A BASELINE PERFORMANCE ASSESSMENT OF A NON-VERBAL LANGUAGE LEARNER'S USE OF HIS AAC DEVICE

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INTRODUCTION

Malcolm Turner, an eight-year-old boy, is non-verbal due to a combination of trauma to his vocal cords and apraxia. Malcolm has an autism diagnosis, but also has experienced brain trauma due to his extreme prematurity. Since he had a tracheostomy from age two months to thirty months, his parents have used American Sign Language (ASL) to communicate. In order to facilitate communication with the non-signing population, a combination of private insurance and Medicaid paid for an AAC device, the Accent 1000 for Malcolm.

Malcolm, a third grader, receives speech therapy at school and at the Grunwald-Blitz Clinic at the University of Arizona. Speech-language pathologists in both settings are working with Malcolm to learn how to use the Accent 1000. In order to measure his progress in using the device, we have used the AAC Institute's AAC Performance Report to assess his usage patterns. We will use this data:

1. to inform on-going therapy,
2. to choose the most effective modes or settings on the Accent 1000, and
3. to measure outcomes.

SUBJECT BACKGROUND

Malcolm Turner is non-verbal, eight-year-old boy who attends third grade in public school in Tucson, AZ. He is in a self-contained autism classroom with a low student-to-adult ratio. He communicates in several different ways: ASL, pointing and gestures, writing, and a speech-producing AAC device. He can produce several monosyllabic phonemes like "bah" (iPad) and "mah" (Thomas) and can approximate alphabet sounds with great effort when prompted; however, he has never produced intelligible speech. He cannot talk because of several causes:

1. **damage to vocal cords**;
   Malcolm was born at 26 weeks and immediately intubated and put on a ventilator to help him breath. Purposeful and accidental extubations led to almost thirty reintubations during his five-month course in the NICU. Edema and scarring of the trachea and vocal chords led to grade-three tracheal stenosis (narrowing of the airway). In order circumvent this near-complete close of the trachea, doctors performed a tracheostomy at two months old. It was not until he was 30-months old and after laryngotracheal reconstruction that he was decannulated (trach removed). Because he did not have speech capability during the first 30 months, he did not experience any normal developmental speech.

2. **brain trauma**;
   Due to his extreme prematurity, Malcolm experienced intraventricular hemorrhaging (IVH) [1] in his brain the first month of life, which led to periventricular leukomalacia (PVL) [2], or scarring.

When Malcolm was five years old, a routine MRI led to the discovery of hydrocephalus [3], an abnormal accumulation of cerebral spinal fluid (CSF) in the ventricles of the brain, which can cause dysfunction and tissue damage due to high pressure. Surgery corrected the condition, but it is unknown how long he suffered.

3. **autism**.
   One of the defining characteristics of Autism Spectrum Disorders (ASD) is severe language delay, although many children who have such deficits make significant gains by age eight. [4] Malcolm has had speech therapy services since he came home from the hospital at five months. Unfortunately, he has made no gains in verbal speech, probably because of the above factors; instead, speech therapy has focused on alternative means of communication and literacy.

WEAKNESSES

In school psychological testing, Malcolm tests as mild to moderately mentally retarded, with an IQ in a range from 55–62, on a non-verbal test. He has some adaptive skills. He is toilet trained, but still needs prompting to initiate and complete personal hygiene tasks like wiping after a bowel movement and washing his hands. He can put on shoes, but about 50% of the time, on the wrong feet. He can dress himself if an adult provides him with an outfit, but if challenged with a shirt *and* sweater, for example, he would not necessarily put them on in the correct order. He can put on shoes and successfully navigate Velcro fasteners, but has not yet learned to tie shoes. Buttons and small zippers are also a challenge.

The greatest challenges Malcolm faces in improving his academic and self-help skills are attention, impulsivity, and "stimming." Malcolm has severe attention deficit with hyperactivity disorder (ADHD) which lends itself to both hyper- and hypo-attention issues. He will often obsess on a favored visual image in a book or on an iPad. If he is not engaged in a highly desired activity, his attention wanes quickly and impulsivity takes over. His desire for a highly prized item can often not be assuaged. Malcolm has a low frustration tolerance that can sometimes lead to swift changes of mood and impulsive behavior. "Stimming," short for self-stimulating behavior. Malcolm compulsively rocks, rolls a small ball of thread or yarn between his thumb and index finger, or taps a keyboard button or a picture key on a tablet or iPad until the device locks up. While these behaviors are not self-injurious, they do block learning, especially on Malcolm's tablet-based Accent 1000.

STRENGTHS

Malcolm has a natural affinity for spatial awareness tasks. He knows where he is when driving in a car at a given time; he often indicates by pointing and yelling which direction he prefers to go. He also enjoys and succeeds at doing jigsaw puzzles up to about fifty pieces. He can navigate an iPad quite intuitively. He keys in search terms, mostly the names of his favorite engines from Thomas the Train.

Malcolm can read approximately on a kindergarten or first-grade level. It is difficult to assess his understanding of written materials because his expressive language deficits. He can point out words (out of the context of his favorite books or digital books) when prompted. He can also respond to basic reading comprehension questions like: What color was the cat?

Easily motivated by highly prized items, Malcolm will work hard on tasks in order to receive an award, which makes designing and teaching him new academic or practical tasks easier.

CURRENT USAGE PROFILE

THE DEVICE

The Accent 1000 [5] is an augmentative and alternative communication (AAC) device. It is a 10-inch tablet-based device, reinforced with a rigid plastic shell that offers boosted speakers, two USB ports, and an AC plug in. It also has a ratcheted handle that can also serve as a prop. It also offers front and rear cameras and built-in Wi-Fi capability.

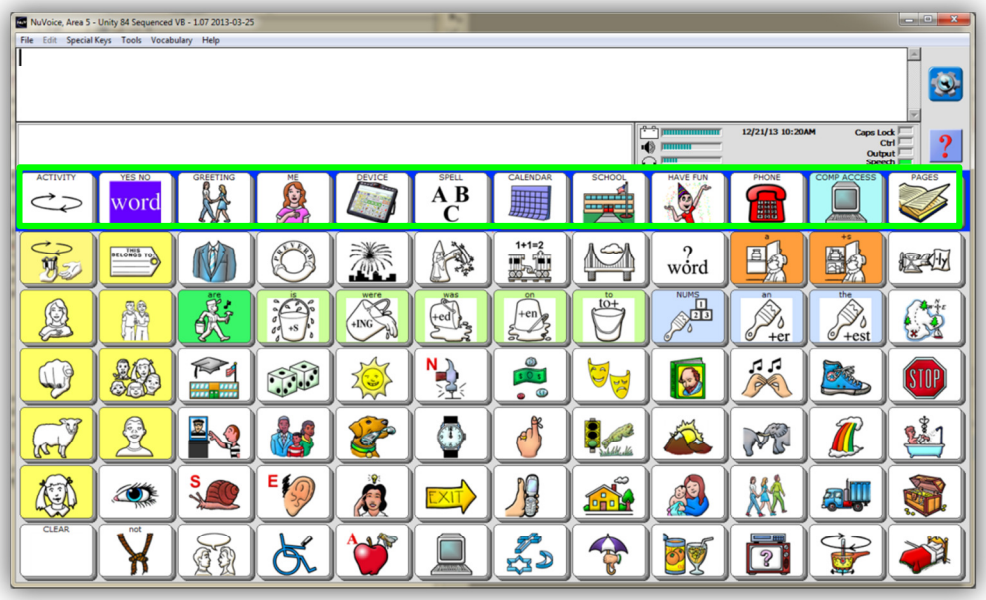
Because the Food and Drug Administration (FDA) regulates AAC devices, there are restrictions on usage. It is a "dedicated" device, and thus, it has a lock; the user cannot add other applications During the course of research, however, we found out that we could pay a fee to Prentke Romich (the maker) to have it unlocked.

THE USER INTERFACE: UNITY

The device comes loaded with Unity software [6], created by one of the founders of Prentke Romich, Barry Romich.

Unity software uses icons to represent language. In this example to right, the user inputs the verb "eat" by first pressing the apple icon, then the green worker icon. Green always represents a verb and the worker the primary verb associated with the previously selected icon.

Below is a view of the home screen for the Unity 84 sequenced setting, which Malcolm uses. (It is a desktop version of the software, so Windows-based menu items at the top appear, although they would not on the device.) You can see the apple icon on the bottom row, fifth from the left.



White Buttons: lead to multi-choice screens.

Yellow Buttons: pronouns

Green Buttons: verbs

Blue Buttons: adjectives

Orange Buttons: articles and nouns

Top Row: Fringe vocabulary and other options

A key feature is that the buttons and icons appear in the same location everytime so the user can user muscle memory to make the tasks automatic, much like typing or playing the piano.

When a user presses a white button, like the apple icon, a new screen appears with multiple options. (See below.)

Eat, the main verb associated with the apple icon appears in bright green, while conjugated options appear in light green.

Other words and concepts associated with the apple icon also appear:

- **food**, noun in orange
- **hungry**, adjectives in blue
- grow, bite, chew, taste

In addition, other vocabulary and phrases that help a user form a syntactically-correct sentence appear: pronoun-helping verb phrases, other associated verbs and nouns, indefinite pronouns and adverbs, the "–n't" negation, and the "–ly" suffix, among them.

The top row switches to **fringe** vocabulary associated with the apple icon, types of food.

The main part of the screen, everything below the top row, is what Prentke Romich calls **CORE** vocabulary, which is similar to Dolch sight words. Core vocabulary contains the 400 or so words that compose 85–95% of our daily vocabulary. [7] The most frequently used Core vocabulary appears on the first screen. [6] Fringe vocabulary is composed of less frequently used words, mostly nouns, that are "activity specific." [7]

METHODOLOGY

In order to measure Malcolm's use of the Accent 1000, we collected and interpreted data using the following tools:

1. language activity monitor (LAM) [8]
2. AAC Performance Report Tool (PeRT) [9]
3. AAC Performance Report [9]

The steps for converting LAM data into the AAC Performance Report are as follows:

1. Upload LAM data from AAC device to a computer.
2. Open LAM file within PeRT.
3. Choose and segment the data manually into utterances.
4. Generate the AAC Performance Report using PeRT.

LANGUAGE ACTIVITY MONITOR (LAM)

The LAM is a built-in option included in the Unity software on the Accent 1000. After activating it on the device, it collects the data from the touch strokes of the device user. It records the time and content of language events (the generation of one or more letters or words). [8] It also includes the method by which the user chose the event, or language representation method (LRM), such as:

1. SMP = Single Meaning Pictures;
2. SEM = SEMantic Compaction
3. WPR = Word PRediction;
4. SPE = SPElling;
5. OWS = Orthographic Word Selection

Malcolm's Accent 1000 is set to Unity 84 Sequenced with word prediction. With that setting, semantic compaction, word prediction, and spelling are the only outcomes.

SEMANTIC COMPACTION

The Unity Sequenced setting lends itself mostly to semantic compaction. This method of choosing words is determined by multiple-meaning icons, as explained above. The advantage is the symbol set is exponentially smaller than for single-meaning pictures. The symbol set essentially fits on a single 84-icon screen. [10] Another advantage is that this method does not require the user to read. The symbol sequences are short, generally 1–3 touches. [11]

SPELLING

A user can access a QWERTY keyboard on the Accent 1000 to spell out a word at will. Using an alphabet-based system requires literacy, and most users will not maximize their potential at the typical rate of unimpaired speech, 150–200 words a minute. [12]

WORD PREDICTION

Word prediction is very similar to word prediction software used in smartphones and iPhones for language generation. It predicts a small range of possible word outcomes based on what letters the user has already entered, as well as what words the user has already entered. Word prediction has proven to increase communication rates. [12] However, it does require literary skills to read the suggested words.

MULTIPLE METHODS

Research shows that having multiple methods available to users is the best option. Hill reports that the most effective communicator use semantic compaction for 90–95% of utterances, while the remaining 5–10% is split between spelling and word predictions. [10]

PERFORMANCE REPORT TOOL (PERT)

PeRT mediates between the LAM files and the AAC Performance Report in a Windows-based environment. It outputs a set of summary measures that characterize the communication performance of the user. [8] It imports raw data, allows the researcher to segment the raw data into spontaneous novel utterance generations (SNUG), a word or sequence of words that indicates meaning. It does not have to be a complete sentence. PeRT color codes the LAM file by type of (LRM). The research highlights the entries she wants to include in the utterance using the mouse. When satisfied that the highlighted entries constitute an utterance, she clicks the **Create Utterance** button, and the utterance appears in the utterance pane of the window. [9] Research has shown that a minimum of 25 utterances must be present to create a valid sample. [13] When the researcher is finished creating utterances from the LAM file, she selects **Create AAC Performance Report**. The generated report appears in html format in a browser window.

An important consideration is that creating the utterance is subjective and requires some academic knowledge of speech-language, as well as the context in which it was voiced. For example, the phrase "in front of the fireplace" might have no meaning alone (and therefore not an utterance), but if it is a response to the question, "Where is the mouse on this page of *Goodnight Moon*?", it does harbor meaning.

AAC PERFORMANCE REPORT

The AAC Performance Report outputs raw data processed by PeRT and displays statistics and charts it in a formatted html file so researchers can use the data to make informed decisions about what intervention goals to use to improve the user's progress in using the device. The report is divided into three basic categories: utterance-based measures, word-based measures, and the appendices, for a total of 17 quantitative measures. For our purposes, we will describe the statistics that we used in this study.

Improving the user's SNUGs is the goal, so we want to look at data that reflects communication that is:

1. Spontaneous (not prompted)
2. Novel (not repeated or echolalic[1])

UTTERANCE-BASED SUMMARY MEASURES

[1] Echolalia is a common speech characteristic of people on the autism spectrum. It involves repeating a word, phrase, or sentence back to the speaker who spontaneously generated the utterance. Sometimes, a particular word or phrase fascinates an individual, and he or she will repeat it regardless of whether someone said it aloud recently. It is sometimes used as a step in the direction of SNUGs, but for individuals with more profound verbal delays, it could characterize their speech throughout their lives. [15]

TOTAL UTTERANCES

Definition: the total number of utterances, as segmented by the researcher

Importance: In order for the research to have clinical value, we must have 25 or more utterances [13]

METHOD OF GENERATING UTTERANCES

Definition: the portion of the total utterances that were generated from words and commonly used word combinations, as opposed to programmed or pre-stored utterances. Expressed in percent (%). [13]

Importance: this statistic will show us how effectively the user is accessing and putting together words into novel utterances. [13]

MEAN LENGTH OF UTTERANCE IN WORDS (MLU-W)

Definition: the average number of words in the utterances. It is a measure of linguistic maturity that can show changes in spontaneous communication. [13]

Importance: This measure can drive therapy. An MLU-w ≥ 3 means that the therapy team should concentrate on semantics or helping the child transmit basic meaning. An MLU-w of 3.0–4.5 suggests concentrating on morphology (putting word components together like adding an –s in the third-person singular verb conjugation) and/or syntax (sentence structure) of simple sentence. Finally, an MLU-w ≤ 4.5 could imply that the user can graduate on to learning more complex sentence structures. [13]

AVERAGE COMMUNICATIONS RATE

Definition: the average rate over the entire language sample at which words are generated using SNUG. Measured in words per minute. [13]

Importance: Many things depend on the rate of communication. If a user cannot generate speech at a rate that keeps up with his or thought process, frustration may set in. A user may give up using the device. On the other hand, if an AAC User is communicating with a verbal communicator, the verbal communicator, who is used to conversing at a rate of 100–200 word per minute, he or she may get frustrated, try to finish the user's sentences, or eventually stop trying to communicate with the user. All of these options are detrimental to mitigating the effect of the user's language deficits and even self-esteem.

PEAK COMMUNICATIONS RATE

Definition: the fastest rate at which the individual is able to generate utterances using the AAC system. [13]

Importance: We can compare with the average communications rate to determine factors that influence performance. [13] Some mitigating factors to take into consideration are: LRM and errors. [7] It may also tell us the potential of the user to increase his or her rate of usage.

WORD-BASED SUMMARY MEASURES

TOTAL NUMBER OF WORDS

Definition: the sum of the lengths of all utterance in the sample. Measured in number of words. [14]

Importance: The larger the sample, the more representative of the user's vocabulary and ability to express himself with the AAC device.

METHOD OF GENERATING WORDS

Definition: Method of Generating Words is an indication of relative use of the available language representation methods (LRMs) used in the generation of spontaneous novel utterances. Measured in percentages (%). [14]

Importance: This statistic lets us know the user's preferred entry method. If the user prefers a slower method, we can encourage a faster method in therapy. We can also change the settings of the AAC device to push one method or the other so the user can practice using the fastest, generally semantic compaction (SEM).

RESULTS AND DISCUSSION

We were able to define 25 utterances in the LAM data file. There were many other entries, but most were the result of stimming behavior. During the two one-hour speech language therapy Malcolm was allowed to explore the device, but he did have tasks to complete, such as answering one of the therapists' questions. He often asked to play with the iPad or particular Thomas trains often used as a reward. The MLU-w was 2.64, which would indicate that his sentence-forming skills are still emerging. This is consistent with his ASL "speech" patterns. His average communication rate was 5.96 wpm, and the peak communication rate was 15.00 wpm. The utterance he keyed in at the highest rate was: "he wants drink," all of which he entered using SEM (semantic compaction method).

In addition, Malcolm entered 66 total words, 83.3% of which were entered using SEM. This is consistent with the settings on his Accent 1000, which is geared towards SEM. All of the 10.6% of the words he spelled out were proper nouns or other words with no available icon . He only entered 4.5% of the words using SMP (single-meaning pictures) and 1.5% using WPR (word prediction). A therapist entered the only word entered using WPR, which shows he is either not aware of the function or chooses not to use it. The three words Malcolm generated using SMP were among his favorites: *blue*, *car*, *truck*.

RECOMMENDATIONS

While this report is meant as a baseline measure of Malcolm's usage of the Accent 1000 device to compare to future speech-language sessions at regular intervals (probably twice a semester), it still offered data to guide his family, teachers, and therapists.

- The high rate of word generation using semantic compaction is encouraging as this is generally held to be the most efficient method.
- The MLU-w was < 3, which indicates his language expression has not developed beyond a very basic simple sentence structure. We need to encourage the use of descriptive words and phrases so he can tell people "which one." Modelling the actions for him is the best way to start. Also, showing him the icon series of longer sentences printed out on paper using the personal computer companion software may help as well. This strategy will also help to increase his total number of words.
- Much of Malcolm's input was stimming. For instance, he repeated "Good morning" twenty times in a row. Later, about 30 minutes into the hour session, he repeated "Good-bye" 12 times. Whether he was simply emphasizing that he was all done with the session, or he was stimming, is not clear. After that, he repeated the suffix "–ly" 20 times in the span of 40 seconds. Then he repeated "jet" 31 times in 35 seconds. When he repeats the same word nearly every second, that is probably a good indication of stimming. Several times he repeats a word 4 times within one second. In order to prevent stimming, we should look into the settings on the device to find out if we can lock him out if repeats one key too often or too many times within a second.
- When he spells a word like "thomas," he uses 2–4 seconds between touch strokes. Over time, we'd like to see him decrease this lag to an average of a second.
- Because he is successful at using the SEM method of entry, we should continue to encourage this behavior, but add new words.

CONCLUSIONS

While non-verbal autistic people are not the only users of AAC devices, they do often have the common practice of stimming. When we prepare the LAM data file, we eliminate the instances of stimming. They are like nonsense babble and do not constitute an utterance. How then do we measure objectively the amount of stimming a person does? We would like to measure if it increases or decreases over time, but if the data is culled from the AAC Performance Report, we have no statistical measure. I would like to see a formula in the form of a ratio between utterances and stimming babble. Any change in this ratio would show progress or regression.

We look forward to analyzing another LAM file for Malcolm at the end the Spring 2014 semester in order to assess progress. In the meantime, we (parent, teachers, and therapists) will continue to encourage Malcolm's use of the Accent 1000 using practices informed by the results of this report.

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