Software and Portable Device to Assist in Applied Behavior Analysis (ABA) Therapy for Speech and Language Disorders

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About

Applied Behavior Analysis (ABA) is a technique that has been shown to help children with autism. One element of ABA is behavior shaping which focuses on taking an observed behavior and modifying it to match a target behavior. The idea presented in this poster is to apply technology assisted ABA therapies to improve speech development in children with delays. The solution incorporates a portable device and software that analyzes and modifies a child's recorded vocalizations to provide a feedback loop.

We envision developing software to identify a child's vocabulary of sounds, matching the sounds to a target word, and modifying the sounds so that they are closer approximations to the desired target words. We believe that by hearing their own (modified) voice in an ABA setting, the child will be able to master the target words. This work is very early and experimental.

Ultimately we envision a tablet-type device displaying an image that matches the target word and real-time shaping of the word by software on the device. In a single session, an ABA therapist would be able to work through multiple improvements of the child's approximation of a target word with the device providing an instantaneous model of the word.

Applied Behavior Analysis[1]

What is Applied Behavior Analysis?

Commonly Referred to as ABA, it is the scientific study of behavior based on the work of B.F. Skinner in the 1930s.

- Application of *systematic* environmental modifications to produce *socially significan*t improvements in behavior.
- Empirically validated based on *scientific research.*
- The subject matter is behavior.
- Individualized treatment approach.
- Focuses on objectively defined *observable behavior*
- Treatment of choice for autistic behavior starting in the 1980s

Characteristics of ABA

- Applied – socially significant
- Behavioral – observable, measurable
- Analytic – demonstrates a functional relationship between the manipulated events and the behavior
- Technological – procedures identified and precisely defined
- Conceptually Systematic – behavior changes are described in terms of relevant basic principles
- Effective – must improve the behavior to a practical degree
- Generality – lasts over time and appears in other environments

Discrete Trial

- Break a task into small, discrete tasks
- 3-term contingency of ABA: Antecedents, Behavior, and Consequences.
- Conducted in a formal training setting, such as a table top

1. Trainer presents discriminative stimulus – the antecedent (Sd)
2. Child gives response – the behavior (R)
3. Trainer delivers consequences – reinforcing stimulus (Sr)

Antecedents

- Verbal directives, environmental changes, presence or absence of people or stimuli, passage of time, etc.

Reinforcer

- An event that follows a behavior and increases the rate of that behavior recurring.

Discrete Trial Teaching

(Sd) ➞ (R) ➞ (Sr)

Cue Response Reward

Behavior Shaping[1] (ABA)

What is Shaping?

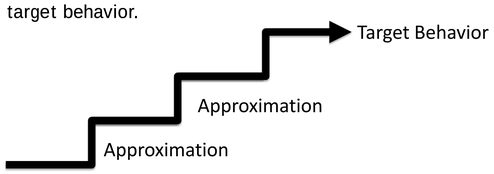
- Also called successive interpretation.
- Technique used when the child initially does not have the target behavior in his repertoire.
- Uses related responses in the child's repertoire, reinforces those responses, and then only reinforces closer and closer approximations of the target behavior.

How do you shape behavior?

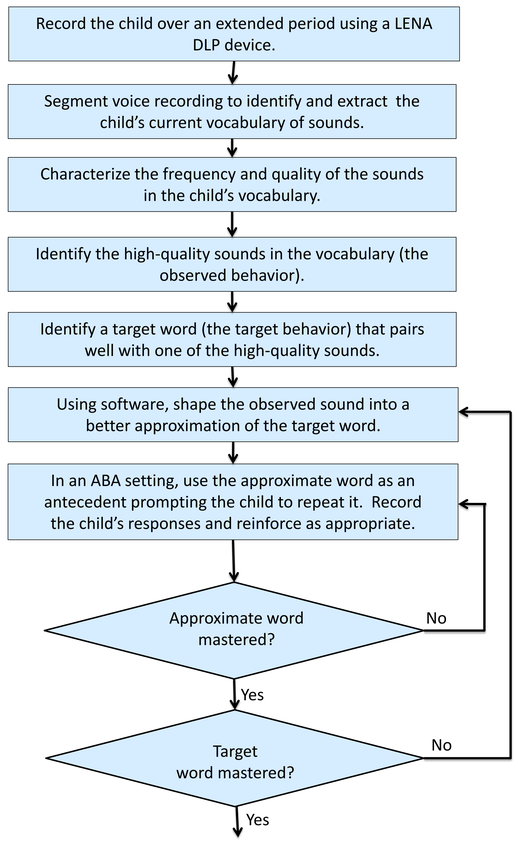
- Begin with an end in mind. Select a target behavior or end goal.
- Identify the child's skills with respect to the target behavior.
- Determine whether the child has the skills to do the target behavior. If not, get those prerequisite skills in place first.
- Reinforce successive approximations to the target behavior.

What is an approximation?

- Steps toward the target behavior that are more similar to the target behavior.



Our approach



Record vocalizations using a LENA device

In this phase the goal is to collect as many vocalizations as possible. The context is not important. What is important is that a repeatable vocalization is observed (the observed behavior). The LENA digital language processor (DLP) is an excellent platform for recording these vocalizations. The DLP can record up to 16 hours and can be worn non-obtrusively in many different environments. The emphasis in this stage is to collect as much data as possible to determine which sounds the child can already make. We do not know how much data must be recorded or the impact of conversation turns with other speakers and adults. For this phase of research we recorded a child who is speech delayed, at home whenever possible. Recording her in public or at her ABA therapies was subject to privacy issues. The LENA foundation provided us with a device for over 6 months in order to collect data.

Characterize the Child's Vocabulary of Sounds

The goal of this step is to capture and characterize the child's current vocabulary of sounds and develop a model of the child's voice. Multiple recordings collected with the LENA DLP are processed offline using the LENA pro software which segments and extracts the vocalizations that are made by the child. Speech recognition software will be used to find a distribution of the frequency of the child's specific vocalizations and to develop a model of the characteristics of the child's voice.

Today we are currently in this stage of development. We recorded 16 hours of the child's vocalizations using the LENA DLP, downloaded the data using the LENA pro software, and repeated these steps until we had about 50 hours of data. Using these data sets and the LENA PRO software we produced multiple Infoture Time Segment (ITS) and WAV files. Using perl and Matlab scripts from the LENA Research Foundation User forum[2], we extracted vocalizations from the corresponding WAV files, producing a WAV file that included only her vocalizations. We are currently investigating voice-feature vectors and clustering techniques[3].

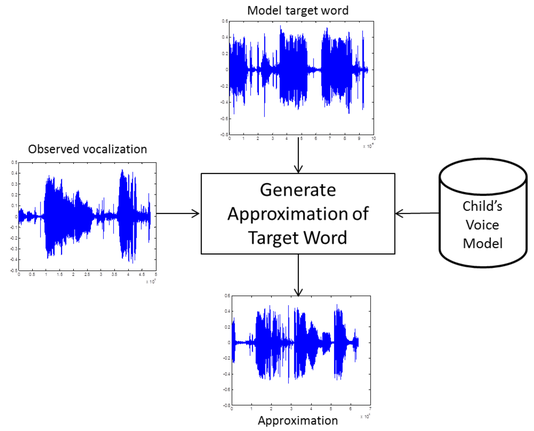
Determine a Target Word (Behavior)

After generating a distribution of the frequency of vocalizations, the goal of this step will be to select specific sounds from the vocabulary (the observed behavior). We envision that the child will have a set of vocalizations that occur more frequently and with higher quality. The next step is then to match the vocalization to a target word (the desired behavior).

A therapist can listen to the vocalizations and select appropriate target words. Ultimately, we envision software that can assist in matching the vocalizations to potential target words.

Generate an approximation of the target word

In this stage, which is currently in development, we use speech processing software, which takes as input the child's observed vocalization, a neutral model of the target word, and a model of the child's voice features. Using this input, the software generates an approximation of the target word in the child's own voice.



Shape the Observed Sound (Behavior) Using ABA

In an ABA training session, the child will be prompted to repeat the current modified approximation of the target word until it is mastered. The approximation is recorded and used again to generate an approximation that is closer to the target word. We believe that over multiple ABA sessions the child will ultimately master the vocalization of the target word.

Discrete Trial Teaching for "baby"

(Sd) Therapist: "Say" [play approximation] "Ba-ba"
↓
(R) Child: "Ba-Ba" [record to update approximation]
↓
(Sr) Therapist: "Good Job!" [or other reinforcer]

References and Acknowledgements

1. Harris, Gerald D., ABC's of ABA Workshop, Presented at Lone Star Association of Behavior Analysis (LSABA) SIG, Houston, TX, April 2012.
2. LENA Research Foundation User Forum, http://forum.lenafoundation.org/
3. Texas Instruments Embedded Speech Recognizer (Tiesr) Project, https://gforge.ti.com/gf/project/tiesr/

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