

Observations from a Specific Carbohydrate Dietary intervention in two children with autism

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Abstract

Background: Recent literature has shown that some autistic symptoms may be ameliorated with a gluten free/casein free diet. A Specific Carbohydrate Dietary intervention has become increasingly popular among parents of autistic children, while medical physicians have become increasingly concerned for these children's nutritional health. There is a lack of studies regarding Specific Carbohydrate Dietary interventions. **Objective:** Based on claims that the Specific Carbohydrate Diet improves autistic behaviors and heals chronic gut issues, the purpose of this project is to understand the Specific Carbohydrate Diet's effectiveness in ameliorating autistic symptoms in two students with autism. **Design:** Physiological and behavioral signs were observed in two children with autism. Based on the abnormal physiological and behavioral profiles, dietary intervention trials using a Gluten Free/Casein Free Diet followed with a Specific Carbohydrate Diet were initiated in both autistic children. **Results:** These autistic children showed less behavioral and physiological problems during the Specific Carbohydrate Diet than during the Gluten Free/Casein Free intervention, though marked improvements were observed throughout both diets. These results are consistent with the claims related to a Specific Carbohydrate Dietary intervention. **Conclusions:** Based on the results of observed behavioral and physiological changes during the adherence of a Specific Carbohydrate Dietary intervention, it is hypothesized that the Specific Carbohydrate Diet does ameliorate autistic expressions in some autistic populations.

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1. Problem statement

It has long been established that elimination diets are often accompanied with substantive benefits. For decades schizophrenic patients have been treated by eliminating grains, particularly wheat [1-10]. Children who are discovered to have phenylketonuria (PKU) are treated, in part, with a diet that eliminates phenylalanine (a nutritionally essential amino acid) [11]. The literature related to both of these disorders is also linked to autism, a neurological disorder presenting with impaired development in social interaction and communication and markedly restricted interests. For example, almost half of untreated phenylketonuria-positive children become autistic [11], and, in some circles, children with autism are said to have childhood schizophrenia. Knowing that elimination diets attenuate symptoms and complications in conditions intimately related to autism, it should not be surprising that the literature also supports connections between diet and behavioral and physiological disturbances among some people with autism.

Autistic expressions are distracting two three-year-old, non-verbal developmental preschool students from an optimal learning environment. Both students were diagnosed by a pediatric neurologist who concluded that they have autistic spectrum disorder with static encephalopathy presenting at eighteen months, i.e., regressive/atypical autism. In this paper, "autistic expression" refers to both behavioral and physiological signs typically associated with autism, e.g., persistent tantrums or gastrointestinal issues among many others. Examples of distracting autistic expressions in the students follow. Student A's cheeks become blood-red and often textured with rash immediately after drinking apple juice. She also becomes hyperactive after eating cereal snacks. Student B crouches into a fetal position onto the floor and tantrums inconsolably after consuming

cereals or milk. Both students suffer from many other similar autistic expressions that make learning seem futile. These students should have a learning environment absent of distractions which deteriorate their ability to learn; this would include a censorship of foodstuffs known to cause or exacerbate undesirable expressions. Since these autistic students are non-verbal, they are unable to communicate how they feel after eating. Given these observations, it seems reasonable to assume that these problem behaviors may be caused or exacerbated by dietary insults. This assumption would be consistent with the Horvath *et al.* (1999) study which found that 70% of the autistic participants had chronic gastrointestinal problems—60% of whom had maldigestion and chronic diarrhea [12]. These findings led to their conclusion that unrecognized GI issues may be causing behavioral problems in non-verbal, autistic children [12].

The primary stakeholders in this situation are the two autistic students who are having difficulty learning due to possibly preventable, environmental insults, i.e., particular foodstuffs. The absence of behaviors destructive to a learning environment would allow both students an optimal opportunity to learn. The secondary stakeholders are the classmates who would benefit from the additional time and attention that educators could ostensibly acquire as a result of eliminating distractive behavior in these two students. Other secondary stakeholders are the student's parents and teachers because they could continue instruction in environments with fewer distractions.

This study will significantly impact the problem at hand by improving understanding about dietary intervention. Ideally, such understanding would narrow the gap between students who attempt to learn concurrent to profoundly debilitating and distracting expressions and students who attempt to learn subsequent to the amelioration of these expressions. If the students'

autistic expressions could be ameliorated through dietary intervention, then their learning potential would also be enhanced. Indeed, this has been demonstrated in other autistic students [9, 10, 13].

Gluten Free/Casein Free (GF/CF) diets have proven to be effective in ameliorating autistic behaviors in many autistic children [7, 9–11, 13, 14]. A Specific Carbohydrate Diet (SCD) is a gluten free diet, and the further elimination of milk products would provide a subspecies of the GF/CF diet. A main claim of the SCD as outlined in *Breaking the Vicious Cycle: Intestinal Health Through Diet* [15] is that it heals the gut. Ostensibly, an SCD should then ameliorate undesirable behaviors, as a GF/CF does, and physiological symptoms that deteriorate an environment conducive to learning, as the SCD claims. The intent is to implement an SCD subsequent to a GF/CF diet and record observable changes to determine SCD credibility. By implementing a GF/CF first, it may be able to tease out the varying effects between a simple GF/CF diet and an SCD intervention on autistic expressions.

In an attempt to determine the effect of an SCD on autistic expression, at least three questions should be asked: what, if any, physiological changes are observed; what, if any, behavioral changes are observed, and; what differences are observed when the SCD is introduced vis-à-vis the introduction of a GF/CF diet (Fig. 1)?

2. Goals

The goal of this project is to understand the SCD's effectiveness in ameliorating autistic expressions which would help determine the SCD's validity as a dietary intervention. If there is no observable change subsequent to an SCD (which also follows a GF/CF), then the SCD would be at least as valid as standard gluten free/casein free diets. If it ameliorates autistic behaviors and/or physiological issues subsequent to a GF/CF diet, then it would appear to be a valid intervention that exceeds the dietary benefits of a standard GF/CF diet. This goal addresses the students' current inability to attend to their environment or instruction due to debilitating and distracting autistic expressions which may be related to dietary insults. It does this by providing a greater understanding of how food affects these students. If the students' autistic expressions are significantly changed, either improved or deteriorated, then it would be reasonable to assume that there is a dietary connection to such expressions. An elimination diet such as the SCD, if it is found to be a valid dietary intervention, would improve the autistic students' opportunities to learn by eliminating distractive, autistic expressions.

This goal is not one that would ordinarily be found within most educators' circle of influence. This author is teaching students who are also his identical twin daughters (see Credibility and Limitations section below). Additionally, they receive twenty hours per week of public developmental preschool, and they are instructed by a masters level autism consultant at the University of Washington's Autism Center. As a parent it is well within the scope of the author's influence to implement an SCD intervention. The students' public school teacher and autism consultant have indicated that they are equally committed to supporting a strict SCD.

3. Research objectives and data collection

This project's objective is to measure change in the autistic expressions of both students A and B during an SCD subsequent to a GF/CF diet. Observing change in autistic expressions during a dietary intervention is useful in determining the viability of each intervention, assuming that change reflects a causal connection. Since autistic "expression" herein refers to behavior and physiology, both will be targeted for observation and data collection.

This objective will be measured with seven data collection tools which will be used among three different data sources during the experimental period (Fig. 1). Three of these tools were designed by autism professionals, thus establishing a greater authority and additional credibility to this study. At the end of the experimental period, data will be placed into a form more conducive to accurate interpretation and triangulation. For example, journal entries will be sifted through for physiological changes and for behavioral changes. Any relevant change that is observed in the journal will then be placed into a table form for easy comparison (refer to Fig. 3). This study's data collection tools are outlined below with a cursory rationale for each one.

3.1 Journals

The parents maintained a journal during the 10-month experimental period from August 2003 through May 2004. They collected observational data by recording noticeable changes in each student. A journal was dedicated to each student—this helped to ensure that the assignment of change would correspond to the correct student. Journal entries were aimed at answering at least three questions for each day: what went well today; what went poorly today; and what surprise occurred today? At the end of the experimental period, the journals were examined for useful information, trends, and patterns that would help identify answers for the three research questions (Fig. 1). One of the more useful characteristics of this data collection method is that it simplifies the comparison of documented trends and patterns of change observed in both students. Journal entries are also ideal for recording physiological changes because of the empirical nature of physical change. The professionally designed tools herein, i.e., ATEC, ASTAR, and AEPS, primarily record behavioral and cognitive change.

3.2 School-home communication journals

This data collection tool was used in a similar manner as the parent's daily journal. The key difference is that this tool was used as a communication tool between school and home. It was set up incidental to school enrollment, and the teacher was blinded to the journals' future use, i.e., during the study period, the school teacher did not know that data from the communication journal would be used as a data collection tool. She was asked at the end of the study to answer the survey questions. The journal adds credible data to this study because the school teacher's entries either corroborate parental observations or contradict parental observations. There are also entries that neither confirm nor contradict parental entries, but the teacher's confirmation or contradiction is what adds another element of quality to the study. The drawback to this data book is the fact that many developmental school teachers are preoccupied by

the need to document improvement per Individualized Education Programs. This preoccupation may be enough to manipulate a teacher's responses, i.e., teachers may falsify or hyperbolize behavioral improvements or omit entries of deteriorating behaviors. Three reasons make this scenario unlikely: the teacher expressed total commitment to synchronizing behavioral treatments between home and school; she indicated total commitment to dietary intervention, and; she provided additional support by voluntarily filling out ATEC scoring sheets and answering interview questions. She filled out a pre-assessment ATEC survey retrospectively and a post-assessment ATEC survey at the end of the experiment period. The retrospective scoring preserved a blinding element to this study at exceedingly little cost because the school teacher collected an abundance of pre-assessment data as a matter of procedure. This data was available for reference during her retrospective ATEC pre-assessment scoring.

3.3 Autism Treatment Evaluation Checklist (ATEC) (Likert scale)

"The purpose of the ATEC is to measure change in an individual due to various interventions - that is - the difference between the initial (baseline) ATEC scores and later ATEC scores [16]." The ATEC also provides for normative data which permit comparison of one individual with others. ATEC measurements have also been used for data collection in other studies [13]. This checklist measures four major areas, all of which are critical in assessing autistic expressions: Speech/Language/Communication, Sociability, Sensory/Cognitive Awareness, and Health/Physical/Behavior. These areas are measured with exhaustive subcategories that are cumulatively calculated in a Likert scale manner. Each subcategory is measured by assigning a varying scale to it and a final tally is processed through the use of an online calculation tool. Measurements were taken monthly by the parents. Also, an ATEC baseline was measured retrospectively by the developmental preschool teacher. The parents and the teacher took ATEC measurements at the end of the experimental period. This tool measures a comprehensive spectrum of autistic expressions, both behavioral and physiological—this fact makes this tool ideal for comparison measurements between dietary interventions, at least in a limited manner because the physiologic expressions measured are quite limited. Another advantage to this tool is that it was designed by autism experts. This adds authority and content validity to this study.

One disadvantage to using the ATEC tool for recording observations over time is that a scorer's urgency regarding particular expressions may also change over time. This would effectively change outcome measurements. For example, there are four possible answers to the Health/Physical/Behavior subquestion about "wets diapers": not a problem, minor problem, moderate problem, or serious problem. A parent may assign her thirty month old child a "not a problem" score, but six months later she may have a greater sense of urgency to this problem and change her answer to "serious problem". A total scoring in this case would reflect behavioral deterioration when in fact there has been no change at all. This cascading effect may be manageable by simply being aware of the problem. An aware scorer would be much less likely to fall into the trap of such a

cascading effect because she could consciously maintain a similar urgency over the scoring period.

ATEC "Total Summary" scores (Fig. 4): assessments were performed on the 15th of each month, with the exception of the baseline assessment and the post-assessment which were performed on the days each diet began and on the last day that data was collected. GF/CF dietary intervention began August 10, 2003. The SCD intervention began January 19, 2004, and data for this study was collected through April 22nd. When viewing Figure 2, PA and PB refer to the parent's assessments of student A and student B, respectively. Parents recorded data with the ATEC tool from the beginning of the GF/CF diet in August through May. TA and TB refer to the teacher's assessments of student A and student B, respectively. The students' teacher contributed to the study, in part, by recording "retrospective baselines" and post-assessments with the ATEC tool.

It is crucial to understand that this study does not look at the calculations per se. What is important to this study is not that the scorers have similar baseline numbers or post experiment numbers, but that they show some kind of similar pattern. For example, if the SCD is a viable dietary intervention, then there should be a downward trend in the scoring of the ATEC (lower scores indicate less severe expressions); a baseline score of 100 and a post-assessment score of 80 would indicate improvement. If multiple people were scoring the student with the ATEC and if all scores indicate a downward trend, then it is reasonable to assume that such a trend reliably indicates improvement.

3.4 Autism Spectrum Treatment and Research (ASTAR) center: behavioral questionnaire (Likert scale)

The ASTAR Center questionnaire is a similar tool to that of the ATEC tool. The ASTAR assesses change in individuals given particular interventions. A baseline was established by the parents scoring the following nine autistic, behavioral symptoms: Social Interactions (interacts with others; affection; eye contact; greetings); Emotional Responses (shares joy or pain or interests; shows appropriate facial expressions); Awareness (aware of environment or siblings; explores; observes; pays attention); Expressive Language (speech; gestures; imitation; clarity); Receptive Language (responds to commands; listens when spoken to); Play & Imagination (appropriate use of toys; drawing; pretend play); Body Movements (rocking; spinning; bouncing; finger flicking; hand flapping); Rigid & Habitual Behavior (resists activity changes; preoccupied with a toy; repeated activities; rituals), and; Other Behavior (tantrums; aggression; hyperactivity; maladaptive behaviors).

This questionnaire seems to be a somewhat comprehensive behavioral assessment. Each behavioral category was scored every day. The scoring range was between 0 (the behavior is never observed) and 4 (the behavior is frequently observed) with "rarely", "seldom", and "sometimes" making up the range between 0 and 4. This tool seems appropriate due to its comprehensive make up regarding behavior.

The questionnaire's drawbacks are twofold. This tool does not explicitly address physiological change which prevents physiological comparisons between the ATEC tool and the ASTAR tool. Secondly, the ASTAR behavioral assessment questionnaire combines areas that may negate each other if they are categorized together. For example, looking at the "Expressive

Language” category we see that it includes both “speech” and “gestures”. If a student, at baseline, gestured frequently, then she would be awarded a score of 4. However, her “speech” baseline may never be observed which would grant her a score of 0. This is a drawback because it makes scoring more difficult rather than more simplified. This difficulty will be addressed later in this paper.

Finally, the fact that the ASTAR measures behavioral change and not physiological change is really only a limited disadvantage because physical observations are empirical, e.g., eczema immediately following the consumption of certain food, or consistent solid stool, etc. Physiological changes may be accurately represented in one of the two aforementioned journals.

3.5 Assessment, Evaluation, and Programming System (AEPS) for infants and children [17]

An Assessment, Evaluation, and Programming System for Infants and Children (AEPS) evaluation was given to both students as an assessment tool to determine the two students’ qualifications for developmental preschool services. This assessment was used as a pre-measurement and post-measurement tool. The advantage of this tool is that it can confirm or disconfirm the ATEC pre-assessment and post-assessment. It acts as a limited checking and balancing mechanism in that it confirms upward and downward trends in behavior. Note that in contrast to the ATEC, the AEPS shows improvement as an upward trend. The disadvantage to using the AEPS is that it does not assess physiological expressions. But as stated earlier, this represents an exceedingly limited disadvantage because observations of physical change are empirical and may be accurately recorded by journal entries.

3.6 Interview

Questions were posed during casual conversation with the teacher as well as with the consultant. The questions were designed to determine what they have observed in students A and B subsequent to the SCD implementation. It seemed useful to solicit answers to these questions without the teachers knowing that they were participating in questioning for a study. Only a few questions were asked and these were scattered over the experimental period. All questions were worded so as to avoid leading the teachers toward particular responses. For example, instead of asking, “What is the effect of an SCD on behavior or on physiology?” the question was asked, “What is the effect of an SCD on students A and B?”

3.7 Written survey

The parents and the preschool teacher and the autism consultant were asked at the end of the study to answer the three research questions found in Figure 1. These questions would be somewhat difficult to answer for the autism consultant because she only met with each girl twice a month. She was a good source of information, though, given her professional experience, education, and predilection to take detailed notes for each student on whom she consults. Their answers were then juxtaposed in an attempt to find patterns and commonalities.

3.8 Coding

Sorting or coding was used in interpreting relevant information from interviews and survey questions and journal entries. Information that seemed relevant to each student’s behavior and physiology were placed into separate piles. These piles were then skimmed for information that may be relevant to behavior or physiology but not relevant to this study. For example, student B was described as “feeling a little gross” on March 23rd. This statement was used in the context of student B’s physiology and behavior, but it did not seem to belong to any trends in change. Consequently, it was censored because it was irrelevant to this study. The information remaining created the framework for Figure 3. An important criterion had to be met before information could be placed in Figure 3. Information had to be explicitly or tacitly recorded within the context of dietary intervention. For example, the developmental preschool teacher wrote, “[Student B] sure is focusing better than before the diet.” In this case, the teacher’s belief that student B is focusing better is clearly linked to dietary intervention. Since this observation was recorded during the SCD, it is transferred to Figure 3 under student B’s SCD behavioral improvements.

4. Method

Using a qualitative action research approach, this study attempted to understand an SCD intervention’s effectiveness in ameliorating autistic expressions vis-à-vis a standard GF/CF diet. Since autistic expression herein refers to both physiological change and behavioral change, SCD effectiveness was measured by observing the change in these two areas. The first consideration was how outcome should be measured. Various possibilities were considered. If, for example, there is not observable change in autistic expressions after starting this SCD, then the SCD would be at least as valid as a standard gluten free/casein free diet; if it ameliorates autistic behaviors and/or physiological improvements, then it would be a valid intervention that exceeds the dietary benefits of a standard GF/CF diet. There is also the possibility that deterioration rather than improvement would occur, thus, demonstrating an inferior SCD. The following example is one possible outcome: No Observable Changes/SCD More Effective than GF/CF: If there is no observable change in a student’s behavior, then there must be observable physiological improvement for the SCD to be considered an enhancement to the GF/CF diet. Conversely, if there is no observable physiological change, then, for the SCD to be considered an enhancement to the GF/CF diet, there must be observable behavioral improvement. Obviously, there are many other combinations.

4.1 Site selection, description, and participants

The study took place in a home-school environment in which the two autistic three-year-olds received instruction from their parents. The instruction modality used at home was primarily Pivotal Response Training (PRT). These techniques were used during every perceived instructional opportunity and included the following elements: Child Attention, Child Choice, Turn Taking, Interspersed Maintenance Tasks, Multiple Cues, Contingent Consequences, Natural Consequences, and Reward-

ing Every Attempt. These elements are detailed in Koegel *et al.* [18].

The students were also observed and data collected in a public, developmental preschool located in the northwestern area of the United States. Their teacher has a Masters degree in Education, twelve years of experience teaching developmental preschool, and she teaches Special Education classes at a local community college.

Student A and Student B received approximately sixteen hours of public school instruction per week through the major portion of this study. This was modified to approximately twenty hours of instruction per week during the last two weeks of the study. A para-educator was assigned to shadow each student throughout the school day. The school primarily used an eclectic educational approach to teaching these students by implementing multiple modalities. Discrete Trial Training was used throughout the school day in addition to other complimentary modalities.

The home setting was used throughout the entire study. The public, developmental preschool setting began two weeks prior to the SCD implementation and through the remaining SCD protocol. Since the students were in school for two weeks prior to the SCD implementation, the teacher and her educational team had the opportunity to witness the students during the GF/CF intervention. This would have been long enough to observe physiological and behavioral changes which occurred subsequent to the SCD implementation.

Participants were selected because it was known that they were going to be placed on dietary eliminations and because of the ease in maintaining a strict dietary regimen for two 5 year-old students. Home and public developmental preschool are appropriate settings because dietary boundaries can be confidently enforced, and observations may be easily and accurately documented.

Those most likely to have information or an attitude or an opinion about the change in autistic expressions being observed in this study are the two students, their parents, their teacher, and their autism consultant. Observations took place throughout the study, and they were recorded via seven tools (Fig. 1). The parents and teachers recorded this information. These are the people holding privileged information regarding changes in the students being studied. They also hold higher educations and specialized knowledge conducive to articulating observed changes. The teachers were partially blinded to the study. This provided unbiased confirmation or disconfirmation of parental observations at exceedingly little cost due to the volumes of recorded information that educators collect incidental to their other responsibilities. It is relatively easy for teachers to accurately record retrospective information given their access to previously recorded information.

These two students present with too many autistic expressions to detail in this paper. Autistic expressions that seem to appear or dwindle due to dietary intervention are of course accounted for throughout the paper.

4.2 GF/CF started

Since this SCD is essentially a GF/CF intervention, i.e., it is a gluten free diet with the further restriction of milk, a way was needed to determine how the SCD differently affects autistic

expression vis-à-vis a simple GF/CF diet. Though the SCD used in this study could be considered a GF/CF subspecies, it is also greatly more restrictive. The SCD further restricts sugar, all grains, and dyes and preservatives. The differences between these diets may be summed up by explaining that the SCD only allows simple carbohydrates. It even restricts unripe bananas because bananas are disaccharides until they completely ripen. The differences between these diets are not trivial. Many studies have shown substantive connections between those foods further restricted by the SCD and behavioral and physiological changes [19]. In order to tease out the different influences that each diet has on autistic expression, student A and student B were initially placed on a GF/CF diet. After four months of observing the students on a GF/CF diet, the SCD was implemented. Because the SCD used in this study is in essence a GF/CF subspecies, the change observed after the SCD implementation may be assumed to be related to the SCD if the SCD were implemented after a compelling, GF/CF trial period. The advantage to implementing an SCD subsequent to the GF/CF diet is that it allowed for some comparison between the two interventions by allowing enough time for GF/CF related changes to occur. It is believed that GF/CF interventions require three to twelve weeks before one could expect to see improved autistic expressions [11, 20].

Each student's baseline was measured with the ATEC (Fig. 2), and the GF/CF diet was implemented four days later. Since the students were not in public school at the time of the GF/CF implementation, only the parents performed GF/CF baseline assessments using the ATEC. Additionally, the parents maintained journals with daily entries.

Milk and milk products were removed from both students' diets, effectively removing the casein protein. Gluten elimination was started concurrent to the removal of casein, but gluten was removed incrementally over approximately ten days. Both students exhibited red and textured rashes immediately upon placing fruit in their mouths. This was diagnosed as eczema by a medical doctor. Since this appeared to be an allergic reaction, fruit was also removed from each student's diet. During the diet, each student presented with similar red and textured rash on their vaginal areas after eating products containing corn oil. Corn oil was then removed from each student's diets.

The GF/CF diet lasted for four months and nine days prior to implementation of the SCD intervention. Four months should have been long enough to identify the GF/CF effects that would have otherwise been seen in the SCD [11]. After the students began school, they maintained a GF/CF diet for fourteen days. This gave the developmental preschool teacher an opportunity to develop robust baseline observations of both students prior to the SCD implementation. ATEC, ASTAR, and AEPS assessment tools were used as post-assessments for the GF/CF diet and baseline assessments for the SCD intervention (Figures 2-8).

4.3 SCD started

The SCD intervention started January 19th, four months and nine days after the GF/CF diet began, and data for this study was collected through April 22nd. The SCD in this study was modeled after Elaine Gottschall's book, *Breaking the Vicious Cycle: Intestinal Health Through Diet* [15]. The diet empha-

sizes elimination of all foods that are not monosaccharides. Ostensibly, this improves gut health by bringing about gut flora equilibrium and gut healing.

4.4 Other interventions

Although the SCD and GF/CF interventions have been proven through use and over time to be safe dietary interventions, it seemed prudent to seek professional advice regarding nutritional supplements. Refer to Table 1 which explains the supplement schedule these students maintained during dietary intervention. The supplements used during the GF/CF diet were started three months after the diet began. The supplements that were only used during the SCD began two weeks prior to the SCD and were discontinued approximately three weeks prior to ending the SCD.

Table 1. Supplement Schedule

Supplement	GF/CF Supplement Schedule	SCD Supplement Schedule
Betaine (TMG) (1000 µg b.i.d.)		X
Calcium & Magnesium	X	X
Eskimo 3 (fish oil)	X	X
Folinic Acid (400 µg b.i.d.)		X
Mehtylcobalamin (B-12) (one injection twice a week)		X
Super Nu-Thera Multivitamin	X	X
Vitamin C	X	X
Zinc	X	X

4.5 Credibility and limitations

As with any qualitative research project, this study seeks to describe and better understand specific events with specific students in specific environments. The very nature of qualitative research limits the generalization of the conclusions due to subject characteristics, context of the research, the treatments, and the data collection methods used. But specific comparisons may still be possible. The data, categories, procedures, and patterns detailed herein are described well enough for other researchers to understand and apply in other settings.

This study's validity is enhanced by the fact that like changes were observed over three different data collection sources, i.e., parent, teacher, and autism consultant. Furthermore, the data collected during this study should interest readers for many reasons, e.g., there are no published studies related to developmental disorders and the SCD. Indeed, the only published work on the SCD is a case study on a typical adult female with Inflammatory Bowel Disease printed September 2004 [21].

5. Results & Discussion

Figure 9 compares the observed and documented changes in both diets, and it was created to provide distinctions between the varying effects of each diet. By distinguishing these differences, it was possible to reflectively and accurately answer research question three. Conclusions about questions one and two become unmistakable in light of question three's contribution.

Considering the different effects caused by each diet, it must be understood that the SCD will likely exhibit *at least* the same changes that the GF/CF diet exhibits because the SCD is a species of GF/CF. It is more restrictive, though, so one could expect that the GF/CF would not reciprocate a similar presentation. This appears to be confirmed in Figure 9.

5.1 Research Question 3

What differences are observed when the SCD is introduced vis-à-vis the introduction of a GF/CF diet? In answering this question, the data collected through journals, school-home communication journals, ATEC, interviews, and written surveys were referenced. The journals seemed to be most informative in answering this question.

Referring to Figure 3, reveals clear answers for research question three. The matrix shows more change occurring during the SCD period than during the longer GF/CF intervention. Student A had four behavioral improvements and one physiological improvement during the GF/CF, in contrast to her fourteen behavioral and five physiological improvements during the SCD. Similarly, student B had two behavioral and one physiological improvement during the GF/CF diet, compared to her twelve behavioral and five physiological changes subsequent to the SCD implementation.

Sometimes quantity is meaningless in view of quality, though. It should be asked, "Is the worth of each change equal?" The answer is of course, no. In the physiological grouping, firm stool is observed during the SCD which is more preferable to diarrhea which was observed during the GF/CF. In the behavioral camp, though, student B's loss of self-mutilation during the GF/CF diet seems to offset any two improvements observed during the SCD intervention. In order to understand the "full story" though, quantity becomes rather important.

A final answer for question three must point out that although self-mutilating behavior is undesirable, it certainly cannot cancel out all of the significant improvements seen during the SCD intervention. So, the immediate differences seen between the SCD and the GF/CF diets are differences in quality and quantity, both of which seem to weigh much heavier on the side of an SCD intervention. Referring to Figure 9, one is presented with evidence suggesting that the SCD is more effective than the GF/CF diet. The ATEC scores shown in Figure 2 seem to corroborate this conclusion by indicating clear overall improvement.

5.2 Research Questions 1 & 2

What physiological changes are observed, and what behavioral changes are observed? In addressing the collected data as it relates to research questions one and two, sample observations from each data collector are provided. These samples reflect the observations of what seems to be the essence of each

collector's contributions. Then each research question is answered after a brief analysis of these observations. All data collection tools were referenced in answering these questions (Fig. 1).

The parents' only notable journal entry during the GF/CF diet and regarding physiological improvement regards the students' stool. Chronic gastrointestinal issues are widespread among autistic children [7, 9–13, 19, 22]. Each student had never had a firm bowel movement, and the GF/CF diet was recommended by their pediatrician. The parents went to the doctor with the observation that each student was experiencing diarrhea 5 to 7 times per day. This frequency decreased two weeks after beginning the GF/CF intervention to only one incident per day. The fact that both students were equally affected seems to suggest that the dietary intervention played a role in the improvement of this physiological issue.

The parents' most prominent journal entries regarding behavioral improvements need to be itemized for each student. Student A's improvements appear to have been in communication. Many entries in the parental journals during the GF/CF diet may be summed up with the following quotes: "first time speaking since her regression," "improved eye contact," "speaking more words." Despite these journal entries and many more like them, the parents' ATEC scores seem to contradict the proposition that communication improved (Fig. 5). At best, the ATEC scores reveal no observable change in communication during the GF/CF diet. If this is the first time that student A has spoken since her regression, then perhaps the ATEC tool should be suspected of being inaccurate. It is not clear that the ATEC is inaccurate given this one apparent discrepancy, though. Previously herein a "cascade effect" was detailed which may account for this apparent contradiction. Or it may be that student A was not saying enough for the parents to justify improving her ATEC scores. If this were the explanation, then it would seem to suggest that the parents are attentive to placebo. At most, this discrepancy suggests that no observable behavioral change occurred during the GF/CF intervention. Overall, a conservative interpretation of parental data regarding student A and during the GF/CF diet reveals no observable behavioral change and some physiological improvement.

According to the parents' journal entries, there were only two patterns that emerged regarding student B's behavioral improvements. Most notably was her loss of self-mutilating behaviors. Student B's parents recorded the following in her journal: "I think the diet is helping because [student B] has not been harming herself for over a week..." There are no further accounts demonstrating that student B has since harmed herself. The parents' ATEC scores substantiate this change as seen in Figure 6: November to December shows a dramatic 28% improvement in the ATEC subcategory, "Health/Physical/Behavior"—which is where self-injury is measured. Accordingly, it appears that student B presents during the GF/CF diet with observable behavioral improvement and observable physiological improvement.

The parents observed one deteriorating behavior in both students during the GF/CF intervention. They did not remark on any physiological deterioration, though. The deteriorating behavior was recorded in a December entry: "[they] don't like chicken any more...but they use to eat everything. All they eat

now are Rice Crunch 'Ems cereal and French fries.'" A second journal entry confirmed this first observation: "It seems like they stopped eating everything... [They] hold out for Rice cereal and potatoes." It has been documented that children with autism self-limit their diets [23], and a self-limiting diet would be considered a deteriorating behavior due to nutritional concerns. It may be inappropriate at this time to suggest that the GF/CF was responsible because there are many theories as to why self-limiting is so prominent among autistic children, but there are no definitive conclusions. Barring a future explanation, it seems charitable to conclude that the GF/CF diet is not necessarily responsible for the self-limiting.

In summarizing the parent's observations of autistic expressions during the GF/CF diet, the following has been revealed: student A has little-to-no observable behavioral improvement and some physiological improvement; student B presents with observable behavioral improvement and observable physiological improvement; both students show a behavioral deterioration that may or may not be related to the GF/CF diet.

Earlier it was shown that observed changes between the SCD and the GF/CF diets seem to weigh in favor of an SCD intervention. The parent's observations during the SCD reflect this inference. For example, according to parental data, both students showed more behavioral and physiological improvement during the SCD (Fig. 3). The journal entries also reveal substantive changes in both students. The parents wrote, "[Student A] is no longer hyperactive." This observation was confirmed when the school teacher made a similar declaration on a later day: "[Student A] has been so much more calm.", and on another day, "...she's so much more in control of herself." These are not trivial transformations because they help provide an environment conducive to learning. Similarly, substantive behavioral changes were observed in student B. Her parents wrote: "[Student B] has better eye contact and is more social, e.g., she approaches us more frequently to show us a picture in a book. Also, teacher says she's laughing and giggling appropriately. We've also noticed her laugh at TV slapstick—something that she has never done [she's three]." These observations reveal not only substantive changes, but, when coupled with the fact that they have been supported by the school teacher, they become powerful persuaders that real behavioral improvements have occurred subsequent to the SCD introduction.

Both students also enjoyed substantial physiological improvements during the SCD. In fact, both students were observed to improve in the same five areas. All are worthy of noting: food induced eczema disappeared; solid stool was seen for the first time in their lives (both began firm stools exactly ten days after starting the SCD); abdominal distention was ameliorated; dark circles around their eyes, usually referred to as "panda eyes", disappeared; and their unique, foul body odor vanished. These five observations represent empirical physiological improvements; the fact that all five have been observed in both students, some on the very same day, emphasizes the unmistakable nature of this conclusion. Furthermore, these observations were reported via ATECs, journals, interviews, and reported by both parents and the preschool teacher.

Also documented was the loss of self-limiting. Self-limiting was considered a deteriorating behavioral change during the

GF/CF diet. Both students stopped eating a variety of foods and would not eat until they were presented with rice or potatoes, specifically, Rice Crunch 'Em cereal and French fries. After the SCD started, both students began eating other foods—they had to because all grains were removed from their diets. They also started eating a greater variety of foods. They began eating chicken and steak. The parents also reintroduced bananas, plums, and pears. Interestingly, in spite of their eating fruits during the four month SCD trial, the students have not presented with eczema.

The school teacher confirmed parental observations in the following response to the three research questions:

“...When it got [close] to time to eat [both students] would cry sometimes even scream. The crying and screaming would stop during eating, but would begin again toward the end of the meal. It almost seemed as if [student B] was anticipating the pain. She wouldn't eat all of her food. Their bellies were hard and distended directly after eating. Approximately 45 minutes after they ate, the girls would cry and scream, wanting to be held. Sometimes they would tuck themselves into the fetal position.” and “Now, the girls scream when they are frustrated, but can be redirected. The girls are now able to eat their whole lunch without tears. Their tummies...do not stick out when they are done eating. The girls make better eye contact now. They smell fresher. Their s[t]ools are consistently more firm. The girls will get our attention with a touch and eye contact to ask for items during meal time. They seem to see meal time as a social experience instead of a painful time. Both girls are able to work for longer periods of time after lunch. Both girls are more interactive and playful.”

The behavioral and physiological advances which the parents attributed to the SCD seem to have been well reasoned in light of this teacher's supporting remarks.

On student A's first autism consultant meeting subsequent to starting the SCD, the autism consultant asked, “Are you guys doing something different?” She was responding to the fact that student A seemed to master new skills more quickly than expected. The consultant added that she would have to adjust student A's curriculum because she had already mastered the imitation skills that were designed for her. Add the ATEC and AEPS scores to these observations (Figs. 2-8), and a strong behavioral improvement trend seems to be confirmed by all participating data collectors. There are strong, parallel improvements indicated by ATEC scores among all scorers throughout the SCD trial (Fig. 2). Likewise, the AEPS show strong upward trends for both students (Figs. 7 and 8). In contrast to the ATEC, AEPS reflects improvements with upward trends. In words: the overwhelming majority of data collected seem to show strong improvement trends in physiological and behavioral changes.

Two data collection tools challenge the previous conclusions: the ASTAR (data not shown) and student A's ATEC scores represented in Figures 2 and 5. The ASTAR information is a behavioral measurement tool—it does not measure physiological change. The ASTAR data simply flat-lines when it is

graphed. This of course demonstrates, at best, that no change has been observed. The overwhelming majority of information collected makes the ASTAR information uninteresting. If one accepts the strongest opposing evidence, though, it would seem to strengthen her subsequent conclusions. Thus, the strongest consequence resulting from the ASTAR outcomes, i.e., the suggestion that no behavioral change has occurred, will be considered in our conclusions.

Looking at Student A's ATEC scores in Figures 2 and 5, it appears that little observable behavioral change has occurred during the experimental trial. This still represents progress because behavioral improvements are reflected by her ATEC through April. But, it is prudent to anticipate the strongest claims against the majority data collected, thus strengthening one's final conclusions. Given that two collection tools suggest no behavioral change has been observed, the same will be conceded. Such a concession would only strengthen the conclusion because the strongest points against the majority of evidence is conceded. Conceding that there is no observable behavioral change, in spite of the fact that most of the evidence and all of the participants corroborate the existence of strong behavioral improvement trends, should add persuasive force to the conclusions. It is not necessary to reconcile the two claims against behavioral improvement in order to conclude that there is clear, substantive improvement. Later this will be demonstrated by presenting conclusions based on both observations, i.e., “there are no observable behavioral changes, but there are observable physiological improvements,” and “there are observable behavioral improvements and observable physiological improvements.”

5.3 Other explanations

Before presenting these two observable outcomes and their implications, it might be asked if something else could be responsible for the observable changes. Can developmental preschool have caused behavioral and physiological change? After all, preschool started two weeks prior to the SCD implementation. Or, could the vitamin supplements be responsible for the observed changes?

It is not likely that developmental preschool was responsible for the improvements that were observed in these two students. The preschool might be incidentally credited to some degree for supporting the dietary intervention during school hours. But recent studies have shown that public school alone is usually responsible for deterioration in language, adaptive, social, and academic areas among autistic children [24, 25]. The fact that school is not solely responsible for the changes observed in the students is more persuasive in light of the data detailed in Figure 3. For example, it is difficult to see how the loss of “self-limiting” behavior or the loss of “night wakings” could result from public instruction. Even if the behavioral improvements could be accounted for by the students' education, one must still reconcile the physiological changes, such as stool change, loss of foul body odor and loss of panda eyes. Developmental preschool then does not seem to be an adequate explanation for all of the observed improvement, though it is possible that the public instruction was incidentally responsible for some observed improvement.

Table 2 is useful in explaining why supplements are not likely the cause of observable improvements in these students (also refer to Figures 4 and 5). The vitamin regimen started two months prior to execution of the SCD, and the B12, TMG, and Folic Acid started two weeks prior to the SCD. B12, TMG, and Folic Acid are expected to show improvements within days to weeks [11]. This suggests that any effects caused by the B12 regimen should have been noticed prior to the SCD start date. Such dramatically fast effects have not been associated with the vitamins that started in November. It is plausible that the vitamin schedule caused delayed improvements. However, it does not seem likely given some of the journal data. For example, both students started the SCD on the same day. Five days from that start date, both students had one loose stool. Five days after the loose stool, both students presented firm stools for the first time in their lives. The SCD seems more logically connected to a physiological improvement affecting both students on the same day because the improvements were more immediate relative to the diet. It would be expected that a vitamin supplement showing delayed improvement would most likely affect two students differently—certainly on different days. For these reasons, one should dismiss proposals linking supplements to the improvements seen in these students.

Table 2. Timeline of Study

Date	Description of Intervention
08/10/03	GF/CF begins
11/10/03	Vitamin supplements begin
01/05/04	B12/TMG/Folic Acid begins
01/19/04	SCD begins
03/30/04	B12/TMG/Folic Acid ends
04/22/04	SCD data collection ends

The fact that goat’s milk yogurt was not used will be of keen interest to some. The SCD relies on goat’s milk yogurt to reintroduce good bacteria to the gut, thus improving gut flora issues. It seemed reasonable to restrict this from the students for at least two reasons. First, goat’s milk yogurt is only one difference between the GF/CF and the SCD. Indeed, yogurt may be a trivial feature when compared with other more substantive differences such as the SCD’s restriction of grains, dyes, sugars, preservatives, etc. Second, the SCD specifically prohibits foods that cause diarrhea. Both students in this study had diarrhea present when consuming milk, so it was decided to reintroduce goat’s milk yogurt into a much later stage of the diet.

Earlier the claim was made that it is not necessary to reconcile ASTAR data and student A’s ATEC scores in order to conclude that there is clear, substantive improvement in the students’ autistic expression. Though it is believed that the evidence presented herein shows that both students made physiological and behavioral improvements, a conclusion that the SCD is more effective than the GF/CF remains tenable even if the weaker observation is conceded that “there are no observable behavioral changes (or behavioral changes are due in part to something other than the SCD), but there are observable physiological improvements.”

What kind of conclusion could one make based on the concession that public education deserves some credit for behavioral improvements, or based on the ASTAR’s data which show that there were no observable changes? Notice that nothing is suggesting that there is an overall behavioral deterioration. This would be absurd given the evidence. At minimum, one’s conclusion could declare: there was no observable behavioral change, and there was clear, observable physiological improvement in both students. This would be considered a weak claim given the presented evidence. If this is accepted, then the SCD adhered to by the students appears to be more effective than its GF/CF predecessor.

It was also shown that a stronger conclusion could be advanced from the presented data. The stronger claim being that there was observable behavioral and physiological improvement in both students. For those persuaded by this stronger claim, they would conclude that the SCD appears to have a greater improvement on these students’ GI symptoms than the GF/CF. Regardless of ones acceptance of the weak or strong claim, the above presented evidence supports the finding that the SCD was a more effective dietary intervention for these two students than was the GF/CF diet.

6. Summary and conclusions

The goal of this project is to understand the SCD’s effectiveness in ameliorating autistic expressions vis-à-vis a GF/CF intervention, thus aid in determining its validity as a dietary intervention. A crucial aspect to understanding the conclusions of this study is to remember that the goal is directed at observing change in autistic expression during dietary intervention. This is a crucial point because the only characteristics worth noting in this study are patterns of change (is there behavioral change and/or physiological change; if so, do all participants acknowledge the same patterns of change, such as trends in improvement or deterioration?). A fair question for such a study would be, “Is a pattern of change in autistic expression revealed by the participant’s scoring?” rather than, “Do all scores among the various participants correlate?” In short, this study is not looking for exact calculations per se; it is looking for similar patterns, specifically, patterns of change concurrent to intervention. For example, if the SCD is a viable dietary intervention, then there should be a downward trend in the scoring of the ATEC or an upward trend in the scoring of the AEPS. If multiple people were scoring students using the ATEC, e.g., parents and a teacher, and if all scores indicate a downward trend, then it is reasonable to assume that such a trend indicates real improvement thus demonstrating the diet to be a viable intervention.

The evidence presented herein shows trends in physiological and behavioral improvement for both students. There were, however, two data collection tools that seemed to challenge the previous observations regarding clear improvement. The challenge suggests that a weaker claim is more likely. Since either the weak claim or the strong claim result in the same conclusion, it is not necessary to reconcile the two data collection tools; regardless of the claim, weak or strong, one still concludes that the SCD is a more effective dietary intervention for

these two students than its traditional GF/CF dietary predecessor.

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Figure 1. Data collection strategy and triangulation

Research Questions	(Data Source 1) Parents	(Data Source 2) Teacher	(Data Source 3) Consultant
What, if any, physiological changes are observed?	<ul style="list-style-type: none"> • Journal • School-home communication journal • ATEC • ASTAR 	<ul style="list-style-type: none"> • School-home communication journal • ATEC • Survey • Interview 	<ul style="list-style-type: none"> • Survey • Interview
What, if any, behavioral changes are observed?	<ul style="list-style-type: none"> • Journal • School-home communication journal • ATEC • ASTAR 	<ul style="list-style-type: none"> • AEPS • School-home communication journal • ATEC • Survey • Interview 	<ul style="list-style-type: none"> • Survey • Interview
What differences are observed when the SCD is introduced vis-à-vis the introduction of a GF/CF diet?	<ul style="list-style-type: none"> • Journal • School-home communication journal • ATEC 	<ul style="list-style-type: none"> • School-home communication journal • ATEC • Survey • Interview 	<ul style="list-style-type: none"> • Survey • Interview

Figure 2. ATEC “Total Summary” scores: PA and PB refer to the parent’s assessments of student A and student B, respectively. Parents recorded data with the ATEC tool from the beginning of the GF/CF diet in August through May. TA and TB refer to the teacher’s assessments of student A and student B, respectively. Downward trend represents improvement.

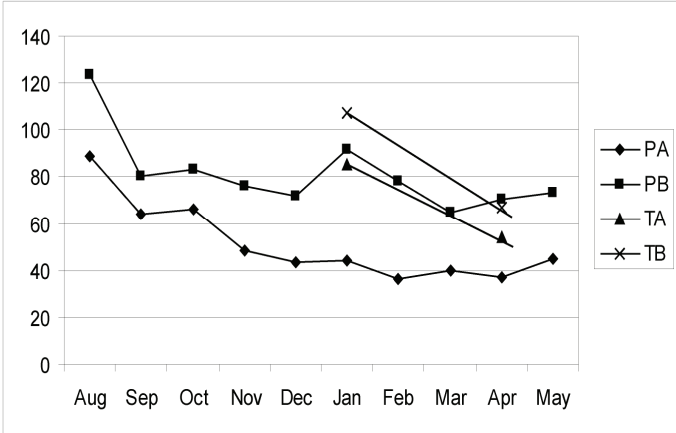


Figure 3. Teacher’s ATEC Scores for Student A. Downward trend represents improvement.

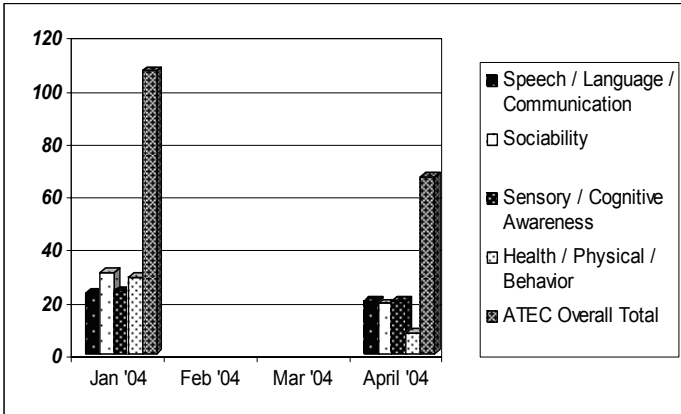


Figure 4. Teacher’s ATEC Scores for Student B. Downward trend represents improvement.

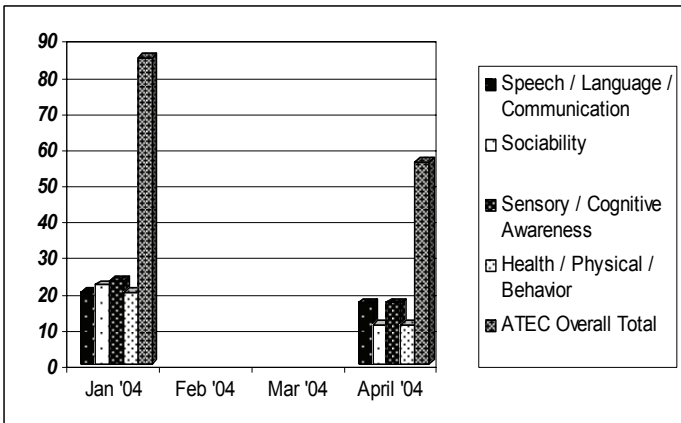


Figure 5. Parent’s ATEC Scores for Student A. Downward trend represents improvement.

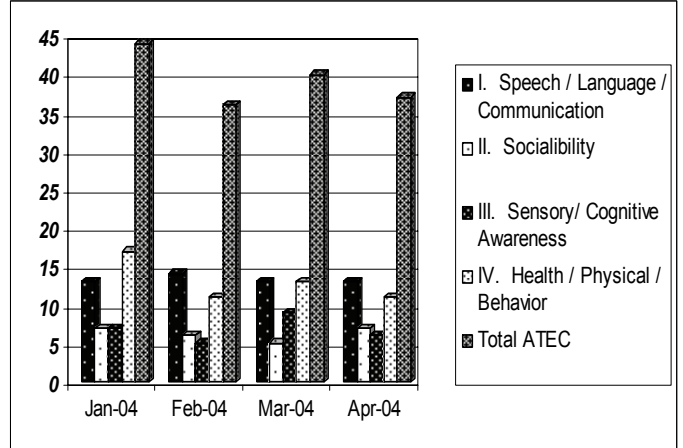


Figure 6. Parent’s ATEC Scores for Student B. Downward trend represents improvement.

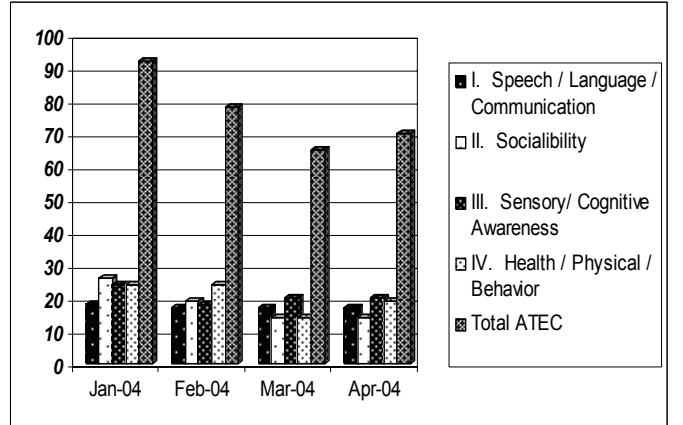


Figure 7. Student A’s Baseline and Post-assessment AEPS Scores. Upward trend represents improvement.

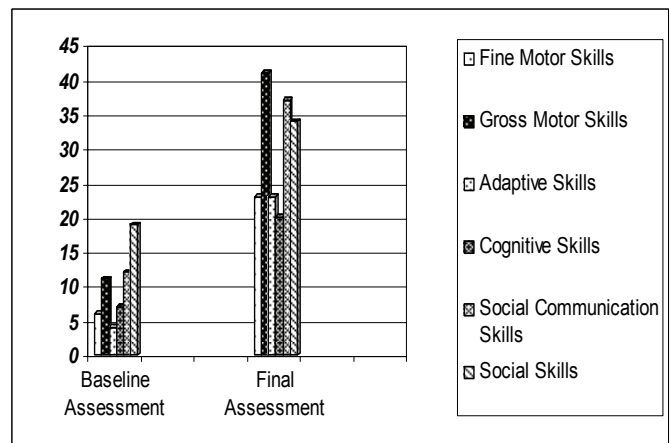


Figure 8. Student B's Baseline and Post-assessment AEPS Scores. Upward trend represents improvement.

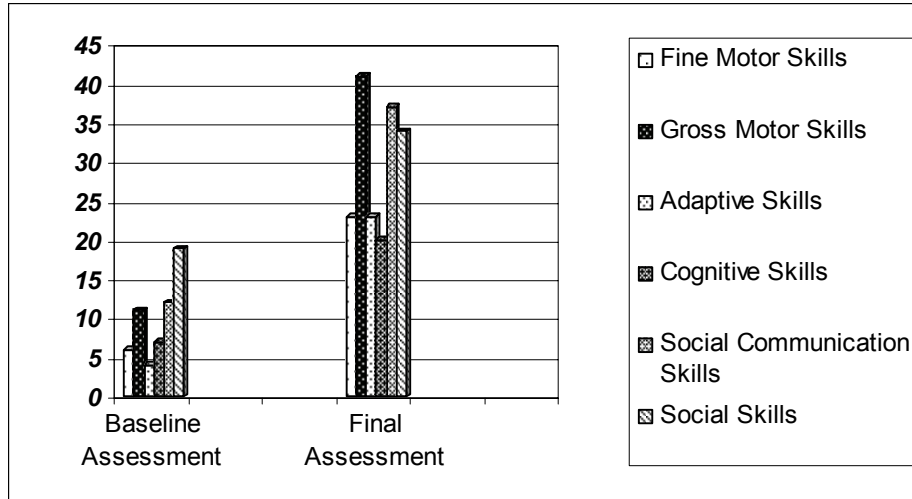


Figure 9. Comparison of changes observed between each intervention.

	Gluten Free / Casein Free Student A	Gluten Free / Casein Free Student B	Specific Carbohydrate Diet Student A	Specific Carbohydrate Diet Student B
Improved Behavioral Changes	<ul style="list-style-type: none"> • Less Stimming • Began to speak for the first time since regression • More vocabulary (echo) • Improved eye contact 	<ul style="list-style-type: none"> • Loss of Self-mutilating behavior • Loss of <i>Constant</i> stimulating behaviors 	<ul style="list-style-type: none"> • No self-limiting • No fetal positioning • No night waking • Loss of autistic gaze • Less tantrums • More words & clearer speech • More aware of environment • Greater imitation skills • Greater self-control / less hyperactive • Loss of head-banging • Less screaming & crying • More social • More helpful • Greater imagination 	<ul style="list-style-type: none"> • No self-limiting • No fetal positioning • No eye covering • Significantly less night waking • Loss of autistic gaze • Less tantrums • More aware of environment • Not biting others • Less screaming & crying • More initiating • More verbalizing • Smiles & laughs appropriately
Improved Physiological Changes	<ul style="list-style-type: none"> • Diarrhea decreased from approx. 7 per day to only 1 per day 	<ul style="list-style-type: none"> • Diarrhea decreased from approx. 7 per day to only 1 per day 	<ul style="list-style-type: none"> • No food induced eczema • Solid Stool • Less abdominal distention • No Panda eyes • Loss of foul body odor 	<ul style="list-style-type: none"> • No food induced eczema • Solid Stool • Less abdominal distention • No Panda eyes • Loss of foul body odor
Deteriorating Behavioral changes	<ul style="list-style-type: none"> • Self-limiting 	<ul style="list-style-type: none"> • Self-limiting 		
Deteriorating Physiological Changes				