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The Realize Language System: An Online SGD Data Log Analysis Tool

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Abstract

Automated data logging is a feature of some speech generating devices (SGDs). Such data can provide clinicians with information on how a client uses a device. Clinicians can then use these data to help improve the client's skills and opportunities. Logged data could also help answer questions such as: What medical and demographic characteristics are most often associated with usage and vocabulary? What are the characteristics of consumers who end up using their devices the least? How many consumers use their devices with the telephone and other devices? Using example data from an online data analysis tool, the authors will outline some of the positive ways in which data logging can be used to ask, and ultimately answer, many questions about how individuals interact with their SGD technology.

Keywords: automated data logging (ADL), speech generating devices (SGDs), graphical representation, vocabulary analysis, Realize Language system

Introduction

"Would you tell me, please, which way I ought to go from here?"
"That depends a good deal on where you want to get to," said the Cat.
"I don't much care where – " said Alice.
"Then it doesn't matter which way you go," said the Cat.
"-- so long as I get somewhere," Alice added as an explanation.
"Oh, you're sure to do that," said the Cat, "if you only walk long enough."

(Alice's Adventures in Wonderland: Lewis Carroll).

In all fields of endeavor, the ability to measure change is critical. This is as applicable to the field of augmentative and alternative communication (AAC) as it is to any other. To make a statement about change in the absence of some kind of metric is *speculation* and not evidence, and it is important that *evidence* drive educational and clinical practice (Byiers, Reichle, & Symons, 2012; Dollaghan, 2007; Lof, 2011; Schlosser, Koul, & Costello, 2007). Fundamentally, the challenge is to decide (a) what should I measure, and (b) how do I measure it? For professional researchers, there is much more to it than these two questions, but for clinicians and educators in the field, taking just a few minutes to consider them before implementing a new technique or strategy is more scientific than "I'll try X and see what happens." Apel (2009) recommends applying a scientific approach to clinical practices to enable clinicians to provide the best evidence-based practices for clients.

The inability to collect and analyze client data over time was pointed out by Lesher, Moulton, Rinkus, and Higginbotham (2000). They noted at the outset that:

> Over the past few years, technical and technological advances in augmentative communication have outstripped our ability to assess the impact of these advances on the actual act of communication. This is due in part to the lack of a consistent and reliable method to measure long-term communicative efficacy. It has been extremely difficult for researchers, clinicians, and manufacturers to perform the kind of quantitative empirical studies that are an essential counterpart to theoretical advances and qualitative evaluations. Without a disciplined quantitative analysis, it is hard to identify and correct problems in a communication interface. (p.1)

Specific analyses of data gathered from logging have been reported in the literature. Romich, Hill, and Spaeth (2001) used logging to demonstrate selection rate for aided communicators; Lesher and Rinkus (2002) used logging to measure improvements in character prediction; Lesher, Moulton, Higginbotham, and Alsoform (2002) analyzed different scanning arrays via logging; and Hill (2004) reported using logs to break down data in different types as found in Prentke Romich devices. All of these illustrate how automated data logging (ADL) can be used to provide information that would not be easy to get manually.

Without the facility to log over extended periods of time, vocabulary samples collected manually from individuals using speech generating devices (SGDs) could be so small as to be of limited value in terms of being representative. Heilmann, Nockerts, and Miller (2010) reviewed a number of studies that recommend the minimum sample size necessary for allowing a reliable analysis and theses run from 50 to 175 complete utterances. Yet for clients who use AAC systems and who have significant physical and/or cognitive challenges, collecting such a sample during one-on-one sessions could take weeks. ADL is an ideal tool for helping to collect much larger samples over shorter periods of time. In a recent article by Hill, Kovacs, and Shin (2015), the authors argue

that in "the ICF [International Classification of Functioning, Disability and Health] framework the most representative samples would be obtained from language generated during participation in activities of daily living" and "Capturing these data is not possible without automated data logging" (p. S10). This ability to capture very large samples is enhanced by the use of ADL as a feature of SGD technology.

Obtaining demographic information on each subject allows for additional data analysis. We can answer a series of questions that can impact usage. Demographic information can be supplemented by medical information (such as hearing, vision, cognitive and dexterity deficiency) related to device use. The more demographic, medical, and education data available, the better we can explain the quantity of usage with multivariate statistical tools.

Demographic data can help to explain variation in the amount of usage associated with age, gender, race, education of user or family, family income, and the availability of contact with other users. Responses to demographic questions may vary depending on whether they are provided by the user or a family member, a caretaker, or a speech-language pathologist. Usage can vary by degree of speech disability because people with minimal ability to be understood will need to use their device more. Usage will increase when the device is also used to keyboard a computer.

Collecting data, therefore, is an essential part of what it means to be a professional in any field. And, it is analysis of the data that can inform future practice. So, it is critical to decide what data is to be collected and how that relates to what is being measured.

In AAC, what we choose to measure is often determined by the goals we are seeking to achieve at any particular point in time (Hill, 2009). A goal such as "will be more communicative" is hard to measure because it is too global. To be more accurate, and more effective, it is usually necessary to have small, explicit targets that can be counted easily. A goal such as "will increase use of prepositions from 3 to 6 over a period of 4 weeks" is much more focused and identifies specific data points that can be scored.

Collecting data is only part of the process that can lead to benefits for an individual using an AAC system. Presenting that data in a format that can be shared among all involved with a client is also important. Whalley (2007) recommends that staff and parents dialogue to develop a shared conceptual framework and common terminology. Shared language facilitates discussion of the ways to improve a child's learning and effective intervention to support and extend a child's learning. Graphical representations can help to provide a "common terminology" by transforming complex log files into easily understood formats.

Privacy Concerns

Collecting data is a feature of the clinical process that has existed within professions prior to the use of computer-based technology. Long before having the option to store data on mobile devices or web-based servers, clinicians would write down evaluations and test results and then lock them away in physical filing cabinets, sharing the information only with professional colleagues on a "need-to-know" basis, or perhaps mail them securely using registered mail. Clinician-client confidentiality has always been part of the therapeutic process that has adapted as the ways of collecting and storing information have changed. Device-based data logging is not "new" in the sense that it is another way of recording data, but there are processes and procedures that need to be in place to maintain the clinician-client privacy.

One critical first step in the privacy arena is simply to make sure that data logging is a process that is optional and requires client permission before it can be used. This means

that if data logging is a feature of a device or app, it should be *off* by default and accessible to the client – or the client's legal representative – so that it can be turned back off at any time. The Prentke Romich Company (PRC) and Saltillo devices have password-protected access to the logging so that clients can lock unauthorized others out of the system. Another way to add extra security is to encrypt the log data at the level of the device and/or at the level of the server to which log files are uploaded.

The Realize Language system includes password-protected access to the website so that only legitimate account holders can access the client data. Furthermore, the server owners cannot access those passwords, which is a security measure included to prevent even individuals within the Realize Language support and development team from seeing individual data collections.

Automated Data Logging

ADL is a feature of some SGDs. Such data can tell clinicians how well a client uses a device, and more importantly, how effective the client communicates. There are limitations to the data, which include:

- absence of input from communication partners;
- absence of any multi-modal elements;
- absence of social/geographical context; and,
- lack of information about teaching interventions that may be present, e.g. on-device modeling.

Even with these limitations the resulting information can be useful. For example, one simple measure of AAC use is to count words used, which can give an idea of an individual's knowledge of the lexicon available to them in their AAC system. Another measure is the time period between linguistic events to estimate communication rate. A third is to look at the types of words being used to determine the spread of different parts of speech.

One challenge with machine-logged data is that, in its raw form, it can be difficult to interpret. It is possible to use manual and semi-automated systems such as SALT: The Systematic Analysis of Language Transcripts (Miller & Chapman, 1983), AQUA: Augmented Communication Quantitative Analysis (Lesher et al., 2000), PERT: Performance Reporting Tool (Romich, Hill, Seagull, Ahmad, Strecker, & Gotla, 2003), and QUAD: Quick AAC Developmental Profile (Cross, 2010) to convert such raw data into more user-friendly formats. SALT is a manually intensive system in regard to data collection. Language samples have to be recorded, transcribed, and then entered into the SALT software. Once there, the system uses a number of different comparison databases against which the client's sample can be matched. AQUA and PERT also require some degree of manual parsing, but they are much better for data collection because they both use ADL. The file formats differ (see Figure 1 and Table 1), so each requires a different piece of software to help with the final analysis. The QUAD is basically a series of checklists and, as its name suggests, it is designed to provide a quick profile and does not have any software associated with it.

In a previous presentation, Cross (2013) demonstrated a web-based automated data analysis software that had been in beta testing for nine months. The system allowed for the uploading of a log file to a secure server, where it was parsed in a number of ways in order to present summary data in the form of a visual dashboard. Since then, the development team has made significant changes to the user interface and modified the underlying database to make it more accurate. The online tool is now called the Realize Language system and the server on which it is housed is referred to as the Realize Language

server. The current version allows for data to be analyzed in terms of word frequency, parts of speech, performance against target vocabulary, and daily/weekly/monthly device use. It is also possible to search for specific instances of words and to see them in context.

The system includes the capability to match the words used by the client against a default target list of 300 high frequency words created from a number of AAC vocabulary studies, or to import any other vocabulary list as a target set.

Automated Data Log Format

Lesher et al. (2000) specified a set of fundamental events that could be tracked using ADL:

- Time: A timestamp can mark the exact time at which an event took place.
- Output: This primarily refers to any text generated by the person using an AAC device.
- Action: As well as seeing textual output, non-text events such as key presses, mouse clicks, and page changes can be tracked.
- Input: A marker to show the input method a client may be using to generate text and actions.
- Type: A marker to indicate whether the action was a character, numeral, shift key, control key, etc.
- Context: Information that immediately *precedes* an entry and which therefore enhances or refines the current meaning.
- Page: The name of the page on which an action was taken or word generated.

Figure 1 illustrates logged data from IMPACT software that was available on Enkidu products.

```
TIME              Absolute time
OUTPUT            Text output
TYPE              Type of selected element
ACTION            Selection action
CONTEXT           Local context
Time: 12:10:39 09/29/1999

$$$ End Header (and begin Body)

12:10:41.0  ""      Shift      key_shift  ""
12:10:42.7  "The "  List       key_f1     ""
12:10:43.8  "b"     Character  key_b      "The "
12:10:45.4  "est "  List       key_f3     "The b"
12:10:46.5  "t"     Character  key_t      "The best "
12:10:47.8  "h"     Character  key_h      "The best t"
12:10:49.2  "i"     Character  key_i      "The best th"
12:10:50.9  "ng "   List       key_f2     "The best thi"

$$$ End Body (and begin Analysis)

Time: 12:10:53 09/29/1999
Output: "The best thing "
Characters: 15
Words: 3
Characters/word: 5.00 (4.00)
Keystrokes/character: 0.47
```

Figure 1. Example log file from Enkidu IMPACT software. Source: Lesher, G. W., Moulton, B. J., Rinkus, G., & Higginbotham, D. J. (2000). *A Universal Logging Format for Augmentative Communication*, p.4. Paper presented at the 2000 CSUN Conference, Los Angeles.

Subsequent AAC devices have included data logging capabilities, although there are variations in the exact formatting because of the need to track features and functions that might be specific to certain technologies. For example, in devices created by PRC, logged data is stored as a LAM file. LAM stands for "language activity monitor" but this is really just a proprietary label for the more generic label of ADL – automated data log. In a PRC device, word strings can be generated using *sequences* of icons rather than specific pages, so there is a need to track that a sequence is being used as opposed to, say, a word on a page or a spelled word. Thus, in a PRC log file, one of the 'Type' markers is the 3-letter code SEM to mark that a word was generated using a sequence. The SEM code is for "Semantic Compaction" and means that the item was stored using a sequence of keys rather than just a single key on a page; the code SPE represents "SPElling" and means the item is a letter key; and, WPR stands for "Word Prediction," meaning the item was chosen from a list of words generated by spelling in the first few letters of the words. Table 1 is an example of how a PRC data log file looks:

Table 1: *Example of Prentke Romich Company data log format.*

Time	Type	Output
17:41:42	SEM	"she "
17:42:17	SEM	"talk "
17:42:28	SEM	"s "
17:43:06	SEM	"to "
17:43:22	SEM	"me "
17:43:31	SEM	"like "
17:44:10	SEM	"a "
17:44:15	SPE	"g"
17:44:17	SPE	"r"
17:44:19	SPE	"o"
17:44:25	WPR	"grown "
17:44:37	SEM	"up"

The Realize Language system was designed primarily to work with the Prentke Romich Company format but in such a way as potentially to allow it to work with data log files created by other devices. The Realize Language system focuses on three aspects of a log file -- time, output, and type. So, if a log file from other sources includes such data, it is theoretically possible to "filter" any file and recreate it in a format that the Realize Language server can analyze. It is now possible to upload and analyze log files not only from PRC products, but also from Saltillo NovaChat devices, and the *TouchChat* and *Words For Life* apps for the Apple iPad. Each of these has different types of information being logged but the RealizeLanguage server can extract time, output, and type data to perform analyses.

The Realize Language Database

To provide a large corpus against which client-generated utterance could be matched, the Corpus of Contemporary America English (Davies, 2008) was used. This was chosen not only because it provides a very large database – far larger than any currently available in the field of AAC – but, also because it includes frequency data and grammatical tagging based on the Constituent Likelihood Automatic Word-tagging System (CLAWS) (Garside, 1987). Both word frequency and syntax (mainly in the area of morphology) are important pieces of information when monitoring the performance of an aided communicator (Binger, 2008; Binger & Light, 2008). Furthermore, such information can help in the development of educational and clinical intervention programs (Cross, 2013).

Lemmatization means that words such as *eating* and *ate* are not just tagged as two separate strings but also as variations of the underlying root verb, <EAT>. This can provide a level of analysis that has implications for the teaching of vocabulary as *word sets* rather than individual lexical items. For example, if a client demonstrates the use of *jump*, *jumps*, *jumped*, *walks*, and *walking*, teaching *jumping* and *walked* to "complete the set" would make linguistic sense. At present, the Realize Language system does not make any significant use of this information, except for using it in conjunction with frequency data to create something called a "smart part of speech (SmartPOS)." This is used to assign a single part of speech to a word that can exist in multiple parts of speech. For example, if a client-generated data log contains the word *blue*, the word itself has many different meanings and could be an adjective, noun, adverb, or verb. For human interpreters, context is what determines the meaning and part of speech, but the Realize Language system is currently not sophisticated enough to do this, so it uses frequency data based on lemmas to assign such multi-meaning words to the most frequent category. See Table 2.

Table 2. *Database representation of the word* blue

Word String	Lemma	Part-of-Speech	Frequency	SmartPOS
blue	blue	ADJECTIVE	54736	ADJECTIVE
blue	blue	NOUN	4006	ADJECTIVE
blue	blue	VERB	41	ADJECTIVE

In the case of *blue*, it is treated as an adjective. In the future, being able to make use of adjacent strings to help determine part of speech is certainly algorithmically possible but such a feature will take some time to develop.

Another major purpose of the database is to provide a reference for determining whether strings generated in a data-log file are "real" words. So the strings *polysemous*, *stipends*, and *unlikelihood* would all be recognized as words by the Realize Language system but strings such a **ploysemus*, **stiipend*, and **unliklyhood* would be flagged as "unknown." This ability to draw a distinction between known and unknown words can be leveraged by the Realize Language system to provide useful data. This will be discussed in more detail in the section headed "List Widget."

A final point about the database is that it can be replaced by any other non-English database to make the Realize Language system available across languages. An earlier beta version was designed to work in German as well as English, and work already is underway to deploy databases that will allow for the analysis of data logs in German and Spanish.

Graphical Representations and Analytical Widgets

A design goal of the Realize Language system was to take text-based data logs and turn them into more easily comprehended graphical representations collected as "widgets" on themed "pages." See Table 3 below for a list of the different widgets available and the function of each. These representations could then be used as a starting point for more detailed discussions among stakeholders. During beta testing of the system, parents who were using the Realize site found that seeing the data graphically as opposed to a native TXT data log file made it possible to talk with therapists and teachers about what their child was doing and ask more questions. As mentioned earlier, there are inherent limitations with using ADL such that simply looking at the data on its own can be counterproductive, but the purpose of the Realize Language approach is not to provide stakeholders with all the answers but to help them ask better questions.

Table 3: *Pages, Widgets, and Functions of the Realize Graphical Interfaces*

Page	***Widget***	***Function***
Overview	Words	A Word Cloud of the words used during the current week from Sunday to Saturday, and links to Words page.
	Use	A vertical Bar Chart of how much the AAC device has been used during the current week, and links to the Use page.
	Analysis	A horizontal Bar Chart showing the frequency of use of words by Part-of-Speech during the current week, and links to Analysis page.
	Log	A Calendar showing every 15-minute period in which the device was used during the current week, and links to Log page.
Use	Daily	A vertical Bar Chart summing every 15-minute period in which the device was used on any day chosen using the Date Range selector.
	Weekly	A vertical Bar Chart summing every 15-minute period in which the device was used for any week chosen using the Date Range selector.
	Monthly	A vertical Bar Chart summing every 15-minute period in which the device was used during any month chosen using the Date Range selector.
Words	Cloud	A Word Cloud showing the most frequently used words during any time period set by the Date Range selector.
	Top 10	A horizontal Bar Chart of the 10 most frequently used words used during any time period set by the Date Range selector.
	A-Z	An alphabetized list of all the different words used during any time period set by the Date Range selector.
	List	A frequency-order listing of known (words in the database) and non-words, as well as words generated as pre-stored items versus those spelled out letter by letter.
Log	Week	A Calendar showing 15-minute periods where the device is used during any week set by the Date Range selector.
	Month	A Calendar showing 15-minute periods where the device is used during any week set by the Date Range selector.

Page	*Widget*	*Function*
Analysis	Parts of Speech	A horizontal Bar Chart showing Parts of Speech by frequency for ant time period set by the Date Range selector.
	Word Groups	An alphabetized display of words used by the client from a Target List of words set using the Manage Goals widget.
	Manage Goals	An alphabetized list of targeted words set by choosing a Goal List from a drop-down menu, or by creating a customized list based on Individualized Educational Program (IEP) vocabulary goals.
Reports		A list of all reports and graphics generated using the Generate Reports tool.

Examples of Graphical Representations on the Realize Language Server

When analyzing data on the Realize Language server, the person performing the analysis can set the time period using a function called "Date Range." This allows the user to set a start date and an end date, and then all the subsequent analyses will focus on that period. In the examples that follow, the date range was set to May 3 to May 9, 2015, and the graphics were generated using a feature called "Generate Report," which enables users to click on a button to create a PNG file of the graphical representation that is currently on screen. Not all the widgets available are included, just a selection of some of the more popular ones.

Word Cloud Widget

Being able to see the words a client has used during a specific time period as a cloud is popular among parents who use the Realize Language system. What it does is show the most frequently used words, with the font size enlarged to indicate increased frequency of word use. In Figure 2, the word *I* appears as the largest with the words *to*, *now*, and *it* coming close behind, demonstrating that the word *I* is the most frequently used word.

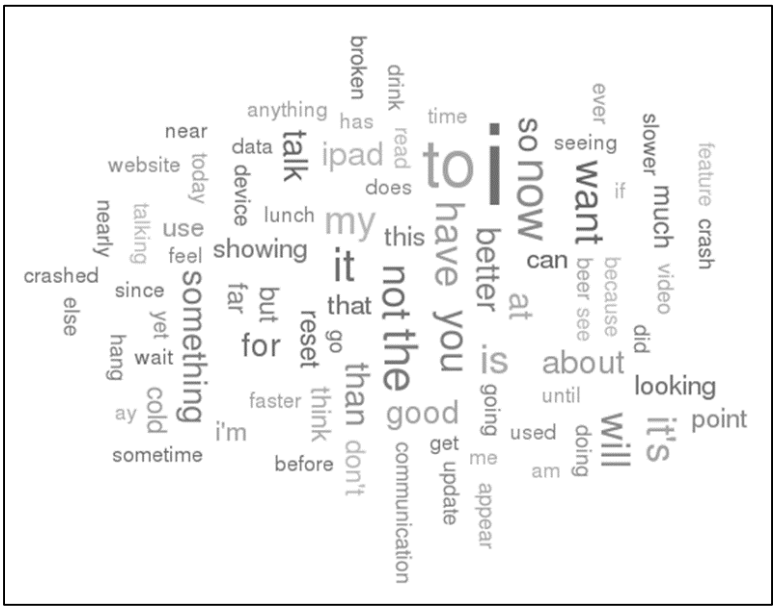

Figure 2. Word Cloud for May 3-9, 2015.

A secondary value of the cloud representation is that it can be used as a physical reinforcement tool with younger clients. Having a simple piece of paper that can be handled, shared, and referenced provides motivation and a sense of achievement. Parents using the Realize Language server have used the cloud graphic as a discussion starter with other people involved in their child's teaching. It can function as a simple way to represent the vocabulary a client is using as well as how frequently words are being used.

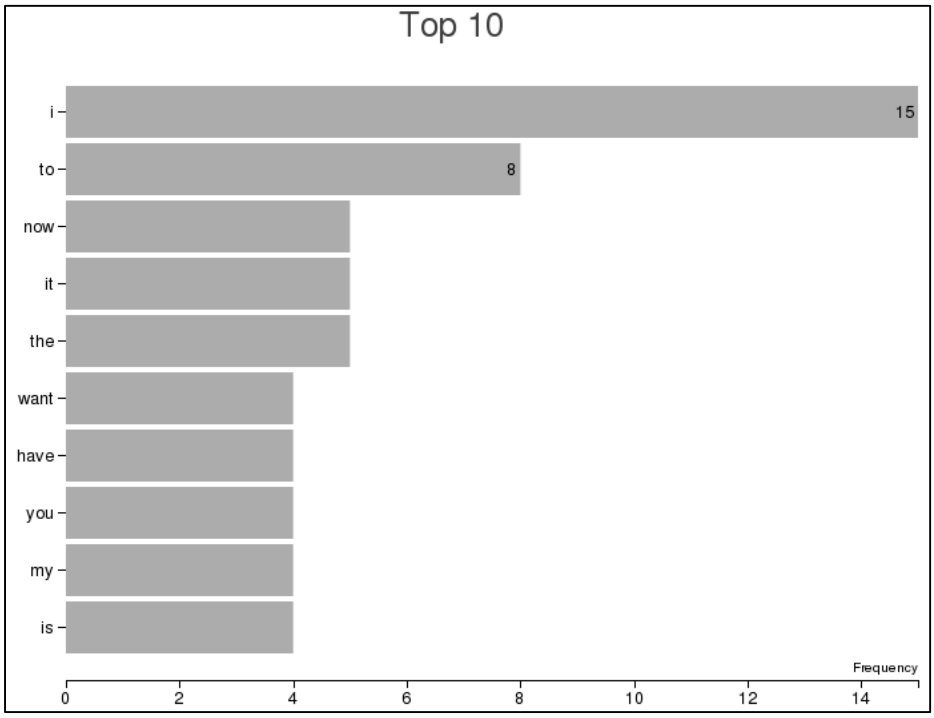

Figure 3: The 10 most frequently used words for May 3-9, 2015.

Top 10 Widget

The Top 10 takes the Word Cloud data to the next level by quantifying the 10 most frequently used words. See Figure 3

The distribution of the words by frequency in this Top 10 approximates what one would expect to find with many AAC vocabulary lists (e.g., Boenisch & Soto, 2015; Clendon, Sturm, & Cali, 2013; Trembath, Balandin, & Togher, 2007) and non-AAC lists (e.g., Brezina & Gablasova, 2013; Lo Bianco, Scull, & Ives, 2008). However, if there had been an unexpected word in the list, this would have been an opportunity to go back to the log data and look at the context in which it appeared and to investigate when and where the exchange took place to see why the word had such a high frequency. For example, during the beta test period for the Realize Language system, one client had a Top 10 list with the word *yogurt*, a word that is not found often in AAC word lists and that scores very low in any large frequency lists. By looking in more detail at when *yogurt* was used, it was apparent that the SGD was only being used at mealtimes and that this was a favorite food. On the basis of this, the need to make the device more accessible outside of mealtimes was identified.

A-Z Widget

Increasing an individual's vocabulary size and use thereof is a common goal in AAC intervention. Being able to track changes in vocabulary use is therefore a vital measure.

The A-Z widget on the Realize Language server can be used to show a sample of current vocabulary use, which can then be used to compare against a later sample. Figure 4 shows all the different words used during the May 3-9 time period.

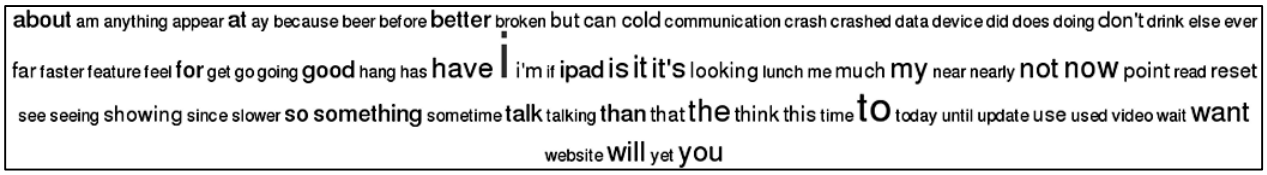

Figure 4: Total different words used for May 3-9, 2015.

List Widget

For clients who are literate, or developing literacy, the List widget provides the facility to see which words have been generated by spelling versus those generated as whole words. In a future revision of the analytical software, the aim is to be able to count such predicted words as a separate category along with "Pre-stored" and "Spelled."

Notice that the list also includes the frequency with which words have been spelled. At present, one limitation with the system is that words generated by using a Word Prediction feature are counted simply as "pre-stored" strings that have been pre-stored. Figure 5 illustrates how setting parameters of "Known" and "Spelled" will produce a list of all the words that it recognizes as being real words (i.e., words that are in the system's database) and that have been spelled out.

Figure 5. Words that were spelled out letter-by-letter during May 3-9, 2015.

Manage Goals and Word Groups Widgets

When working with individuals to help develop their use of vocabulary, it is not uncommon for clinicians and educators to set up specific goals and to develop a set of vocabulary targets as a word list. Text-based word lists can be uploaded to the Realize Language system and used to track when and how often these occur in a client's data log. The Manage Goals widget is where you can input a list and then monitor a client's performance against this list using the Word Groups widget. For example, in Figure 6 there is a customized list of 100 target words.

Figure 6. Goal list of 100 words

The box marked "100 Word List" is actually a drop down selection and multiple lists can be stored in the system. The key point is that at any one time the user can have a single goal list that works in conjunction with the Word Groups widget. Once the user has selected a Manage Goals list, he/she can switch to Word Groups to see how closely a client is following that list. See Figure 7.

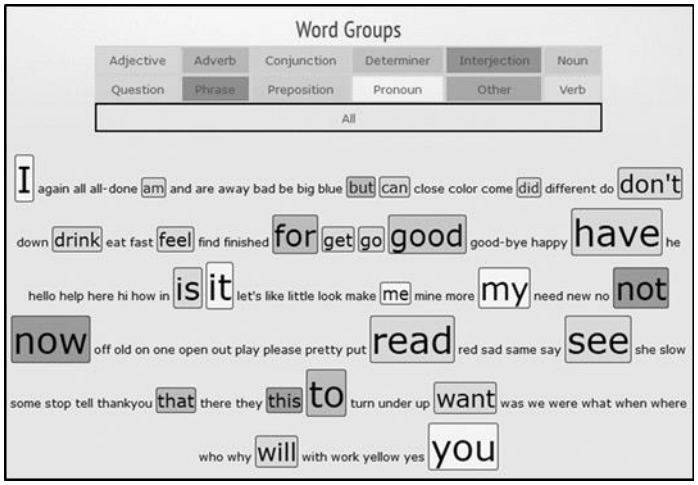

Figure 7. Client use of target words as set in the Manage Goals widget.

In Figure 7, any word that has been outlined in a box has been used in the data log file, and the size of the box relates to relative frequency of use. So the words *now*, *read*, and *have* appear to have been used most frequently. The words are also color-coded by part of speech and clicking on any of the buttons at the top will isolate those words, e.g. clicking on the ADJECTIVE button will show only instances of adjectives.

Example Case Study: Tom

For the purpose of illustrating how the Realize Language tools can be used for specific clients, consider the case of Tom, an ambulant 7-year-old boy with cerebral palsy who has moderate to severe learning problems. He had been using a Prentke Romich Vantage device for three months and was still in the early stages of using the device when beta testing the system. Data logging was enabled for a one-month period between October and November 2014. What follows are observations and comments based on that sample period, split into four weekly periods for the purpose of illustrating changes over time. See Table 4. Specifically, the focus will be on the behavior of four words: *circle*, *I*, *that*, and *want*.

Period	Date
Week 1	10/19 – 10/25
Week 2	10/26 – 11/02
Week 3	11/03 – 11/10
Week 4	11/11 – 11/18

Table 4: *Sample periods for data log analyses*

A-Z Analysis

The A-Z Widget not only lists all the different word types used during a sample period, but also presents the most frequently used one in a larger font. "Type" refers to a distinct string of letters that makes up a word, which contrasts with "token" that is used to indicate the number of times a type is used. For example, in the sentence "I think that I should have finished that paper earlier" there are eight types and 10 tokens, with the types 'I' and 'that' being used twice. The A-Z widget shows the number of different words types used each week. See Figure 8.

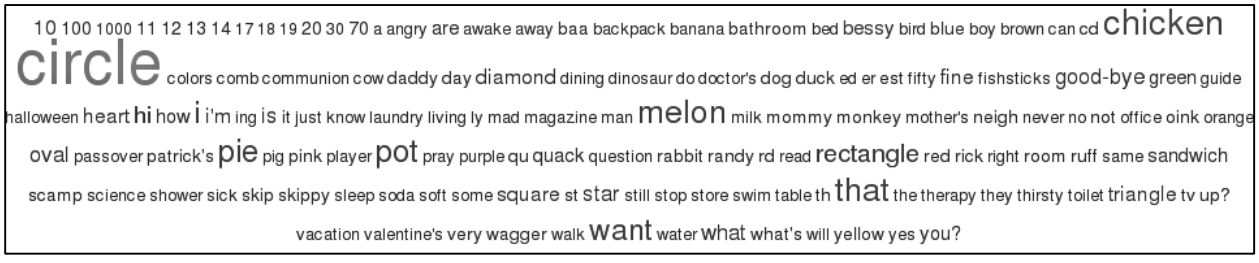

Figure 8. A-Z for Week 1

Period	Date	Word Types
Week 1	10/19 – 10/25	128
Week 2	10/26 – 11/02	164
Week 3	11/03 – 11/10	231
Week 4	11/11 – 11/18	179

Table 5: *Word types by week*

The results for the four-week period are summarized in Table 5.

During the logging period, all of Tom's team was aware that his device use was being tracked and so efforts were made by all to encourage communication activity. From Week 1 to Week 3 there was an increase in the number of different word types being used with a drop in Week 4. One of the possible reasons for this was that Tom's device was not used on 11/18 and so there was a day without logging.

Word type measures can give an indication of how broad a client's lexicon might be but knowing more about the frequency of use of these words is much more useful. So to look in more detail at this, the List widget can be used.

List Analysis

The List widget (see Figure 9) supplies frequency data for the word types and thus provides more information about vocabulary use.

151 circle	10 sandwich	2 cd	1 boy	1 soft
59 chicken	9 how	2 daddy	1 they	1 question
51 melon	8 green	2 yellow	1 a	1 soda
51 that	6 blue	1 guide	1 swim	1 fishsticks
47 pot	5 it	1 milk	1 stop	1 sleep
47 pie	5 skip	1 awake	1 never	1 backpack
44 i	5 mommy	1 shower	1 away	1 brown
43 want	4 randy	1 dinosaur	1 just	1 banana
26 rectangle	4 day	1 cow	1 still	1 purple
21 hi	4 scamp	1 pig	1 right	1 science
19 good-bye	3 neigh	1 walk	1 can	1 man
18 star	3 what's	1 bird	1 fifty	1 the
17 oval	3 red	1 bed	1 know	1 water
16 is	3 pink	1 halloween	1 vacation	1 magazine
15 what	2 tv	1 same	1 some	1 comb
14 i'm	2 bathroom	1 office	1 thirsty	1 no
14 fine	2 duck	1 toilet	1 passover	1 do
14 square	2 monkey	1 living	1 orange	1 table
13 triangle	2 rabbit	1 dining	1 colors	1 will
12 diamond	2 dog	1 store	1 player	1 pray
11 heart	2 room	1 laundry	1 mad	1 communion
10 are	2 very	1 read	1 sick	1 yes
10 quack	2 not	1 therapy	1 angry	

Figure 9: List of words used during Week 1

The most frequently used word is *circle* followed by *chicken* and *melon*. The high frequency words *that*, *I*, *want*, *is*, and *what* come further down the list. Notice that *pot* and *pie* have the same frequency and that suggests they are actually used as the compound *pot pie*. It is possible to check this using the "Find Words" feature of the Log page.

By using the List widget to see the data for Weeks 2 through 4, it becomes apparent that the word *circle* is the highest frequency word used throughout all weeks. In general, *circle* is a low frequency word and therefore it is unusual to see it being used so often. The Log page provides more information about how and where it is being used.

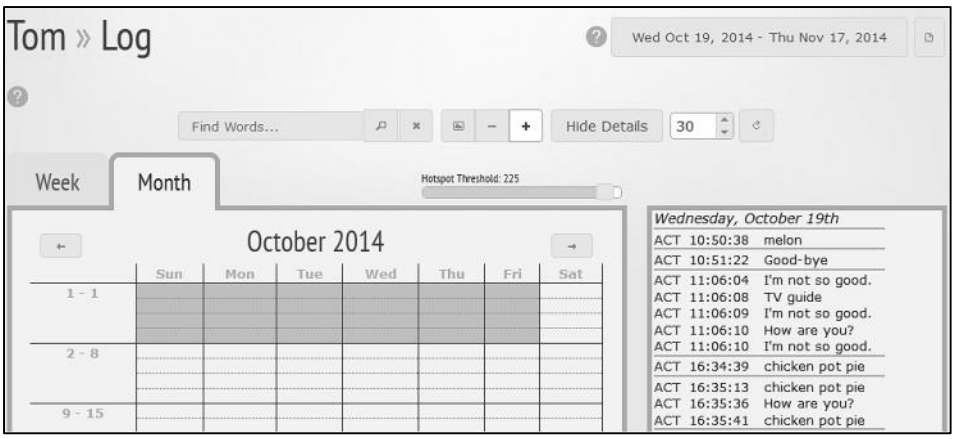

Figure 10: The Log Page

Log Page Analysis

The Log page is a multi-functional tool that can be used to see when a device is being used and what is being said within a context. It is also includes a "Find word" feature so you can see where specific words and phrases occur. Figure 10 indicates that the "Month" tab has been selected to display device use during a single month. The "Week" tab allows the user to switch to a more detailed breakdown of use in 15-minute intervals. On the top right the time range that is currently being analyzed (in this case, the entire sample from 10/19 to 11/17) is displayed, and it can be changed to analyze shorter periods.

The column on the right shows each language event along with a time stamp. This example shows how *pot* and *pie* are yoked as part of the compound phrase "chicken pot pie" and this confirms the earlier suspicions of how they were being used.

The other word about which we were curious was *circle*, and by typing the word into the box marked "Find Words" the system will mark each time period during which it was used with a small black dot. See Figure 11.

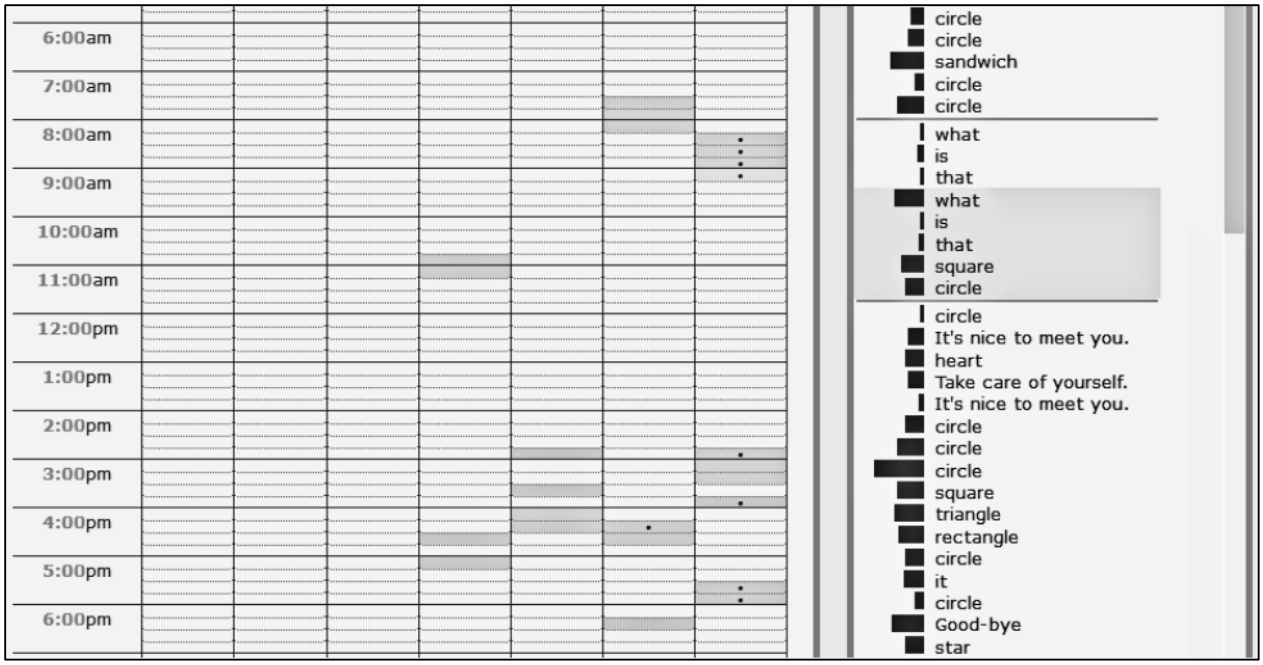

Figure 11: Occurrences of *circle* during Week 1

The word *circle* appears to have been used predominantly on Saturday and repetitively, as the log in the column on the right shows. Its appearance in the Top Ten was seen as being unusual when compared with the low frequency of *circle* in any vocabulary lists used in AAC, or even outside of AAC. Looking through all the instances of when *circle* was used, it seemed to be a perseverative behavior not based on any specific communication need.

Based on the overuse of the word *circle*, one of the behavioral targets Tom's team decided to focus on was to reduce the overall frequency of its use by promoting more use of the words *I*, *want*, and *that*. One simple way to track this was by using the Top Ten.

Top Ten Analysis

Comparing the Top Ten widget week by week, it is possible to see how promoting the three target words affects the positioning of these relative to others. See Figure 12.

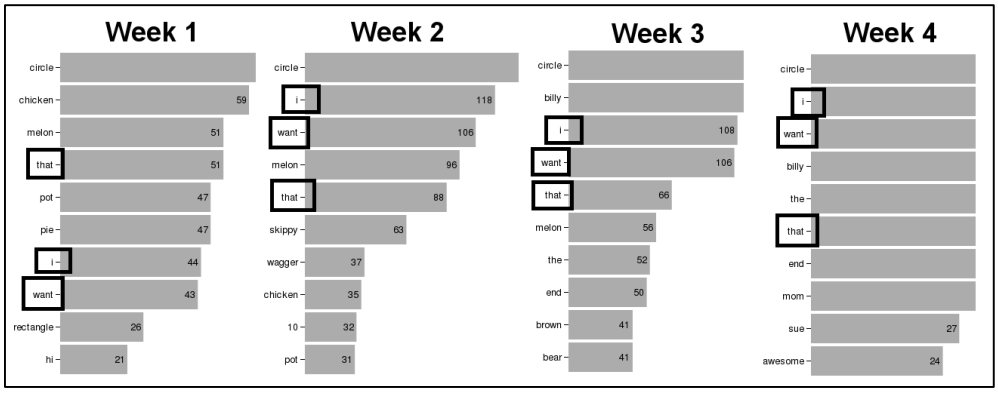

Figure 12: Relative frequencies of target words over four weeks

Note that the word *circle* is still at the top of the list but the aim is to reduce its frequency over time. If the frequency of the words *circle*, *I*, *want*, and *that* are plotted as percentages of the top ten words, a trend emerges over the month. See Figure 13.

This graphing capability is *not* a feature of the Realize Language system but it is relatively simple to extract the data from the Top Ten widget and create the chart in Figure 13.

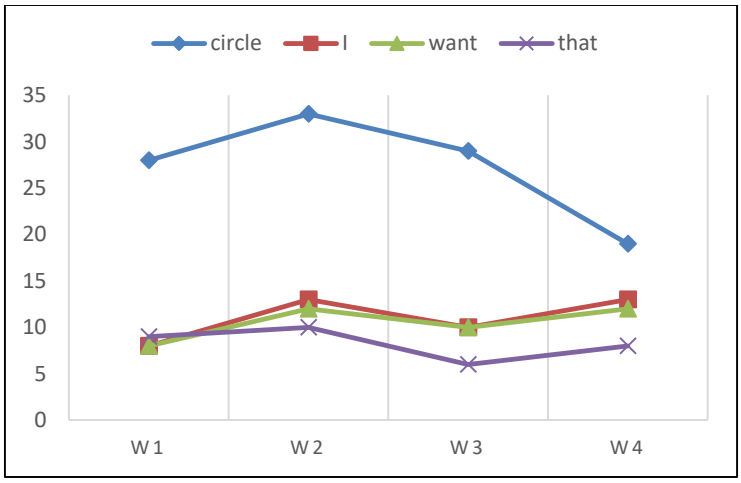

Figure 13: Target words as percentages of the top ten words

Case Study: Summary

This example has focused very specifically on just four words, and the decision to choose these words came from the first week of data logging when the team could see how Tom was using words. Furthermore, there is no "right way" to use the Realize Language analytical tools because each client will produce very different patterns of vocabulary production. In Tom's case, as he is non-literate, there was no need to use the List widget to investigate spelling; all the words he used were already pre-programmed into his device. This includes the names of friends, family, and pets. Nor did this analysis make use of the "Manage Goals" and "Word Groups" widgets to track performance against a target vocabulary list because the team had identified a measurable goal (decrease in the use of *circle* with a concomitant increase in the use of *I*, *that*, and *want*) that could be tracked using just the Top Ten widget.

Change over a four-week period is likely to be very small with clients who have significant learning challenges, but for clients such as Tom, the value of the Realize Language tool is that all the data collected during this sampling period will always be available and in the months to come can provide the team with a reference point for future measurement. And, as Tom continues to use his device, all the data logged is added to create a large cumulative sample that can map his progress for years.

General Discussion

The Realize Language system is the first step in a journey to create visual tools for data analysis. In this first iteration, the focus has been primarily on the development of a database and a framework for the creation of special tools. With this in place, new tools can be added based on specific requests and needs. For example, there are currently two

significant tools that have been requested. The first is for one that allows for the calculation of mean length of utterance (MLU) scores, a measure that is often used by researchers and speech pathologists. The challenge in doing this is that an automated MLU analysis is very difficult because MLU calculation requires knowing when a sentence starts and when a sentence ends – a task that humans can do much more easily than computer code. Current language analysis software that provides MLU scores still requires someone to manually mark sentences before a calculation can be made. The second request is for a tool to filter out any data that may have been modeled by a third-party helper. Often in a therapy session a clinician may model a specific vocabulary item, phrase, or sentence, then wait for the individual using the device to imitate. This is certainly a legitimate teaching strategy, but the AAC device has no way of knowing who is making selections. Currently the simplest solution that practitioners have used is to turn the data logging feature OFF during teaching sessions, but they then must remember to turn it back ON or risk losing new data. Ideally, there should be ways for the log to be able to be tagged when modeling is taking place, coupled with a filtering function at the Realize Language server that can then ignore these when performing any analyses using the widgets. Both the tool for calculating MLU and filtering modeling are good examples of how the system as a whole could be improved.

There are certainly challenges in both modifying the data log parameters and then modifying the server software to interpret these. But all systems are constantly in a state of change and the process of improving and expanding the features of the Realize Language system is part of the normal challenge of creating a sustainable product, for without sustainability, any service will simply become moribund and unusable. Nevertheless, despite these – and other – recognized limitations, there are still sound benefits that can come from using the system as it is.

Outcomes and Benefits

The successful development of a robust vocabulary for an individual using a SGD can be enhanced by the measurement of actual device use. Such data also may be employed to look at the patterns of use, for example, when a device is used for speech communication versus its use as an alternative keyboard for text generation, such as in writing emails, sending text messages, or creating articles. Automated data logging allows for large data samples to be collected over long periods, which can in turn help to show change or lack of change. The Realize Language system provides people who use AAC devices and their support teams with a highly visual way of representing logged data that lends itself to providing a springboard for discussions about client performance.

Another benefit is that the use of graphical representations makes it easier to share information among support staff who are not language or AT professionals. Even teachers tasked with supporting children with AAC needs may have had no training in how to do this or be unfamiliar with assistive technology (Alper & Raharinirina, 2006; Van Laarhoven, Munk, Lynch, Bosma, & Rouse, 2007). The graphics are an attempt to create a common language that all involved can understand.

Finally, it is worth noting that a non-technological benefit of using simpler graphical representations is that it encourages more dialogue among shareholders about the nature and interpretation of the data. During the beta-testing period, it was noted that parents who took an active role in tracking data felt much more empowered to discuss what they were seeing with other members of their child's support team. They felt they did not have to rely on a "specialist" to provide all the answers, but could take a more equal part in determining future goals for their child.

As one of beta testers said, "What an incredible help Realize has been for my child. I can't wait to share the program with his IEP Team at his school." And as a result of this enthusiasm, she was able to attend her child's IEP meeting along with printouts from the Realize Language data and work with the team to develop some "next steps."

Declarations

The content is solely the responsibility of the authors and does not necessarily represent the official views of ATIA. The author Russell Thomas Cross disclosed a financial relationship as an empoloyee with Prentke Romich Company and no non-financial relationships. The author Dr. Bob Segalman disclosed no financial and no non-financial relationships.

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