Maximizing language skills in children with cochlear implants

Paula Brown, PhD

Cathy Quenin, PhD

Nazareth College of Rochester

Cochlear implants have been a great invention

- However, not a panacea
- Considerable variation in outcomes
- Even children obtaining the best outcomes are not like hearing children

BACKGROUND

Demographics

- Almost 13/1000 children under age 18 have some degree of hearing loss
- GRI 2005 survey 11.2% have ci
  - 7000 children in 2000
  - 14,000 children in 2005
- Number is increasing dramatically
  - EHDI legislation
  - Modifications in eligibility criteria

- Over 75% of D/HH children educated in inclusive settings
- 45.8% of SLPs in school setting regularly serve individuals with diagnosis of “hearing disorders”
- M=3.2 students on caseload

SLP self-perceptions

- Low level of confidence (Palacio, 2001)
- Feel undertrained
  - Weak in clinical experience
- Low comfort level working with ha and ci (Watson et al, 2004)

Our Premise

- SLPs need to understand
  - Unique aspects of language learning by deaf individuals
  - Advanced technology for facilitating access

Apply What You Know

SLPs need to feel comfortable applying what they know about best practices in spoken language facilitation to a unique set of individuals

Understand your students

- Heterogeneity in d/Deaf population
  - heterogeneity in language and communication preferences
  - heterogeneity in attainments in spoken and written English

Some key points

- Some children using implants may not have sufficient access to spoken language to develop English skills commensurate with their hearing peers and/or to use spoken language as their primary avenue for learning in school

Key points, cont'd

Deriving benefit from ci varies

- with differences in perceptual processing of spoken language (Pisoni and colleagues)
- With quality of parent involvement and access to quality rehabilitation (Robbins, 2000)

Key points, cont'd

- Sign language prior to implantation may facilitate language and cognitive development, particularly acquisition of vocabulary (Connor et al 2000; 2004)
- Cued speech prior to implantation may aid in establishing phonological representations of spoken words (Descourtieux et al, 1999)

Our focus and concern is LANGUAGE

3 levels of concern

- Prevention
  - Facilitate early language learning
  - Maximize access to sound
  - Engage parents
- Intervention
  - Transition to school
  - Closing the gap
- Remediation
  - Older students

INTRODUCTION

Perception and Language Learning

Main Points

- Language input-->perceptual specialization
- Cortical organization primed for visual-auditory integration
- Cued speech offers visual information that can be integrated with audio to create percept that more fully represents phonological aspects of language
- Cued speech facilitates language learning and reading in deaf children, including those using cochlear implants

Predictors of success with ci

- Age of implantation
- Years of usage
- Quality of follow-up/training
- Quality of parent interaction
- Language skills prior to implant
- Hearing experience prior to implant

However…considerable unexplained variance. Related to specifics of individual language processing?

What is the task of learning a language?

How do individuals process an auditory signal to extract meaning?

Implicit learning of complex sequential patterns

- Learner extracts relative frequencies of co-occurrence of sound pairs
  - Distinguish recurring sequences that comprise words
  - Learn from exemplars
- Discovers acoustic cues correlated with word boundaries

Language Learning

- It’s not explicit sequence learning, but the inducement of the probabilistic patterns
- Representing patterns in working memory using phonological code may also be key component of language processing (Conway, Karpicke, Pisoni 2007)

Language Learning

- Do not process speech in strictly linear manner
- Perception is largely context-dependent
- As gain experience, learn which dimensions to attend to
  - Which are reliable and valid in signaling meaningful distinctions
- Knowledge imposed on structure changes
- Move from large to small, global to discrete

So, what might we expect with children using ci?

Can we predict that they will have better language outcomes because they are able to encode and make use of sequential regularities?
(Cleary et al, 2001, 2002)

Would seem so, if, in fact, they have access to the necessary information

but…Do they?

Early Implantation

- What was initially considered early (before 5 yrs and then before 3 yrs) is now late
- Early is at 12 months or even younger
- Optimal benefit seems to be at the time when the perceptual system is organizing around the meaningful patterns of the target language

Remember!

Cochlear implants do not amplify sounds.

Cochlear implants extract information from the acoustic signal and code it into a temporal and sequential pattern of stimulation

Cochlear implants promote the development of a cognitive system that can attach meaning to electrical impulses

- Sequencing abilities correlate with STM, vocabulary learning, and other cognitive skills
- Pisoni and colleagues have investigated sequential processing and STM in relation to ci outcomes

The brain is wired to analyze and derive patterns from a fully represented language

A degraded signal constrains language learning

So…□

1. Improve the signal
2. Improve processing

Considerable evidence that quality time on task improves outcome

Is the answer to bombard the system with auditory only information?

Can we improve the signal and improve processing through visual exposure to phonological information?

Integration of Visual and Auditory Information

Normal acquisition

- Intersensory redundancies
- Multimodal perception

Key point

- Auditory cortex is specially suited for multisensory convergence
- Depriving auditory cortex of visual input may actually impede rather than promote cortical organization

premises

- Vision and audition are complementary
- Auditory stimulation necessary during critical/sensitive period
- Central auditory, cognitive, and linguistic factors contribute to variation and individual differences in outcomes

Vision and audition are complementary

Children with ci perform better on speech perception tasks when have auditory-visual information

- True for consonant features (Tyler, Fryauf-Bertschy et al, 1997)
- True for words (Geers et al, 003)
- True for sentences (Bergeson, Pisoni, Davis 2004)

Auditory stimulation during critical/sensitive period

- Children who receive ci prior to 30 months obtain McGurk fusion condition scores on par with normal hearing children (Schorr & Fox 2006)
  - Age of implantation predicted auditory-visual integration
- Cortical response latencies to speech reveal maximal plasticity up to about 3.5 years (Sharma, Dorman, & Spahr, 2002)

Bergeson, Pisoni, & Davis (2004)

- Followed children from pre-implantation to 3 years post implantation
- Found better performance with audiovisual presentation than unimodal
  - Children from OC>TC
  - Early (before 53 months)>late (53 m-9 yrs)
    - Early primarily use auditory information
    - Later primarily use visual information

Bergeson, Pisoni, & Davis (2004)

- Preimplantation lipreading and auditory-visual speech perception can predict speech and language skills after several years of implant use

The norm is integration!

- With early identification and early ci, have advantage to capitalize on system that is ideally suited for multisensory integration

Eisenberg, Martinez, & Boothroyd (2004)

- Looked at imitation of CV monosyllables by children with normal hearing, hearing aids, and CI
- Children with ha>children with ci
  - Probably related to finding that performance scores decreased with increasing hearing loss
- Children with ci do better when can integrate audition and vision
  - Contrasts most difficult to perceive are difficult to see
    - Contrast would be clarified with cued speech

Bergeson, Pisoni, & Davis (2004)

"measures of auditory-visual perception might reveal fundamental processes that are used to **recover phonetic information** about speech articulation and the linguistically significant gestures of the speaker that are used to **encode and represent distinctive phonological contrasts** in the sound system of the target language in the environment"

Integration of simultaneous information provides strong argument for cued speech

hand cue becomes part of visual signal

Cued Speech

System to represent spoken language visually

Cued Speech: Auditory-Visual Access to Spoken Language

System Description

- Eight handshapes
- Four placements near the mouth
- Natural lip movements of speech
- Cue+lipshape uniquely specifies phonemes of spoken language

DVD

- Intro 0-1:43
- History 1:45-2:45
- CS demo, includes chart 2:50-4:00
- CS and lang acq 4:00-7:55

McGurk Stuff??

- Study of deaf cuers using the McGurk paradigm (contradictory signals) indicated that cuers with early exposure integrate the hand cues and speechreading info.
  - Alegria and Lechat, 2005

More on processing of CS

- fMRI studies of cuers
  - CS users used the “auditory cortex” to process phonological information
  - Left lateralization of linguistic tasks for early CS users.

Cued Speech provides

- Accurate reception of spoken language
  - Nicholls & Ling, 1982, Uchanski et al., 1994
- More accurate reception of spoken language than auditory and auditory+speechreading conditions
  - Descourtieux, 2003
- Efficient reception of connected spoken language
  - Quenin, 1992

CS can improve

- Auditory comprehension of speech after CI (Cochard, 2003)

A cued language environment can provide:

- Opportunities for interaction with fluent language models
  - (Torres, Moreno-Torres, & Santana, 2006)
- Potential for development of phonological awareness and strong spoken language base

Language Skills in Cueing Children

Phonological awareness is a key predictor of literacy in both hearing and deaf children.

Exposure to CS builds phonological awareness

- Young CS users judge rhyme like hearing agemates.
  - Leybaert & Charlier, 1996
- CS users generate rhyme comparable to hearing subjects.
  - LaSasso, Crain, & Leybaert, 2003

Development of Morph-Syntax Skills

- Deaf children with early exposure to CS develop morphology along hearing milestones.
  - Kipila, 1985; Metzger, 1994
- Native deaf cuers are able to use English morphological rules appropriately and consistently.
  - Koo, 2003

Morpho-Syntax

- Deaf cuers had more advanced syntax three years post-CI than oral and signing subjects.
  - Vieu et al., 1998

- Children rated as “Profile I” -- making fast and continuous progress with language following CI -- were predominately CS users.
  - Cochard, 2003

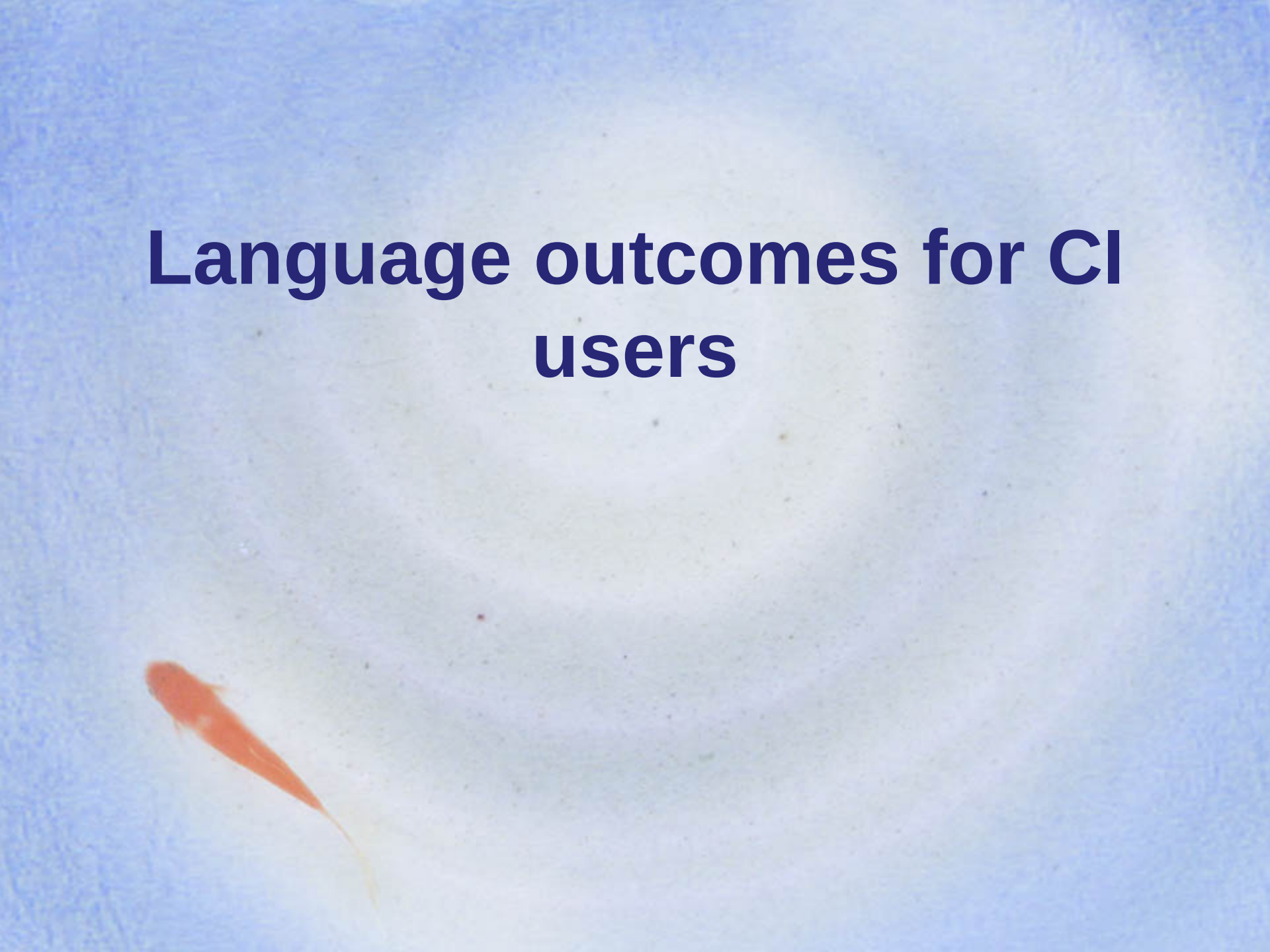
Development of Vocabulary

- Preposition use by CS users is comparable to that of hearing control subjects.
  - Santana, Torres, & Garcia (2003)

- Deaf CS subjects showed comparable digit recall as hearing subjects.
  - Coryell, 2001
- Deaf cuers used internal speech recoding similar to hearing subjects on working memory tasks, and did not show reduced working memory capacity.
  - Ketchum, 2001

OUTCOMES

Language outcomes for CI users



What happens to kids after cochlear implantation? Paramount that they learn to listen; must recognize electrical excitations as meaningful

Makes sense that time on task is a major factor but no one knows how much time

Age at implantation

- Strongest gains in language being associated with younger age at implantation
  - Difficult to separate age and years of use in some studies
- Language growth advantage for children receiving ci as young as 12 mo of age (Svirsky, Teoh, Neuburger 004; Tomblin, Barker, Spencer et al 2005)

Recent study by Nicholas & Geers 2008

- Significant amount of variance in language outcomes explained by degree of aided residual hearing before receiving ci and age at implantation
  - Children with favorable thresholds who got implant after 30 months didn’t do as well

Enhanced language associated with use of ci

- Have access to auditory information usually unavailable to deaf individuals using hearing aids
  - May provide more access to grammatical morphemes (Spencer, Tye-Murray, & Tomblin 1998
  - Morphological development influenced by acoustic accessibility of forms (Svirsky, Stallings, Lento, Yong 2002)

Children with implants still struggle with language

Who is doing the best?

- Early id
- Early ci using recent ci technology
- Enrolled in oral emphasis program from time of implant
- Normal nonverbal intelligence
- Live in middle to upper-middle class household where English only languge spoken
- Have parent heavily involved

What about the others?

Children not receiving implants by age one (majority of students you are seeing in school) are probably experiencing some language gap

Nicholas & Geers 2008

- Age appropriate performance on auditory comprehension, expressive communication, and vocabulary at 4.5 y
  - Implanted by 1-13 m
  - Pre-CI aided threshold of about 65 dB

concern:

Gap is likely to increase rather than decrease; though some evidence of continual gain 6 years post implant, don’t catch up

Our Recommendations?

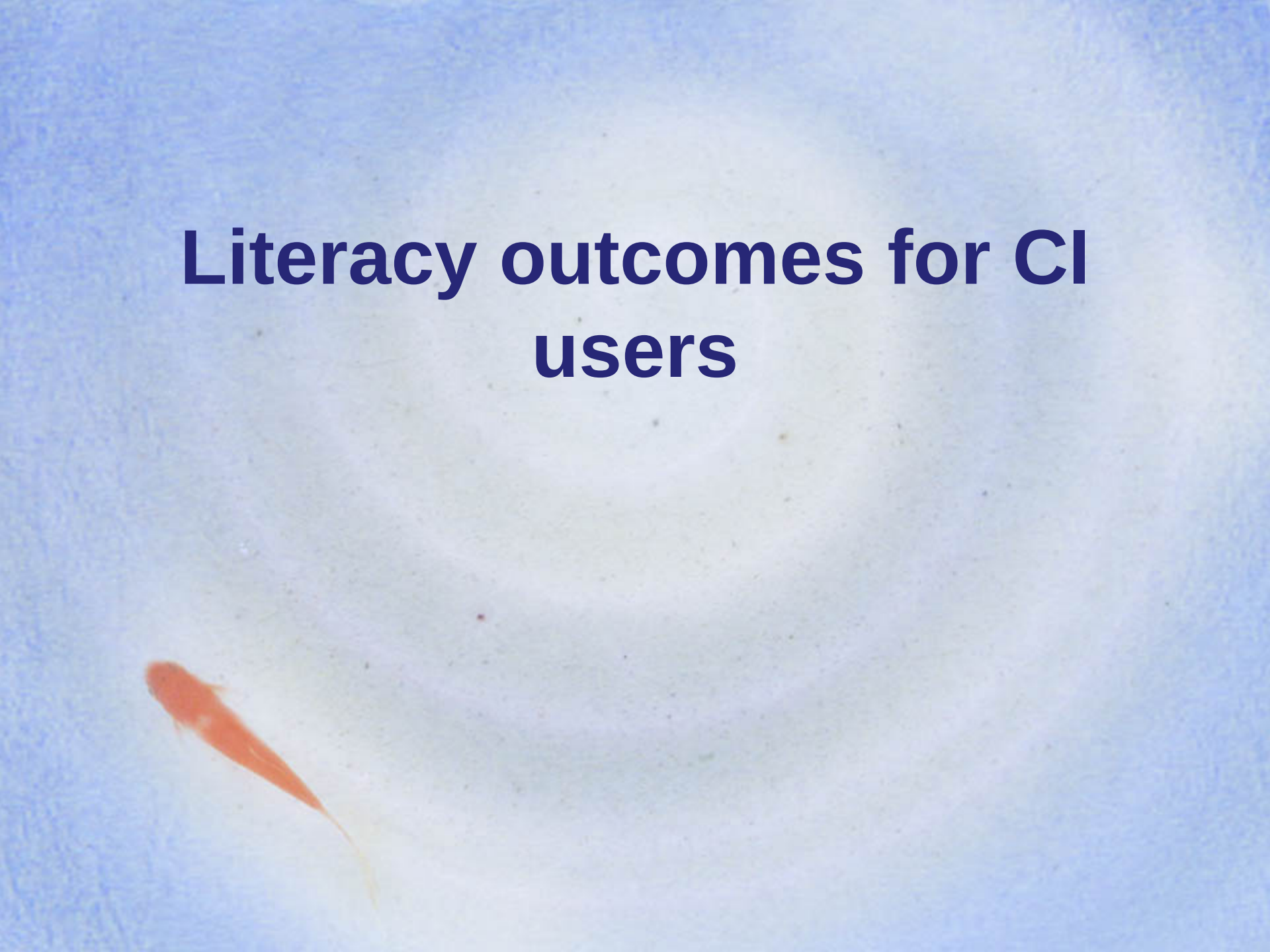
- Identify early-->immediate amplification
- Commit to implantation before or at 1 year
- Provide strong auditory-visual signal
- Utilize cued speech
- Provide natural language learning context

- If implanted later than one year and don’t use cued speech, use sign supported speech maintaining a strong oral/visual emphasis

Children using CIs enter school

- Language learning
- Literacy
- Socialization

Literacy outcomes for CI users



Are language skills sufficient to succeed in mainstream

- Perhaps, but not without support

CI and Literacy

Novice readers need:

- Word recognition skills via phonological awareness, alphabetic principle, decoding
- Language knowledge base
  - Background
  - Vocabulary
  - Syntactic constructions
  - Verbal reasoning ability
  - Knowledge of literacy conventions

- Hearing children are already competent language users when they begin to learn to read.
- Deaf children may be bringing an incomplete knowledge of phonology, morphology . . .
- Deaf children may experience the 4th grade “topping out” of reading skills when a basic sight word vocabulary is insufficient to decode new words encountered in print.

What does the literature say about the effects of CI on literacy?

- Use of a CI may provide better literacy results than we've seen in the past.
  - 70% of children with CI in private oral educational settings read within the average range. Moog, 2002
  - Half of 181 children who had used CIs 4-7 years read within the average range for their hearing agemates. Geers, 2003

Phonological Awareness Benefits of CI

- Early-implanted children (2-3.6 yrs) had better PA outcomes than later-implanted children (5-7). James et al., 2008
- Late-implanted group made no significant gains over time.
- Wide individual variation in performance.

More Phono Processing with CI

- Wide range of performance on non-word repetition measure of phonological processing. Dillon and Pisoni, 2004.
- No significant correlation between nonword repetition accuracy and age at CI, duration of CI use, CA, and number of active electrodes.
- Some correlation with early exposure to speech and oral educational environment.

Vocabulary Knowledge

- CI use can accelerate vocabulary development, especially when children are implanted at or prior to preschool. Connor et al, 2006
- Some CI users will be in the average range for vocabulary skills. Spencer, 2004

Syntax

- CI may provide syntax comprehension advantage (Geers & Moog, 1994).
- Approximately half of 8-9-yr-olds who had CIs at preschool age had IPSyn scores comparable to hearing agemates (Geers, Nicholas, & Sedey, 2003)

Narrative Skills

- Children with greater speech perception benefit with their CIs have structured narrative more like hearing children (Crosson & Geers, 2001).

Narrative Skills

- 3 children with ci used Narrative-Based Language Intervention
  - Focuses on syntactic target and story grammar tagets
  - Involves families
- Child making minimal gain had least amount of implant use (2 yrs), late implantation (6yrs, 2 m), and lowest language level
- Child making most gain had highly involved parents

Parent Involvement

- Used multisensory strategies
- Knew how to acoustically highlight syntactic targets
  - Repetition
  - Shortened phrases
  - Increased or decreased intensity
  - Increased duration
  - Adequate response time
  - Provided recasts and contingent responses

Parent Involvement

- Parents valued child's text and valued literacy
  - Child read created story to family members

(Justice, Swanson, & Buehler (2008)

- Evidence to date suggests that use of cochlear implants can facilitate development of phonological awareness and other language skills related to reading.
- Picture of long-term effects of implantation for literacy is still unclear.

What tool do we know has a significant & long-term effect on reading?

Results of visual exposure to spoken language: reading

- Exposure to unfamiliar cued words led to ability to decode these words in print.
  - Alegria, Dejean, & Capouillez, 1990
- CS users demonstrated phonics and spelling abilities comparable to hearing subjects.
  - Leybaert & Charlier, 1996; Leybaert & Lechat, 2001)

- Profoundly deaf CS users achieved reading comprehension scores like hearing peers.
  - Coryell, 2001; Wandel, 1989
- CS users with CIs had inferential reading skills comparable to hearing peers.
  - Torres et al. 2008

- Cued Speech appears to have great promise in providing the phonological awareness critical to development of strong language and literacy skills.

PART 2

Maximizing language has different purposes at different points:
prevent/promote
intervene
remediate

Promoting Language Learning

Primary Strategy:

enhance input and uptake

Input and uptake

Capitalize on developmentally critical time when brain creating perceptual categories

- develop phonological representations

Language Intervention

Young Children

Parental communication key

- Use best practices with hearing children
  - Reciprocal conversations
  - Shared attention
    - Talk about what going on; talk<-->context
    - Follow child's lead
  - CDS
    - Alter length and complexity; exaggerate prosody

Parent communication

- Learn from deaf mothers (Spencer & Harris 2003)
  - Engage in protoconversations
    - Use facial expressions
  - Produce language timed to visual attention
    - Use visual attention-getting and directing strategies
    - Wait before commenting
  - Produce accessible and consistent input

Language Intervention Strategies

- Language goals
- Social competence and peer interaction

Use best early intervention techniques at your disposal as a speech-language pathologist trained in language

- Maximize opportunities for meaningful use

Social competence and peer interaction

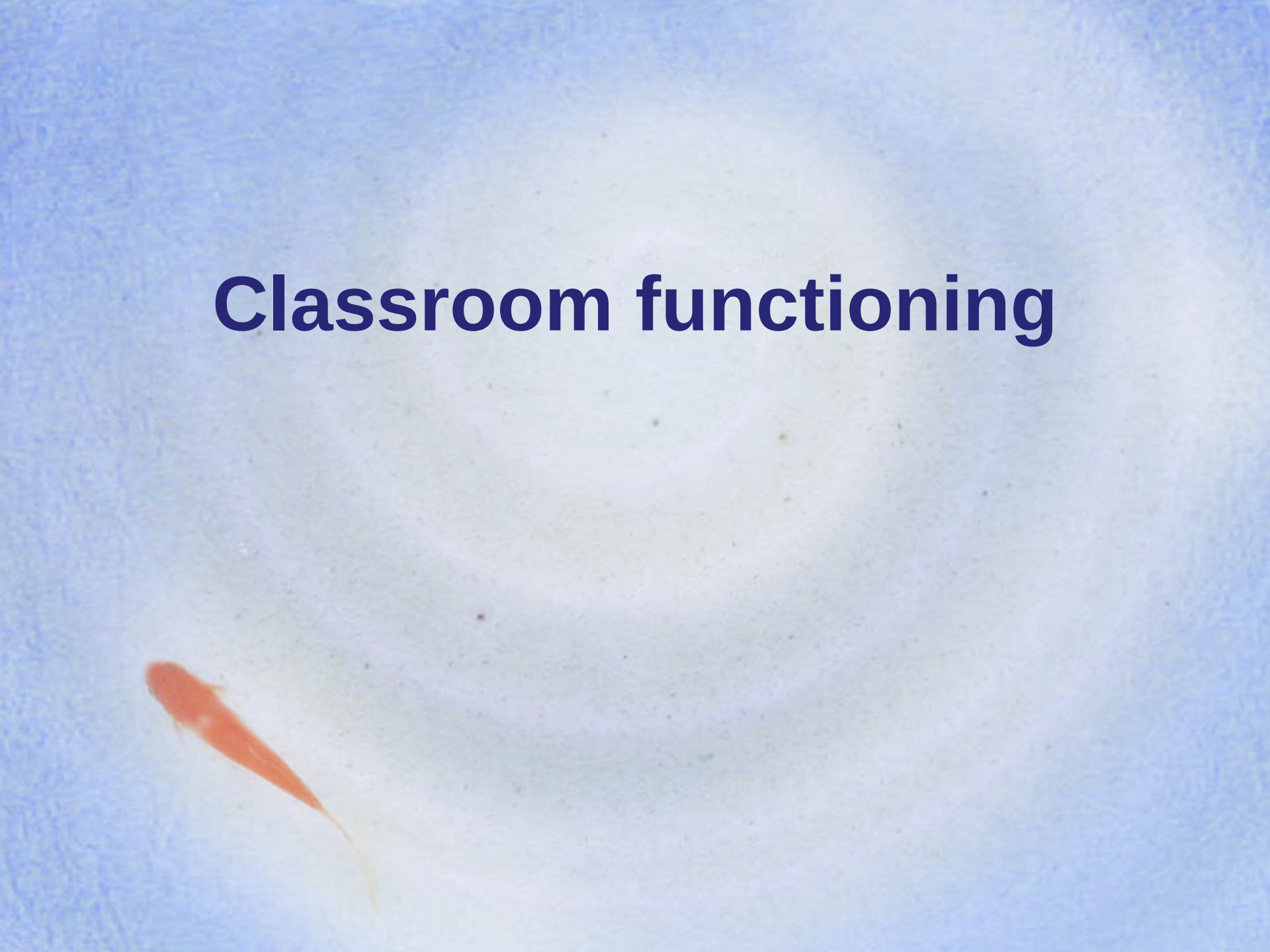
Peer interaction in general education classes

- Deaf students interact more with other deaf students
- Interactions more likely when hearing peers have greater patience
- Interactions likely to be positive when deaf students have relatively more hearing or English language ability
- There are limitations in communication access, particularly in informal situations
- Feelings of apprehension may inhibit communication and make it less satisfactory

Notice and evaluate

- Social skills/ social maturity
- Social integration/acceptance
  - Accepted as friends/playmates?
- Affective functioning
  - Self esteem
  - loneliness

Classroom functioning



- Engaged in learning?
- Participating in class?
- Able to read to learn?
- Using problem solving skills?

Language Remediation Strategies

For older students

- Continue to rely on tried and true language facilitation techniques
  - Increasing saliency of input
  - Focus child's attention on specific aspects of communication
  - Real conversations--real interactions--real situations
  - Multiple opportunities with feedback
  - Focus on spoken and written literacy
  - Curriculum-based instruction

Saliency

- Maximize executive function in language learning
- Promote metacognitive processes
  - Monitor
  - Control
  - Revise
- Brown and Long, 1992
  - Reciprocal teaching in writing

Focus Attention

- Focus on form
  - Writing
    - Berent et al 2008
- Focus on utterance
  - Speaking
    - Language instruction video
- SEA--Supporting English Acquisition
  - Website familiarizes instructors with structrues

Real Conversations/ Meaningful use

- Real interactions and real situations
- Conversational management
  - Website and demo
- Monitor and revise
- Interviewing
- Use ESL materials

Classact website

- www.rit.edu/ntid/drt/classact
- Maximize access to curriculum
- Classroom strategies for teachers to use to facilitate learning by deaf students

Targeting areas for remediation

- Spoken and written literacy
  - Interdependence of spoken and written language

observations of cognitive domain-general differences

- monitoring for importance, relevance
- Using inductive reasoning to go from specific to general
- Identifying relations between events, objects, structures
- Self-regulating performance

Differences influence performance in:

Math

Problem solving

Reading

Writing

Language predictors of performance in math

- Reading grade level
- Knowledge of morphology

(Kelly & Gaustad, 2006)

- Use of inner voice (Davis & Kelly, 2003)
- Verbal-operational consistency of relational statements (Kelly et al, 2003)

Good Readers

- Use phonological code
- Monitor comprehension
- Create macrostructures using relevant and important information
- Fill-in missing and inferred information

Poor Readers

- Slower
- Difficulty differentiating details and main ideas
- Miss discrepant or incongruent information
- May draw irrelevant or incorrect inferences
- Have weaker vocabulary
- Have reduced world knowledge or strategies for accessing knowledge for top-down processing

Reading strategy instruction

- Create discrepant texts and use scaffolding to identify and revise
- Create rich texts that promote learning of new vocabulary through context
- Insert questions or probes in reading materials requiring “stop, think, review”
- Be careful if simplifying text, alterations may make it MORE difficult to integrate and infer

Morphology instruction

- Morphological knowledge related to word recognition and reading skill
- Teach word analysis procedures involving prefixes, suffixes, and roots

Expressive Language

- Differences at all levels
  - Morphology, vocabulary, syntax
- Apparent in written and spoken modes
  - Though one or the other may be better
- Many parallels to users of English as a second language
  - Suggests constraints on acquisition

Research by Jerry Berent

- Deaf learners and ESL learners make similar mistakes

  – Related to restricted access to input--> COMPROMISED NOTICING

- Need to enhance input

Focus on Form

- Writing strategy whereby all uses of a particular syntactic form, correct and incorrect, are highlighted for student
  - Visual enhancement facilitates noticing of target language form
- Berent et al (2007) JDSDE

Supporting English Acquisition

- Website created by Jerry Berent
- www.rit.edu/ntid/rate/sea/index2.html
- Resource for teachers of students who have limited English proficiency
  - including students who are deaf and hard of hearing or second language learners

Review and Revise Form

- Spoken language intervention strategy
  - Highlight utterance
  - Analyze utterance
  - Revise utterance
- Video example language instruction www.ntid.rit.edu/speechlangpros

Foster metacognitive monitoring and control

- Students must reflect on, analyze, evaluate, control their spoken and written language
- Self-regulate language use
- Brown & Long (1992) Volta Review
  - Used reciprocal teaching to internalize process of planning and evaluating writing

Promote development of narrative skills

- Elicitation strategies and materials
  - See website
- Spoken vs written mode
- Narrative analysis
  - Establishing setting and characters
  - Local and global cohesion
  - Referent specification
  - Logical and temporal connectives

Promote development of conversational skills

- Conversational analysis
  - Interactions on split screen
- Monitoring and repairing

- Pragmatics section of website