NELL: A Game based Approach to Neuroplasticity in Early Language Learning

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Project Objectives

For decades, studies have shown that young children have a unique ability to rapidly acquire new language skills. Today's researchers from neuroscience, psycholinguistics, and second language acquisition have been able to locate the biological foundations of this ability and measure the cognitive benefits associated with it, gaining a better understanding of the brain processes and the overall benefits bilinguals exhibit in executive functioning and general learning.

The NELL game aims to create an interactive game for children ages 6-9 that will immerse them in a naturalistic language environment in order to enhance their ability to distinguish new sounds and structures, helping to 'prime the brain' for language learning experiences. Research shows that when specific language learning pathways are established in the brain at an early age, those pathways can facilitate the building of new language connections later in life.

We hope to replicate the thinking process that young bilinguals experience: balancing knowledge of two different languages at the same time and having the mental flexibility to choose between them in a given situation. Neuroplasticity in Early Language Learning (NELL) will provide players with practice in these mental balancing skills by focusing on a variety of unique sounds and grammatical structures from several stylized languages in order to generalize the learning behaviors involved in natural language acquisition.

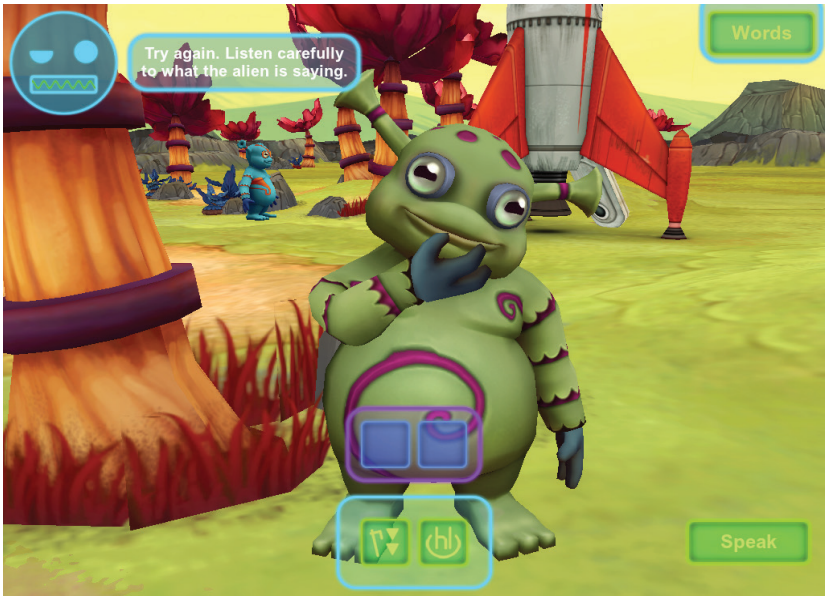


Figure 1: NELL game screen showing language interaction

Language Interaction Goals

To meet our goals, we need the game to create a series of specific language interactions. We wanted these interactions to emulate the natural-language learning experiences that young children might experience. From the following list of language-interaction goals, we developed targeted game mechanics:

1. Hear distinctions between similar sounds, especially sounds not present in English
2. Pick out familiar words and phrases in a natively-spoken sentence
3. Use context to determine what is being said

4. Recognize patterns in the language and apply them
5. Use novel grammatical structures (different from English)
6. Develop sensitivity/ear for tones as potential components of phonemes
7. Sort and make meaning from input from different languages (as a bilingual does)

NELL Game Design

Overview of Game Mechanics

The game provides challenges where players will engage with and learn a game pseudo-language in order to interact and communicate with friendly “aliens”. Within this context, we have developed sets of game mechanics that create specific natural-language-learning experiences, including:

- Listening to and identifying novel syllables and phonemes sounds (with non-English characteristics), and “collecting” sounds
- Combining sounds to create words that describe objects in the game environment
- Listening and Identifying known words within sentences spoken by “aliens”
- Use known words and context to understand meaning of friendly alien’s statements
- Develop awareness of differing grammar systems among languages by comprehending and constructing statements using simple grammar and word order

Player Role, Game Story and Gameplay Summary

In the game, players assume the role of a space explorer. Arriving at a new planet, they receive a message in an unknown language. Unable to understand the message, the player descends to the planet and, with the help of a Computerized Human-Alien Translator (“CHAT”), the talking computer in their spacesuit, the player interacts with friendly aliens on the planet to learn some of their language, and decode the messages.

The game features multiple planets and aliens, each with different languages – so players will have the chance to compare and work with sounds and structures across multiple languages. This experience with multiple languages has been shown to be a factor in bilingual children’s abilities to more easily learn additional languages. The game will provide multiple ways for players to interact with language fundamentals with the aliens, starting with learning phonemes, then putting those together to form words, learning the meanings of words from the aliens, and working out how the words go together in different ways to form simple questions and statements.

The completed game will utilize voice recognition to enable players to actually “speak” alien words as part of the gameplay. In multiplayer mode, two players will communicate with each other (in the “alien” language they have learned) to complete tasks together.

Computerized Human-Alien Translator (“CHAT”)

The player’s suit has a friendly onboard computer AI that communicates to the player about objectives and gives them tips on what they might be doing wrong when communicating with the alien. CHAT is encouraging and helpful without being condescending and serves more as a friend to the player than a teacher. CHAT will be the source of any in-game tutorials on how things function, as well as being a source of subtle hints, and constructive reinforcement. CHAT will provide commentary and point out things we want the player to pay attention to as they play the game. CHAT will be the voice of the game and communicate anything we need to the player.

Interacting with game Pseudo-languages

The game aims to engage students in natural-language-learning experiences with several different “alien” pseudo-languages. The pseudo languages will be the languages of “alien” creatures in the game.

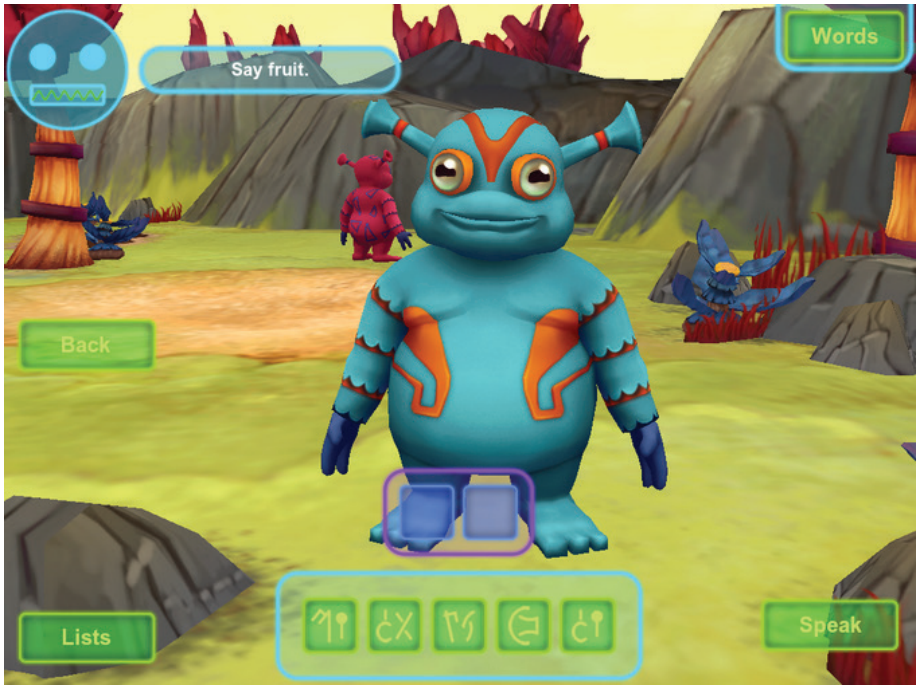
- The pseudo languages are strongly based on real languages
- Sounds and phonemes come directly from the language.

- Grammar structure is taken from the real language
- It is important that the pseudo-languages differ from the real language in some ways:

Gameplay Levels

The game has a series of Levels that lead students through an ordered sequence of language interactions so they build on vocabulary and skills to take on more complex language challenges in the Alien game-languages. The activity for each Level are repeated with variations for each new Alien language and set of Aliens the player encounters.

Level 1: Identifying sounds, constructing and learning words.



Upon landing on the planet, the player meets and can talk with an alien. The alien speaks a simple, complete phrase which the player, naturally, can't understand. CHAT is encouraging, and suggests a way that the player can learn some alien words (with the alien's help):

- The player collects images by looking around their surroundings and tapping on them. Images without words are added to "unlearned words" collection. As the Alien speaks, each sound they speak is added to the player's Sound Inventory. These sounds will be shown as symbols on Sound Tiles.
- The player drags these tiles to try to match the sounds the alien has spoken. When the player gets the sounds right, the alien gives a happy response, and the word is added to the player's Learned Words. (The aliens give humorous responses and reactions to "wrong" sounds.)

Level 2: Identifying words in natural speech

Once the player has learned some words, they can try identifying them in phrases the alien speaks:

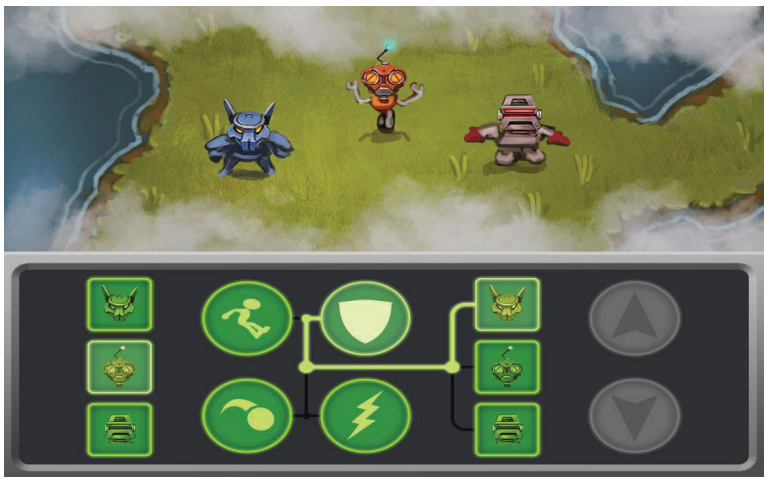
- When player hears a word they know in a sentence spoken by an alien, they can speak it back to the alien and tag that part of the sentence with the image that represents the word.
- Once the player has tagged all the learnable words in a sentence, CHAT will help the player work out its meaning.
- Through this process, players will recognize different sentence structures and grammar rules that overlap between alien sentences. Once the player has learned all the words and spoken to each Alien and under-

stands their sentences, they will be able to translate the message they received on the spaceship. The message will lead them on to the next challenge in the game.

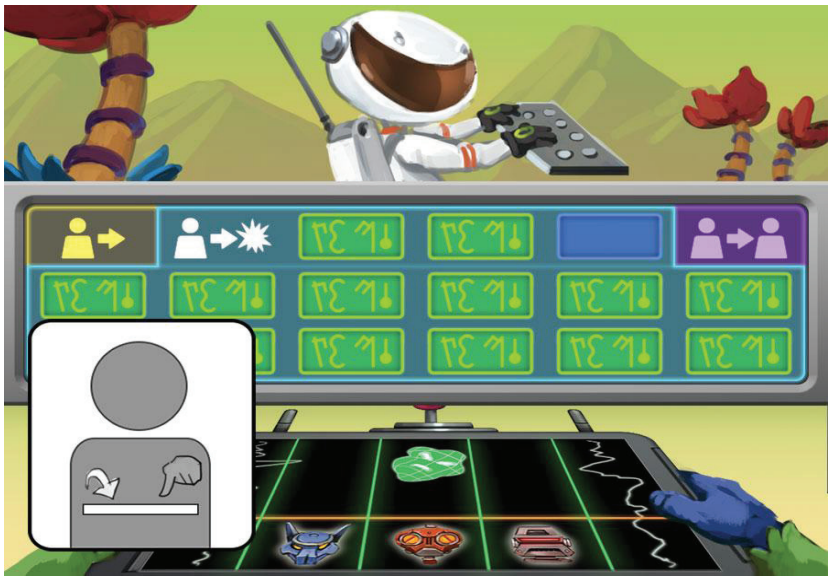
Levels 3 and 4: Intrinsically Learning Simple Grammatical Structures

In Levels 3 and 4, players will work with different kinds of grammatical structures to help their alien direct a trio of robots to carry out an important task. Our goal is for players to understand through experience that different languages use different word orders and structures to construct meaning, and to look for those differences. The player will be required to learn a few words throughout gameplay. This includes the names of the three robots climbing the walls, four verbs, two adverbs (up and down), and an additional noun (zapper). These 10 words can be combined in many ways to represent the grammatical variations listed above. Studies with children have shown success in implicitly teaching grammar with a limited vocabulary so that the learner quickly begins to process the input like a native speaker (Lichtman, 2013). This game will make use of that method.

Later in the game, the player and alien will "switch". The player will see a radar-like readout of the mountain that clearly shows all of the obstacles. They will then give instructions to the alien using the alien language. This will either be done using voice recognition software, or by using a modified version of the syllable palette.



***Level 3**: The player controlling the robots will see a control panel with a series of images representing the different robots and a series of images representing the actions the robots can perform. Listening to the player with the radar, they will translate what's being said into commands they will input with the control panel buttons.*



***Level 4:** The player lowers their tablet and sees a selection of alien words and grammatical structures where they can plug those words in. The player will use the information gained by looking at their radar to give directions to the other player controlling the robots.*

Testing and Assessment Plan

In the Testing and Assessment phase (Task 2), we will evaluate neuroplasticity using behavioral and physiological measures, before and after students work with the NELL game software. The following section describes the Assessment and Testing in detail.

Language learners at higher levels of proficiency are capable of displaying behaviors and patterns of brain activity that resemble those of native speakers, suggesting that the neural substrates supporting language processing can be modified during the long-term learning process (e.g. Stevens & Neville, in press). Our plan of research identifies how these neural pathways are established, seeks ways to exercise them through a game design, and then assesses how well our prototype achieved the goal of improving cognitive flexibility.

Given our understanding of neuroplasticity, we are focusing on evaluating the project's effectiveness using cognitive measures which directly relate to language learning. We identified these factors based on studies which delineate the cognitive advantages of bilinguals over monolinguals. These studies found that bilinguals demonstrate increased abilities in learning additional languages later in life, including:

- increased metalinguistic awareness;
- increased ability to tune out distractions,
- focus on relevant information, and maintain information in working memory (elements of Executive Function) and;
- an ability to balance multiple language forms simultaneously in order to communicate effectively in a given situation.

While these cognitive functions are not exclusive to language learning, their combined effects contribute to language learning success. We anticipate employing a mixed methodology that encompasses pre- and post-tests of executive function and metalinguistic awareness, and student interviews to evaluate learning strategies as they engage in the project. In addition, event-related potential (ERP) studies measure brain responses to audio and/or visual language input both pre- and post-game exposure.

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Accessing the Game prototype

We are interested in getting feedback from interested parties on the NELL prototype. Please email Bert Snow at bert@muzzylane.com to get a link to the prototype.