	71		NW	10G18	10.00		CLR	1004.8	29.68	28.883								OK
20 Feb 7:54 pm	52	42	69		NW	16G23	10.00		CLR	1002.6	29.61	28.815								OK
20 Feb 6:54 pm	60	46	57		NW	18G29	10.00		BKN032 OVC050	1000.9	29.57	28.776								OK

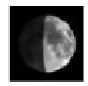
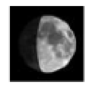
APPENDIX E

Location: 64114
ZIP/Postal Code or City,State
Month: Feb
Year: 2011
Go

Please note: If you are in a location that does NOT follow Daylight Saving Time, your data will be an hour off. Subtract one hour.

Just interested in the Full Moon? At a glance, see 2010 (through 2014) Full Moon Dates.

Previous Month Next Month

SUN	MON	TUE	WED	THU	FRI	SAT
		1  2% 28 days	2  New Moon 8:32 P.M.	3  0% 1 day	4  3% 2 days	5  6% 3 days
6  12% 4 days	7  19% 5 days	8  26% 6 days	9  35% 7 days	10  45% 8 days	11  First Quarter 1:20 A.M.	TODAY 12  64% 10 days
13  74% 11 days	14  83% 12 days	15  91% 13 days	16  96% 14 days	17  99% 15 days	18  Full Moon 2:36 A.M.	19  97% 17 days
20 	21 	22 	23 	24 	25 	26