CiApplication: A user-centered web app for postoperative cochlear implant rehabilitation

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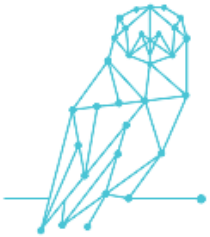

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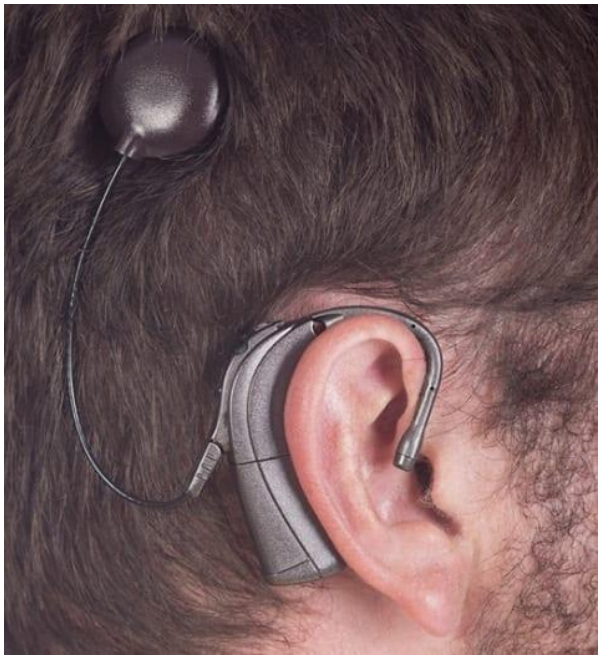
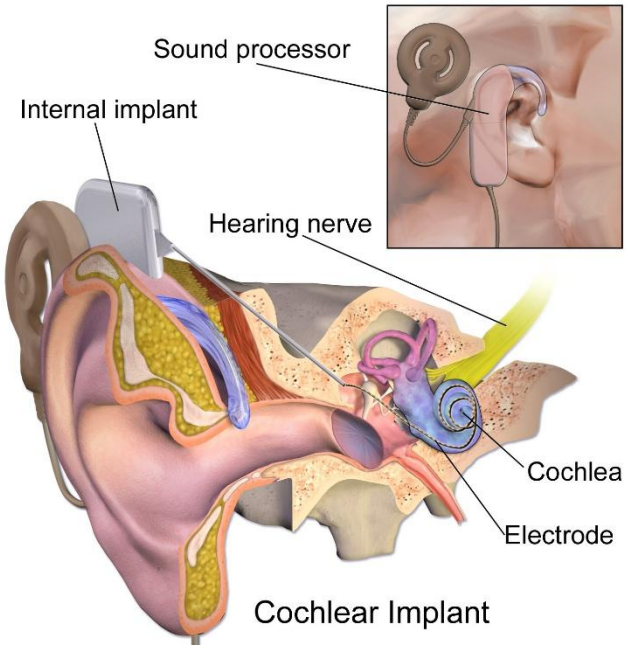
Introduction

- **Cochlear implants (CI)**
  - Assistive technology for people with deafness or severe hearing loss[1]
  - Bypass the cochlea and directly stimulate the auditory nerve
  - Users must relearn how to interpret sound => extensive rehabilitation

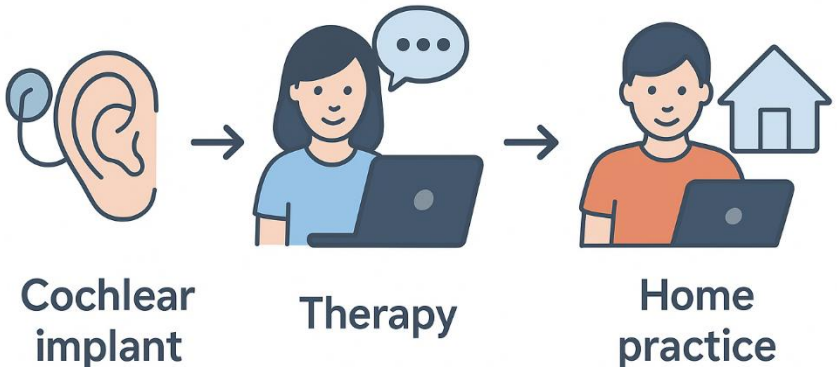




[1] Wilson, B. S., & Dorman, M. F. (2008). Cochlear implants: a remarkable past and a brilliant future. *Hearing research*, *242*(1-2), 3-21

Research motivation and goal

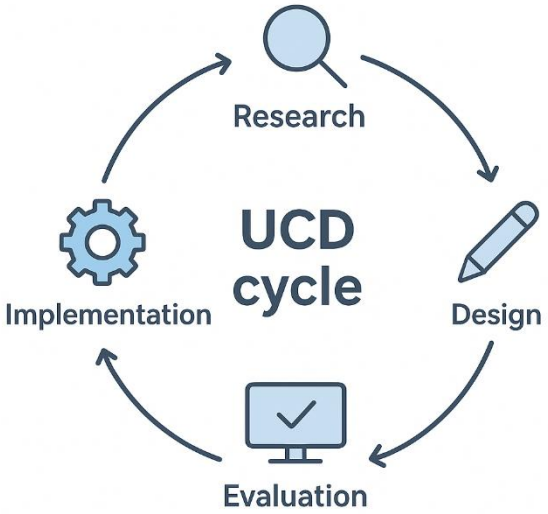
- **Research motivation**
  - Need for home-based cochlear implant rehabilitation, complementary training (not replacing therapy)[1]
- **Research goal**
  - Develop an interactive tool (named CiApplication) to support personalized home-based cochlear implant rehabilitation
    - **Individuals with CI** => Practice exercises at home
    - **Therapists** => Upload & personalize training material



[1] Fu, Q. J., & Galvin III, J. J. (2007). Perceptual learning and auditory training in cochlear implant recipients. *Trends in amplification*, *11*(3), 193-205.

CiApplication Analysis & Design (1/3)

- **Software design process**
  - User-centered design for interactive systems
  - Involved people with CI, caregivers, therapists
  - User requirements study
    - **Questionnaire (19 items):** 32 participants (23 CI users, 9 caregivers)
    - **Interviews (16 items):** 11 (CI users)
  - Continuous input & content from a speech-language therapist specializing in CI rehabilitation
  - Iterative prototypes + evaluation
  - Formative user testing study
    - 10 participants (CI users), not involved in user requirements study
    - Perform tasks and complete SUS

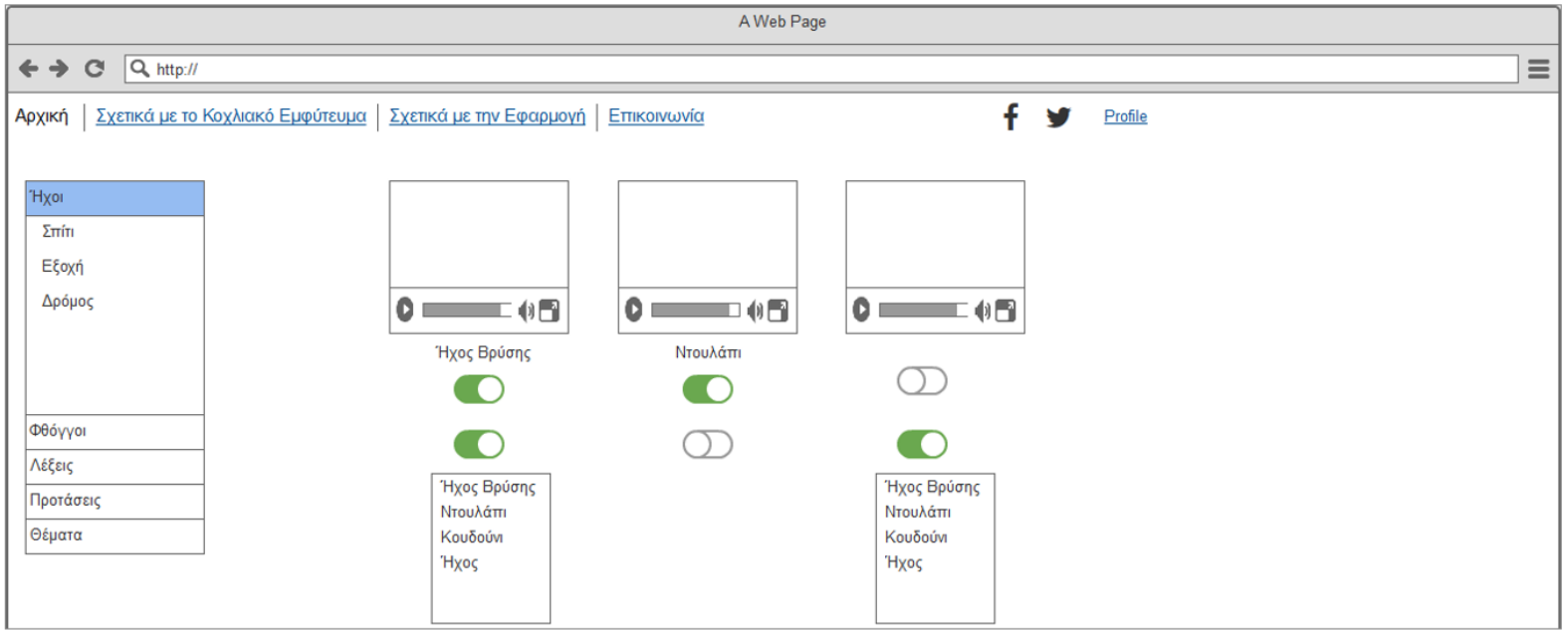


CiApplication Analysis & Design (2/3)

- **User requirements study (highlights)**
  - Highly diverse sample of users involved
    - **User age**: from 14 months (a parent was involved) to 68 years
    - **Implantation age**: between 11 months and 56 years
    - **Speech therapy duration**: from 2 months to 13 years
  - Key user needs
    - Specific types of exercises (e.g., phoneme/syllable discrimination, auditory-verbal training)
    - Realistic listening scenarios (e.g. phone talk, music with lyrics)
    - Multi-voice exercises
    - Multimodal feedback (e.g., visual, haptic)
    - Progressive difficulty
    - Progress tracking
    - Gamification

CiApplication Analysis & Design (3/3)

- **Prototypes**
  - Mockups created with Balsamiq (online mockup tool)
  - Functional prototypes created using the dev tools for the actual end-product



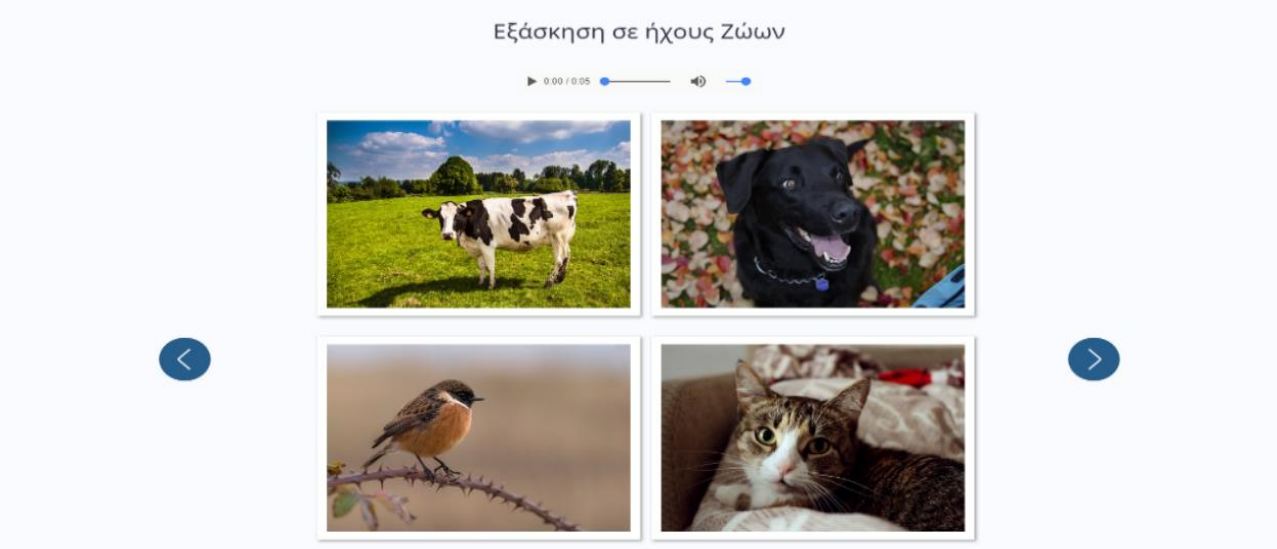
CiApplication mockup example for the auditory training exercises with sounds.

CiApplication Implementation

- **Technologies**
  - Apache HTTP server + MySQL + PHP
  - WordPress as the dev platform + 5 plugins (user management, content upload, navigation) + Talon template (bootstrap-based) + Custom code
- **Why WordPress?**
  - Convenient for the Dev team
    - Ready-to-use functionalities (e.g. easy customization of any content)
    - Easy to extend with plugins and/or custom code (open-source software)
  - Convenient for the End users
    - Therapists can easily customize content without having programming skills

CiApplication
Main user flows (1/4)

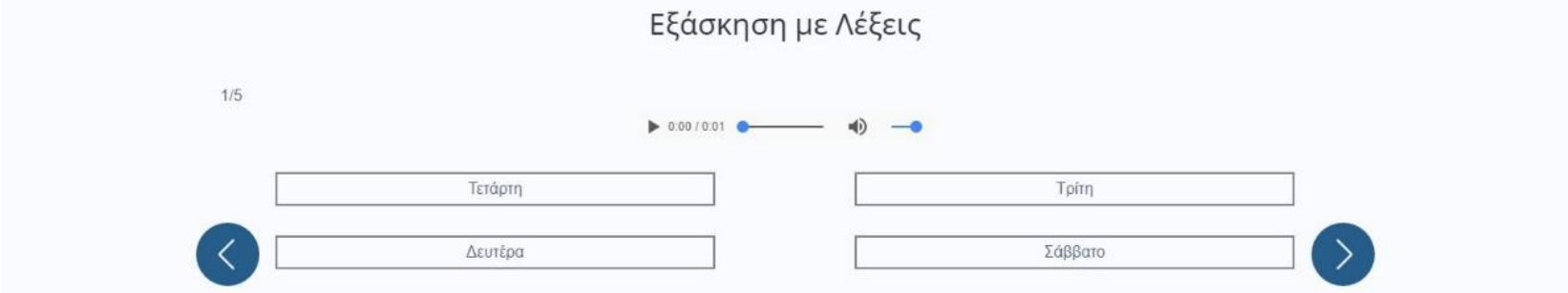
- **Learners using CI engage in auditory training (1/3)**
  - Exercises covering sounds, phonemes, syllables, words, sentences
  - Sound discrimination exercises
    - Listen to an auditory stimulus and select the correct visual representation
    - Realistic listening environments (animal, domestic and urban sounds)



CiApplication user interface example for sound discrimination exercises (animal sounds)

CiApplication
Main user flows (2/4)

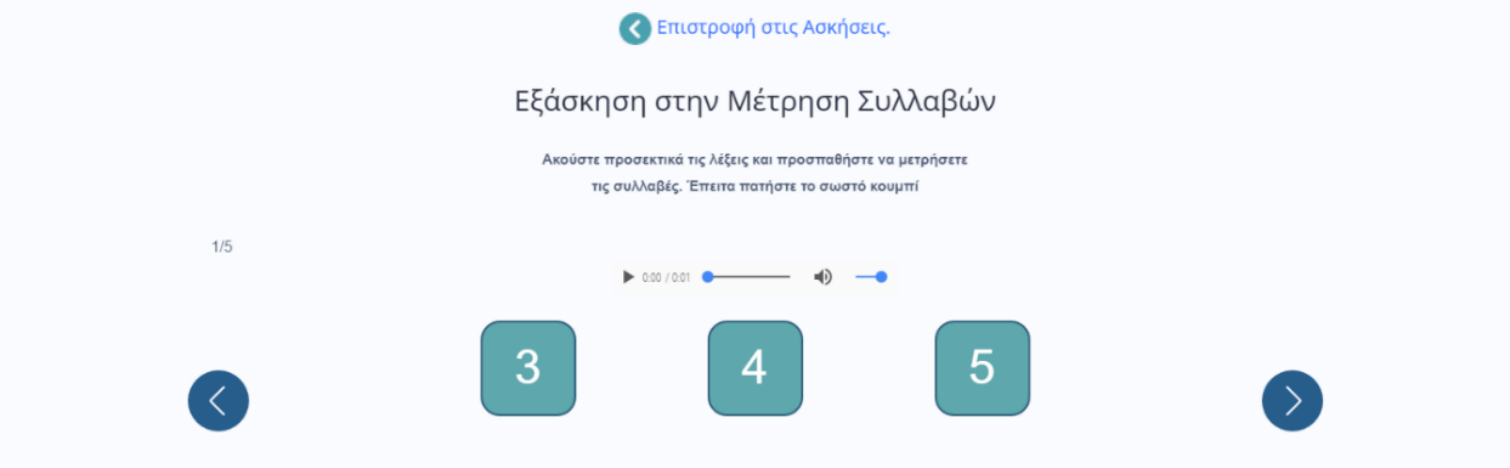
- **Learners using CI engage in auditory training (2/3)**
  - Phoneme discrimination exercises
    - Listen to a stimulus and select the matching text from four options
    - Hear three phonemes (two identical, one distinct) and find the distinct one
    - Exercises include recorded words and sentences varying in syllable and word count, featuring everyday vocabulary (e.g., colors, days, clothing)



CiApplication user interface example for word discrimination exercises (days of the week)

CiApplication
Main user flows (3/4)

- **Learners using CI engage in auditory training (3/3)**
  - Syllable- or word-counting tasks
    - Listen to a word or sentence and count its syllables or words respectively

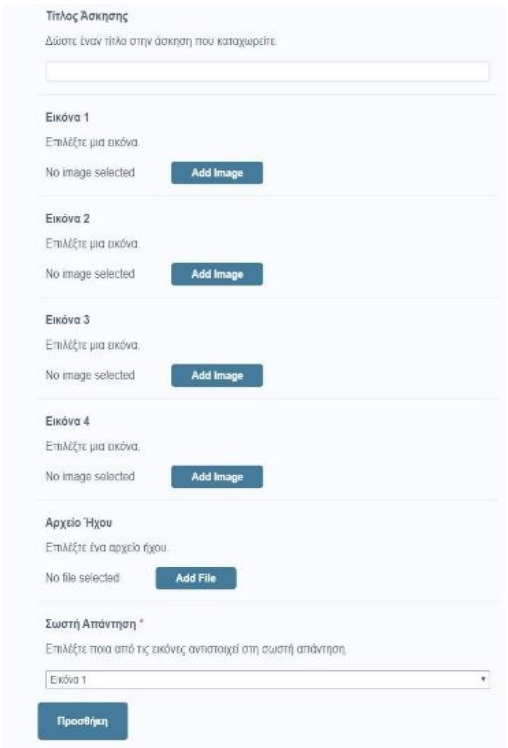


CiApplication user interface example for syllable counting exercises

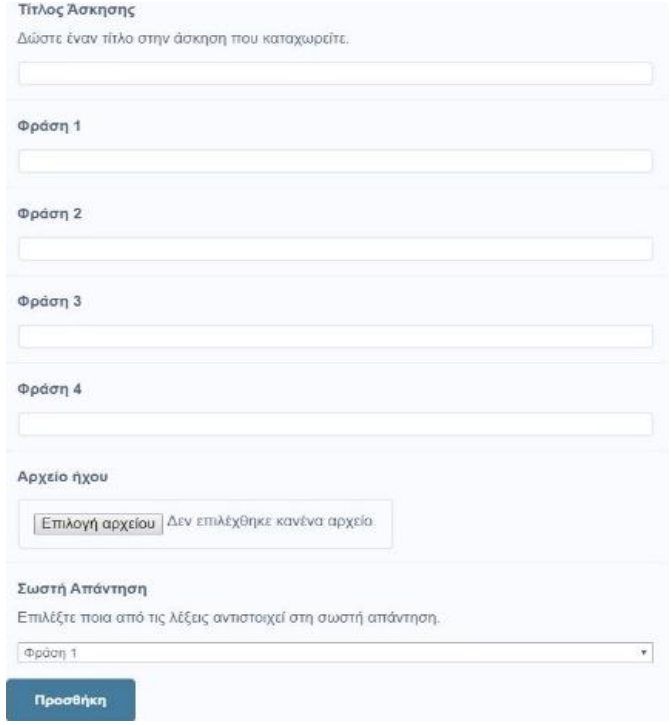
  - All exercise types: immediate feedback + points system (gamification mechanism)

CiApplication
Main user flows (4/4)

- **Therapists personalize auditory training**
  - Therapist dashboard: upload/modify personalized exercises



CiApplication user interface for adding or modifying sound discrimination exercises



CiApplication user interface for adding or modifying auditory training exercises with words

CiApplication Preliminary evaluation study: Methodology

- **Quantitative** usability evaluation study (user testing)

- **Participants**
  - 10 CI users (not involved in user requirements study)
  - Native Greek speakers

- **Procedure**
  - Participants performed tasks with the application
  - Participants completed the System Usability Scale (SUS)[1] and, in specific, its Greek version (SUS-GR)[2-3]

[1] Jordan, P. W., Thomas, B., McClelland, I. L., & Weerdmeester, B. (Eds.). (1996). *Usability evaluation in industry*. CRC press.
[2] Katsanos, C., Tselios, N., & Xenos, M. (2012). Perceived usability evaluation of learning management systems: a first step towards standardization of the System Usability Scale in Greek. In PCI 2012 (pp. 302-307). IEEE.
[3] Orfanou, K., Tselios, N., & Katsanos, C. (2015). Perceived usability evaluation of learning management systems: Empirical evaluation of the System Usability Scale. *The International Review of Research in Open and Distributed Learning*, *16*(2).

CiApplication Preliminary evaluation study: Results

- CiApplication achieved a **mean SUS score of 87.0** (SD=12.1; 95% C.I.: 78.3-95.6)
- This means "**Good to Best Imaginable**" perceived usability[1]
  - 7 participants rated it above 90 ("Best Imaginable")
  - 1 rated it 82.5 ("Good-to-Excellent")
  - 2 rated it 65 ("OK-to-Good").

Adjective	Count	Mean SUS Score	Standard Deviation
Worst Imaginable	4	12.5	13.1
Awful	22	20.3	11.3
Poor	72	35.7	12.6
OK	211	50.9	13.8
Good	345	71.4	11.6
Excellent	289	85.5	10.4
Best Imaginable	16	90.9	13.4

Descriptive Statistics of SUS Scores for Adjective Ratings (Source: Bangor et al., 2009)[1]

[1] Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS scores mean: Adding an adjective rating scale. *Journal of usability studies*, *4*(3), 114-123.

Limitations & Future directions

- **Limitations**
  - Limited participation of therapists: One therapist was involved user requirements and design, and none in user testing
  - Only usability evaluated: The evaluation study was limited to assessing perceived usability
  - Gamification elements very limited: Only point-system used

- **Future work**
  - Involve more therapists in evaluation
  - Assess clinical effectiveness beyond usability
  - Extend features: gamification, social interaction, more sounds & voices

Summary & Questions

- **Summary**
  - Presented CiApplication, a web-based tool for CI rehabilitation that enables home-based practice and therapist personalization
  - Designed following a user-centered approach
  - Found to have "Good to Best Imaginable" perceived usability in a preliminary user testing study

- **Questions?**
  - Shoot!

- **More questions and not enough time! No worries ☺**
  - Christos Katsanos (ckatsanos@csd.auth.gr)