Flappy voice: an interactive game for childhood apraxia of speech therapy

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Flappy Voice: An Interactive Game for Childhood Apraxia of Speech Therapy

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ABSTRACT
We present Flappy Voice, a mobile game to facilitate acquisition of speech timing and prosody skills for children with apraxia of speech. The game is adapted from the popular game Flappy Bird, and replaces touch interaction with voice control. Namely, we map the child's vocal loudness into the bird's position by means of a smoothing filter. In this way, children control the game via the duration and amplitude of their voice. Flappy Voice allows the therapist to create new exercises with different difficulty levels, including an assisted mode for children with limited skills, and a free mode for advanced players. Results from a pilot user study with children support the feasibility of the game as a speech training tool.

Author Keywords
Childhood apraxia of speech; games for health

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces –Voice I/O. **J.2.3 [Computer Applications]:** Life and Medical Sciences –Health.

INTRODUCTION
Childhood apraxia of speech (CAS) is a neurological pediatric disorder that can delay the acquisition of skills, including prosody control (pitch, loudness, and duration) and the production of speech units (phones, syllables and words) [1]. Treatment of CAS requires frequent, intensive, individualized, and naturalistic motor-based interventions [5]. However, the high ratio of children with CAS to speech language pathologists (SLPs) makes such intensive treatments unviable – CAS is estimated to affect 5-6 % of children. Thus, there is a need for cost-effective interventions to complement face-to-face therapy.

As a step towards this goal, Parnandi et al. [6] developed a remote therapy system that allows children to practice CAS exercises on a mobile app in the comfort of their homes, and the SLP to assign exercises and monitor progress remotely through a server. Results from the study showed that children, parents and SLPs prefer tablet-based delivery over paper-based activities, but also highlighted the need for interactive activities to keep children engaged.

In response to this need, we present Flappy Voice, a voice-driven game for speech motor acquisition. Adapted from its eponymous game, Flappy Voice replaces touch input with a speech detection algorithm that allows users to control the game with the duration and intensity of their voice.

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RELATED WORK
Computer-based interventions have been shown to lead to higher levels of engagement and reduced error responses in children, as compared to traditional therapy. Umanski et al. [7] developed a voice-based game to promote the development of speech rhythm skills for children with speech disorders. The player controls an avatar skiing down a slalom slope in a way that each syllable onset causes a change in direction. Hailpern et al. [3] developed a real-time voice visualization tool for children with autism and speech delays. The clinician and child take turns to utter the same word, and the system provides a visual representation of the two utterances on a screen. Various other speech therapy apps have been developed for children, including PocketSLP, ArtikPix, Speech with Milo; and Apraxiaville; see [6] and references therein.

SYSTEM DESCRIPTION
While the causes for CAS are not well understood, recent studies have suggested that a central deficit in timing of speech sound production and prosodic variations may be implicated [2, 7]. Accordingly, Flappy Voice is designed to allow repeated practice of timing and vocal loudness exercises. As illustrated in Fig 1, Flappy Voice is a side-scrolling game whose goal is to fly a bird through a sequence of obstacles. Our implementation is adapted from an open-source Android clone of the original game known as "Zombie Bird" [4], replacing its apocalyptic theme with one more appropriate for children.

Voice Control
To control the game, the child's voice activity is mapped into the bird's height H_t via a low-pass filter:

$$H_t = s \times H_{t-1} + (1 - s) \times A_t \quad (1)$$

where A_t is the speech amplitude at time t, computed as the logarithm of the root-mean-square of the speech signal over a 200 msec window, and s is a sensitivity parameter that controls how quickly the bird reacts to the speech input.

Calibration

To accommodate for individual differences in voice loudness, microphone characteristics or ambient noise, the speech amplitude A_t is normalized relative to the maximum and minimum amplitudes observed thus far in the session:

$$A_t = (A_t - A_{min})/(A_{max} - A_{min}) \quad (2)$$

This allows Flappy Voice to adapt to changes in the child's amplitude or ambient noise levels from session to session.

Free and Assisted Play

Flappy Voice offers two different play modes: free, and assisted. In *free* mode, crashing into an obstacle ends the game, which can severely disrupt practice. Thus, we have also developed an *assisted* mode, in which the bird's height is maintained within a "flight envelope" defined by tracing lines between consecutive obstacles –see Fig. 2a. This prevents the bird from ever hitting the obstacles, and allows endless play. To maintain player engagement, points are only awarded for clearing the obstacles without hitting the upper or lower soft barriers. In the free mode, a highest-scores board (not shown) provides an element of challenge over multiple sessions.

Customization

Flappy Voice can be customized to meet the needs of individual children. In addition to selecting between the two play modes, the SLP can also modify the sensitivity parameter in eq. (1) and the width of the vertical clearance at each obstacle –see Fig. 2b, which in turn affect the game's difficulty. Finally, Flappy Voice provides an interface that allows the SLP to create new screens with an arbitrary number of obstacles –see Fig. 2c.

USER STUDIES

We performed a pilot study in which children (N=6; 5 male; ages 4-12 years; 3 CAS, 3 control) were allowed to play with the game and then asked to complete a short survey describing their experience. When asked *What did you think about the exercises?*, children unanimously responded that the game was "fun" and that they enjoyed it, though one child responded that the bird was a "bit hard to control at times." When asked *What did you like about the exercises?,* one child replied that "Not as hard as the actual flappy bird and I don't think many people would get very angry," whereas another child replied "That he didn't die." Interestingly, children with CAS liked the assisted mode, whereas control children expressed preference towards the free mode. When asked *What did you not like about the exercises*?, three children replied that they did not like having to wear a headset microphone –a necessity in our study due to the poor quality of speech recorded from the tablet's built-in microphone. Altogether, the user study provides encouraging results, suggesting the game is fun to play and well-suited for CAS therapy.

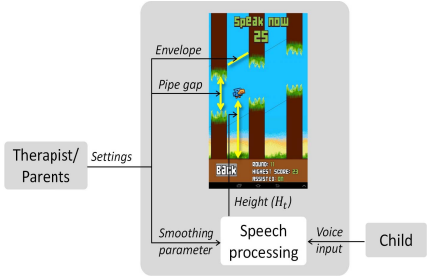
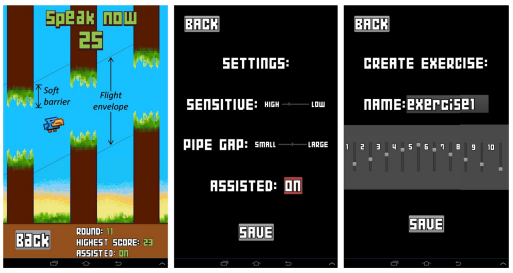


Fig 1. System diagram of Flappy Voice



(a) (b) (c)

Fig. 2. (a) Flappy Voice in *assisted* mode shows the flight envelope; (b) Settings menu (c) Exercise editor.

FUTURE WORK

Work is underway to allow the game to be controlled by pitch; this would broaden the range of prosodic activities beyond amplitude control. Visual cues may also be added to each obstacle, e.g., an image of a lion to represent low pitch vs. a chipmunk for high pitch, or images of objects the child is to name. At present, Flappy Voice is a standalone app; additional work is needed to integrate the game with remote therapy systems [6]. User studies are also needed to test the games' effectiveness as an intervention for CAS.

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