Development of auditory attention

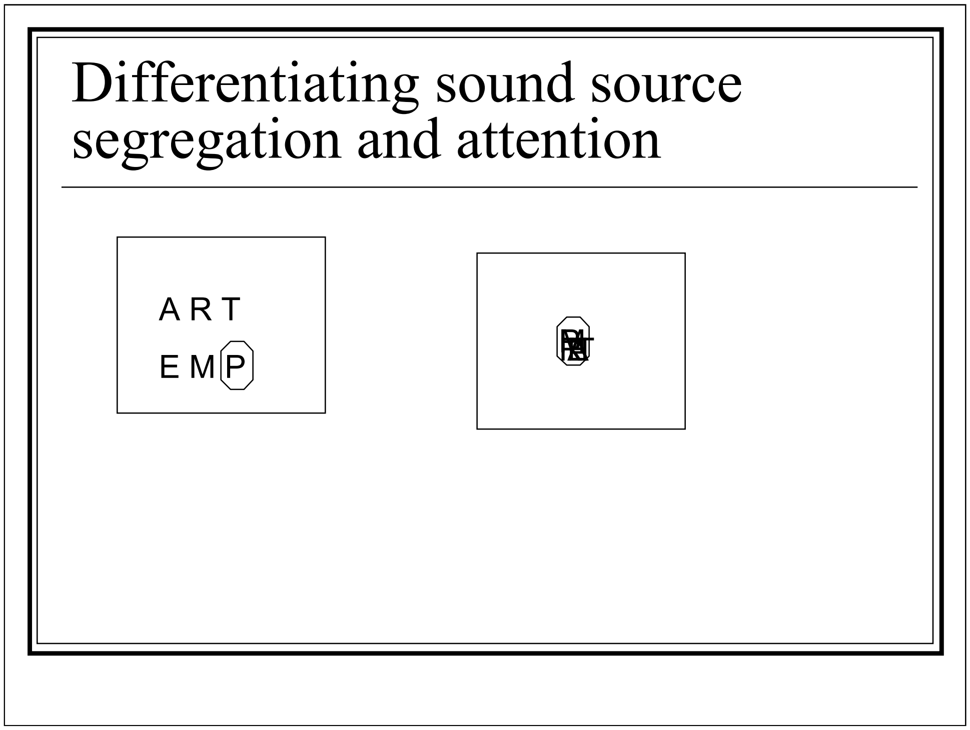
Another potential contributor to the maturation of hearing

We have discussed the possibility that infants and children might have more trouble detecting a tone in noise, or following one voice in the presence of other sounds, might be a limitation on sound source segregation. However, even if a child can segregate one sound from another, he still needs to be able to attend to the target sound to be able to process it fully. It is the process of attention that we will discuss today.

Definition of attention?

- William James: “Everyone knows what attention is.”
- What is agreed upon
  - limited capacity
  - selective

Even though we use the word “attention” all the time, its definition is elusive from a scientific perspective. Attention can mean different things in different contexts. The two basic ideas behind attention are, first, that we can’t process all the information that is available to us at an instant in time-- that is, we have a limited processing capacity. To deal with this limited processing capacity, we select some pieces of information for further processing, but not others. It is the process of selective processing that we refer to as attention.

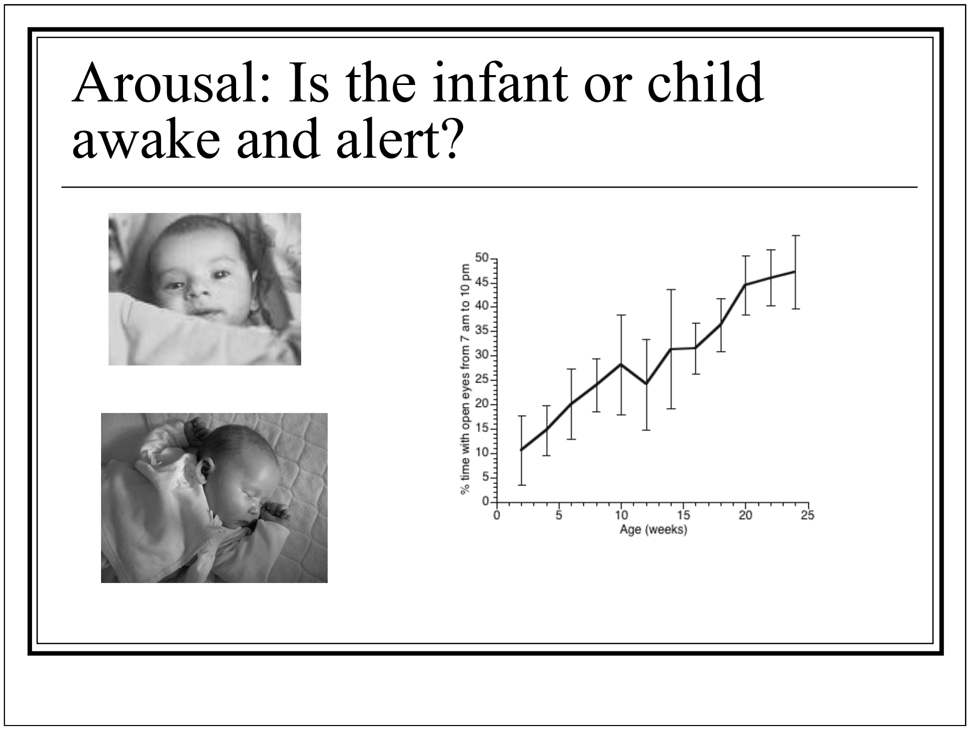


One of the things we have to be careful about is confusing sound source segregation with attention. If you are studying visual attention, you put six letters on the screen and tell people to only report the one you indicate. But when we present sounds simultaneously, it is as if we are presenting the letters overlapping in space. If the viewer can't segregate the letters, it is hard to report just one of them. In the same way, if a listener can't segregate sounds, she can't attend selectively to one of them. In selective listening studies, researchers have frequently presented simultaneous sounds to kids and asked them to report on just one, but they have presented the sounds in a way that might make it difficult for the sounds to be segregated. So as we go through this material, we need to be especially careful to notice how the sounds were presented.

Varieties of attention

- Arousal
- Orienting
- Sustained attention
- Selective attention

So if attention involves selective processing of some stimuli, then we can really talk about 4 varieties of attention. The first is “arousal”, which refers to how alert the listener is-- how prepared she is to process stimuli in general. Orienting involves directing processing resources toward the stimulus. Sustained attention refers to maintaining a state in which stimuli can continue to be processed. Selective attention means that we process some stimuli, but not others. Each of these varieties of attention changes as a child develops.



One of the big things that changes that allows infants to respond to and learn about stimuli is that they spend more time in an awake, quiet and alert state as they get older.

A 2 week old may spend on average, only 10% of the daytime in this state. By 24 weeks, the percentage is up to 47%. Development of the Waking State in Young Infants

J. Dittrichová; V. Lapáčková

Child Development > Vol. 35, No. 2 (Jun., 1964), pp. 365-370

The other thing that changes, but that takes much longer to become adultlike is the extent to which arousal is under cognitive control-- basically, can you wake yourself up to get something done?

“

During the first few months of life, the infant’s level of arousal changes frequently and fluidly (33). Development is evidenced by the increased time spent in an awake, alert state and by more differentiated transitions between states. General levels of arousal are most frequently included in developmental studies of attention as baseline conditions orexclusionary criteria (29).

Adult theories of arousal have suggested that there is a dual-level control mechanism, consisting of a passive, low-level, physiological arousal system, mediated by the reticular formation, and a higher-level, cognitive arousal system (34- 35). The higher-level system can modulate the lower-level system to establish or maintain an optimal level of arousal for performance of a particular task. The reticular arousal system is established early in development. The cognitive arousal system develops later as the child gains control over self regulatory functions. This second system is especially important for maintaining attentional focus and consequently is critical for sustained attention.”

(p. d109, Gomes et al., 2000)

1.Gomes, H., S. Molholm, C. Christodoulou, *et al.*, The development of auditory attention in children. Front Biosci, 2000. **5**: p. 108-120.

Orienting

- Cardiac deceleration
- Decreased respiration rate
- EEG desynchronization
- Increased skin conductance
- Decreased motor activity

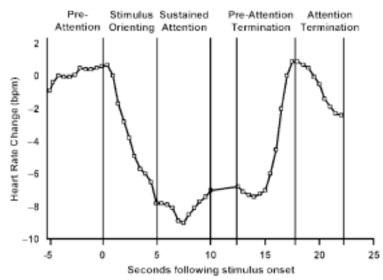
Orienting is an indication that an organism is ready to receive stimulation-- the system does all that it can to reduce the noise that it creates. These are all components of an orienting response. People frequently distinguish orienting from a defensive response (“get me outa here”), which involves cardiac acceleration, increased respiration and possibly increased motor activity. Although it doesn’t happen very often in very young infants (because they aren’t awake that much), we know that orienting responses to sound can be recorded in premature infants who are only 35-36 weeks conceptional age.

Schulman, C. A. (1969). "Effects of auditory stimulation on heart rate in premature infants as a function of level of arousal, probability of cns damage, and conceptional age," Dev Psychobiol, 2, 172-183.

Sustained attention

Anyone who has dealt with children could tell you that sustained attention undergoes considerable development during infancy and childhood-- although sometimes kids seem able to sustain attention for quite some time.

Heart rate indicates sustained visual attention



John Richards has studied the development of sustained visual attention in infants by examining the timing of cardiac decelerations relative to looking at a stimulus and learning about it. Unfortunately, it is not known whether auditory attention develops in the same way.

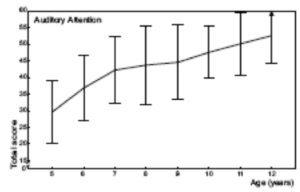
Richards found that after a listener orients to a stimulus-- initial cardiac deceleration, the heart rate remains low while the viewer is looking at the stimulus. This is the time period that is labeled sustained attention in this graph. In adults, the heart rate, eye movements, and learning are synchronized with each other. It is harder to distract the viewer during the sustained attention phase than during the other phases. If a stimulus is presented during the sustained attention phase, the viewer is more likely to remember the stimulus than if it is presented at other times. These features of sustained attention are present in young infants, but younger infants have shorter periods of sustained attention and their heart rate, looking and learning are not as well synchronized as in older infants, children and adults. Major changes in sustained attention occur between 14 and 26 weeks of age.

Richards, J. (2000). "Development of multimodal attention in young infants: Modification of the startle reflex by attention," Psychophysiology, 37, 65-75.

Richards, J. E., and Hunter, S. K. (1998). "Attention and eye movement in young infants: Neural control and development," in Cognitive neuroscience of attention: A developmental perspective, edited by J. E. Richards).

Richards, J. E., and Lansink, J. M. (1998). "Distractibility during visual fixation in young infants: The selectivity of attention," in edited by (Ablex Publishing, Stamford, CT), pp. 407-444.

Sustained attention: Vigilance



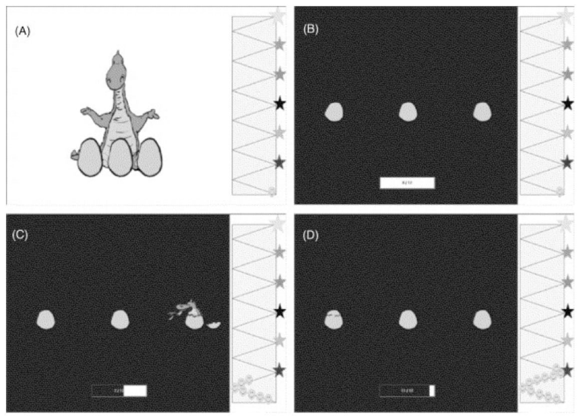
Several studies have looked at children's performance in vigilance tasks. Basically, the subject is required to listen to an ongoing sequence of sounds and to respond whenever they hear some specified sound. This could be an increase in frequency or intensity, or a particular word in a sequence of words. The results of one study like this are shown in this slide. Klenberg et al. had kids listen to a sequence of color names and each time they heard the word "red", they were supposed to put a red square in a box. They counted how many times the child responded correctly and subtracted the number of times that the child put the square in the box when the word wasn't "red" to get the scores you see here. The sequence contained 180 words, so it took several minutes to complete the task. What you'll notice is that the score increases with age between 5 and 12 years.

One of the issues that hasn't always been addressed in studies like this is whether the younger kids are having trouble sustaining attention or they are less sensitive to the sound change than the older kids. So for example, maybe they couldn't tell the frequency changed. It is more important to see if performance decreases over time, not just what it is like overall. Few studies have actually examined performance in this way, but at least one study has shown that performance gets worse faster in younger children.

Klenberg, Liisa1, Korkman, Marit2 , Lahti-Nuuttila, Pekka1 Differential Development of Attention and Executive Functions in 3- to 12-Year-Old Finnish Children. Developmental Neuropsychology; 2001, Vol. 20 Issue 1, p407-428

SWANSON HL A DEVELOPMENTAL-STUDY OF VIGILANCE IN LEARNING-DISABLED AND NONDISABLED CHILDREN. JOURNAL OF ABNORMAL CHILD PSYCHOLOGY 11 (3): 415-429 1983

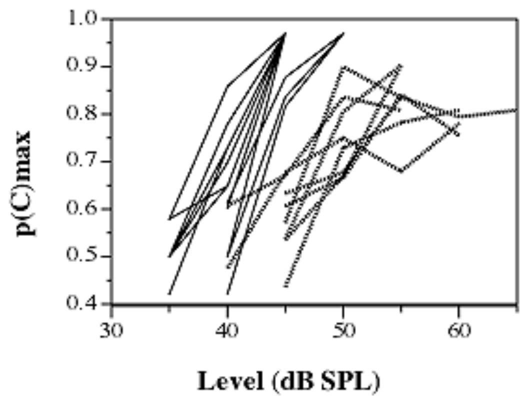
Performance on psychophysical tasks is affected by sustained attention



One thing you may have been wondering about all quarter is how this sort of attention influences auditory performance. We make appealing pictures and procedures to try to keep infants and children involved in a psychophysical task, but we can never guarantee that they will be on task on every single trial. Just because the child is looking at the screen or the infant looks attentive, that doesn't mean that they are “listening”.

One consequence of a failure of sustained attention-- which I will refer to is inattentiveness-- is that even when a sound should be audible to the child 100% of the time, the child does not detect the sound 100% of the time. We can see this in the psychometric functions of infants and children.

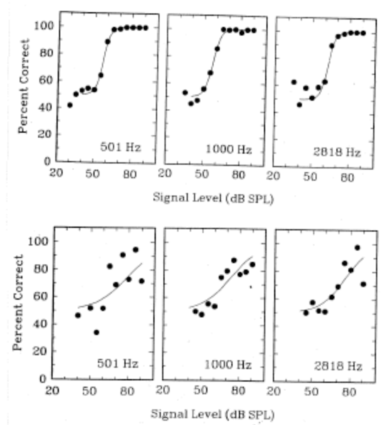
Development of the psychometric function for detection in noise



These are psychometric functions of adults and infants detecting a 1000 Hz tone in broadband noise, in an observer-based procedure. They plot p(C)max, which is an unbiased version of proportion correct, as a function of the tone's level. The infants were 7-9 months old. The adults are shown in solid lines and each line is for one subject. The infants are shown in the thinner dashed lines. You can see that both infants and adults have function that (more or less) go up as the level of the sound goes up, but while the adults are getting essentially 100% correct at the highest level, the infants, on average, only get to 85% correct. Even if we increase the level to, say, 70 dB SPL, they don't get more than 85% correct.

1.Bargones, J.Y., L.A. Werner, and G.C. Marean, Infant psychometric functions for detection: Mechanisms of immature sensitivity. J Acoust Soc Am, 1995. **98**: p. 99-111.

Development of the psychometric function for detection in noise



These aware psychometric functions for 3 different frequencies of tones detected in broadband noise in a 3-alternative-forced-choice task by children (bottom panel), and adults (top panel). In each panel, the adults achieve 100% correct a the highest levels, but on average, the children achieve 85 or 90% correct.

1.Allen, P. and F. Wightman, Psychometric functions for children's detection of tones in noise. J Speech Hear Res, 1994. **37**: p. 205-15.

How does inattentiveness influence threshold?

60 dB: 100% audible — 70% of trials

60 dB: guess - 50% correct — 30% of trials

% correct = .7 X 100% + .3 X 50% = 85% correct

So this is a simple model of what will happen to performance when a listener is inattentive. Let's say that the level of the tone is 60 dB SPL, and that when the baby is "on task" (I.e., attentive), he responds to the tone 100% of the time. Let's further assume that the baby is attentive 70% of the trials. So the baby will respond to the tone on 70% of the trials. On the other 30% of the trials, the baby is inattentive. He has no idea whether a tone was presented or not. So he "guesses" (or the observer guesses)-- and he will end up being right 50% of the time if tone and no-tone trials are equally likely. So the baby will get 30% times 50% additional trials correct by guessing, which would be 15%. Total percent correct is then 85%.

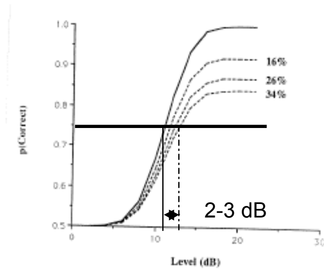
The same thing would happen at every level of the stimulus. If the level is 50 dB SPL, and the baby only responds to that level 70% of the time, then the baby will get 70% correct on 70% of the trials, for a total of 49% correct, and then he will get an additional 15% on inattentive trials, for a total of 64% correct. So the whole psychometric function will be affected by the inattentiveness.

Viemeister, N. F., and Schlauch, R. S. (1992). "Issues in infant psychoacoustics," in Developmental psychoacoustics, edited by L. A. Werner and E. W. Rubel (American Psychological Association, Washington, D.C.), pp. 191-210.

Werner, L. A. (1992). "Interpreting developmental psychoacoustics," in Developmental psychoacoustics, edited by L. A. Werner and E. W. Rubel (American Psychological Association, Washington, D.C.), pp. 47-88.

Wightman, F., and Allen, P. (1992). "Individual differences in auditory capability among preschool children," in Developmental psychoacoustics, edited by L. A. Werner and E. W. Rubel (American Psychological Association, Washington, D.C.), pp. 113-133.

Effects of inattentiveness on threshold



This effect is shown here for 3 different rates of inattentiveness. The solid line is for the perfectly attentive listener. The dashed lines show what the psychometric function would like if the listener were inattentive on 16, 26 or 34% of the trials. The upper asymptote of the function is lower than 100% by the inattention rate divided by 2, and the function is shallower when there is inattentiveness.

But remember that the definition of threshold is the level of the tone that produces, for example, 75% correct. The thick red horizontal line is drawn at 75% correct, ant the thin red solid line shows that the threshold for the perfectly attentive listener would be maybe 11 dB. The dashed red line shows what the threshold would be for a listener who was inattentive 34% of the time. The threshold is now maybe 13 or 14 dB; the threshold only increased by a couple of dB.

So it is likely that failures of sustained attention explain part of the difference between infants and adults in masked threshold, but the difference is something like 10 dB and inattentiveness would only give us a 2-3 dB difference. Of course the threshold difference between kids and adults is pretty small by the time you get to 4 or 5 years, so inattentiveness could account for a lot of that difference.

Development of selective attention and its effect on auditory sensitivity

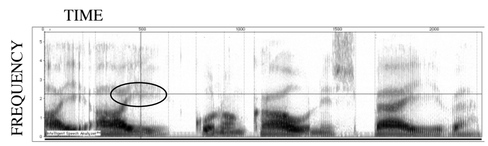
- Attention to relevant features within a sound
- Attention to one sound source among several

The final variety of attention is selective attention. But again, we can think of selective attention in different contexts. When we hear, for example, a word, there are many acoustic features that could tell us what the word is. Adults, however, may just use a couple of those features to identify the word. If conditions change (e.g., in a noisy background or when the word is distorted), adults may switch to using different features to identify the word, but they don’t usually have to use all of the features. By being selective, adults are able to process speech very quickly.

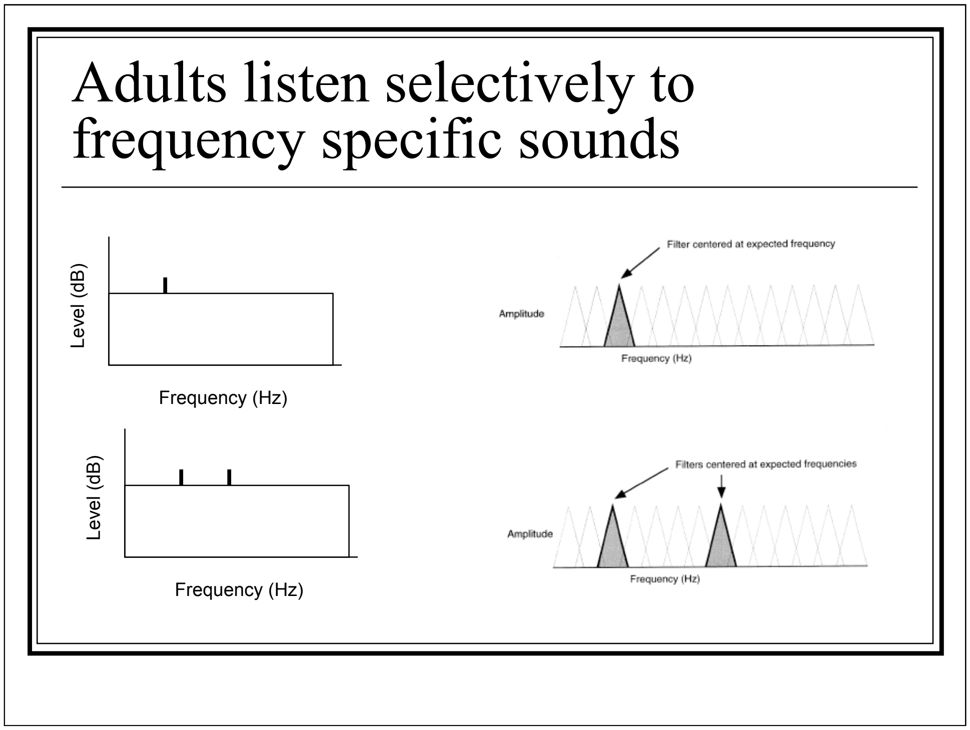
The other sort of selective attention occurs in the situation in which there are multiple concurrent sound sources. Assuming that the listener can segregate one sound from another, the listener is generally able to process that one sound source while ignoring others.

Both of these sorts of selective attention apparently develop.

Selective attention within a sound



So let’s first consider selective attention within a complex sound. The simple case we always fall back on is detecting a tone in a broadband noise.



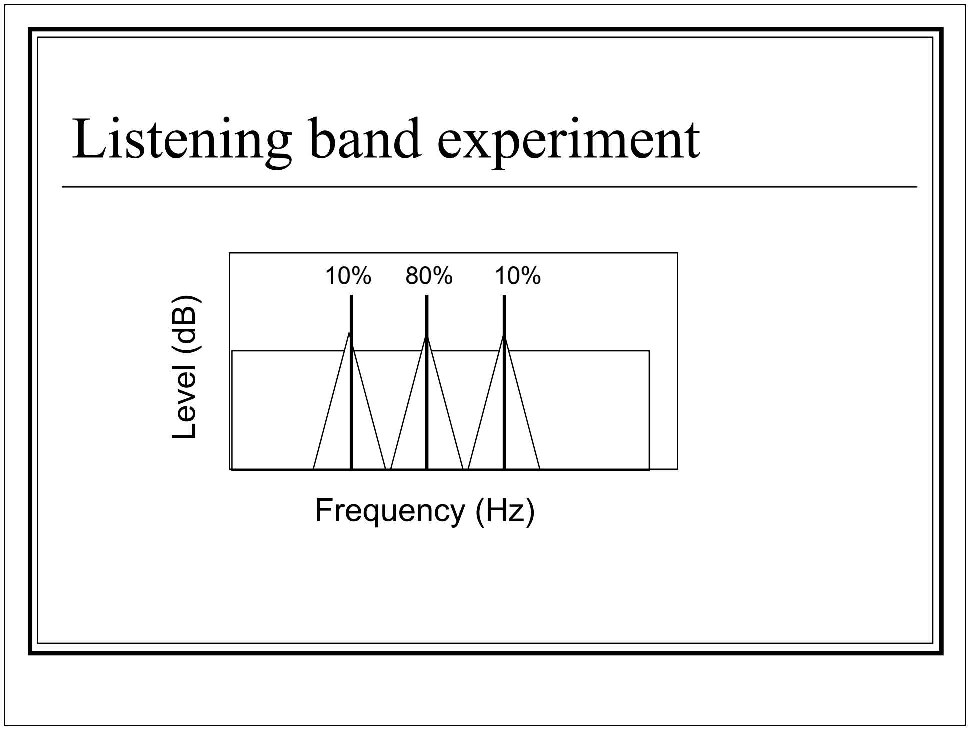
Even in a simple case in which an adult is detecting a tone in noise, she listens selectively at the frequency of the tone she expects to hear. These drawings show the amplitude spectra of stimuli in two different conditions, and the In the drawings on the right, the bank of auditory filters is shown in light line, the filter that is centered on the expected tone frequency is outline in black, and the shaded filters are the ones being monitored by the listener. Remember that the auditory system gives the listener the ability to filter out the noise that falls at frequencies away from the tone frequency. The listener is thought to listen through the filter that is centered on the tone's frequency. In fact, if I ask Listeners to detect two tones, or one of two tones that occur equally often, they can monitor two filters, one centered on the frequency of each tone, simultaneously. Of course, the more filters you monitor, the more noise gets through, so it is not optimal to monitor filters other than the ones where the signal is expected to occur.

So this is a type of selective attention. The listener processes the sound that comes through one (or two) filters, and not the sound coming through others.

Greenberg, G. Z., and Larkin, W. D. (1968). "The frequency response characteristic of auditory observers detecting signals of a single frequency in noise: The probe-signal method," J. Acoust. Soc. Am., 44, 1513-1523.

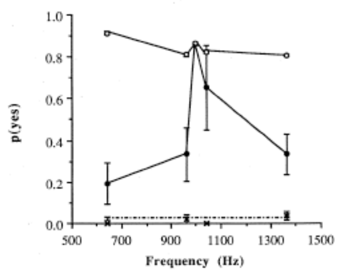
Scharf, B. (1987). "Focused auditory attention and frequency selectivity," Percept. Psychophys., 42, 215-223.

Schlauch, R. S., and Hafter, E. R. (1991). "Listening bandwidths and frequency uncertainty in pure-tone signal detection," J. Acoust. Soc. Am., 90, 1332-1339.



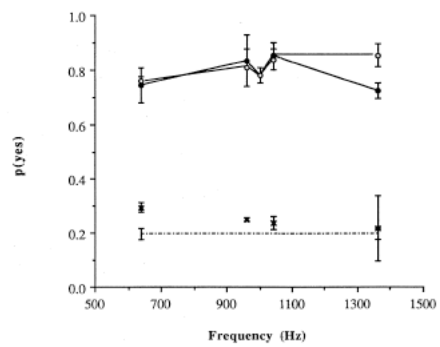
It is relatively easy to show that adults listen at the frequency of a tone they are detecting. E call this the listening band experiment. We have tones at several frequencies; here I've just drawn the amplitude spectra of tones at 3 frequencies. Let's say tat we set the level of these tones to be a little above threshold, and then we measure how often the listener can detect each one. We [resent the three frequencies in random order, but on 80% of the trials one frequency is presented, and the rest of the trials are divided between these other tow frequencies. The listener could monitor all three frequencies, but if he did that, most of the time he is going to be getting three "filterfuls" of noise and his sensitivity will be poorer. He can actually do better if he just concentrates on the frequency that is presented most often. If he does that, he won't hear those other two frequencies, but he'll get more trials correct overall. And that is what subjects do.

Adult listening band

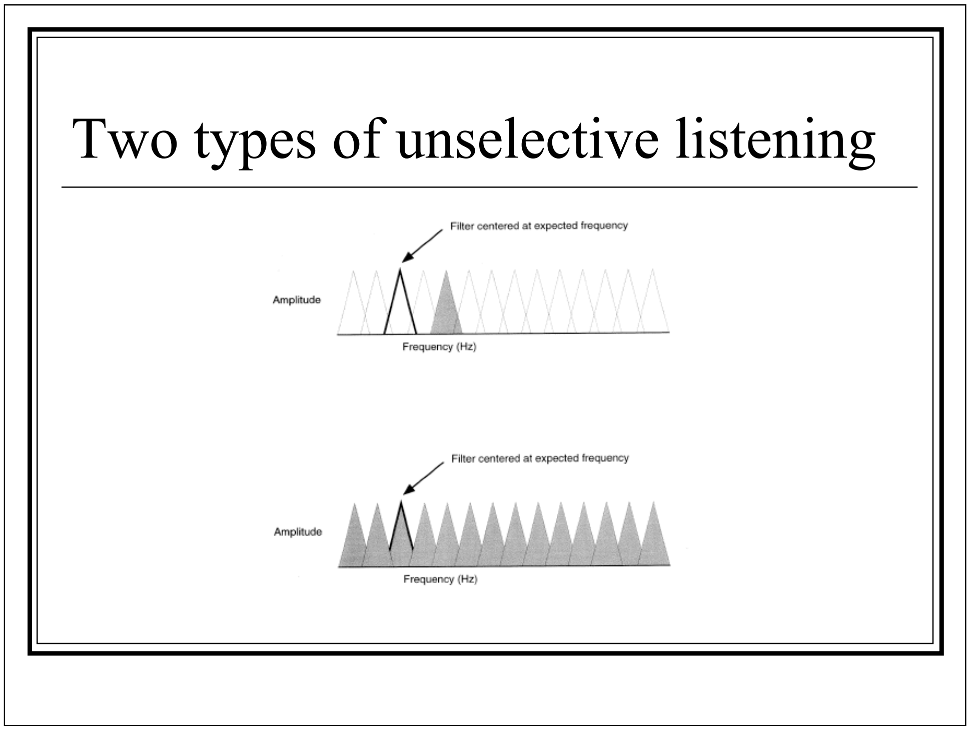


This is the result of a listening band experiment with adults. The unfilled symbols represent the percent of time that h the listener could detect each frequency when it was the only frequency presented to him. They detect the tones all about 80-90% of the time. The solid symbols show what happens when a 1000 Hz tone is presented on 75% of the trials, and one of these other frequencies on a smaller proportion of the trials. Now the listener detects 1000 Hz about 85% of the time, but detects the other frequencies much less often. That tells us that the listener was monitor the filter centered at 1000 Hz and excluding the other filters.

Infant listening band

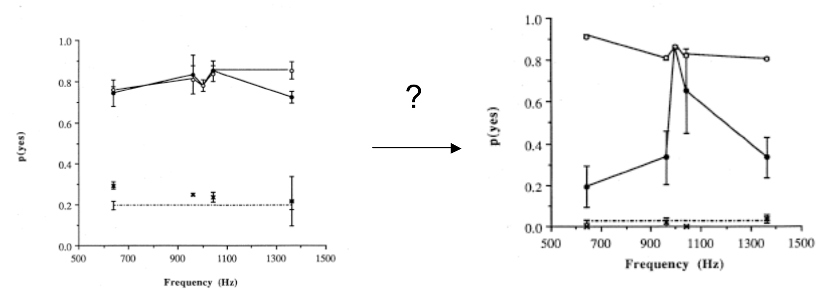


Bargones and Werner (1994) repeated this experiment with 7-9-month-old infants and these are their results. The infants detect each of the tones about 80-85% of the time when that frequency is the only one presented to them, and they detect each of the tones about 80-85% of the time when 1000 Hz is presented on 75% of the trials, with other frequencies only presented on a small proportion of the trials. This tells us that the infants are not just monitoring the filter that is centered on 1000 Hz. They are not selective listeners/



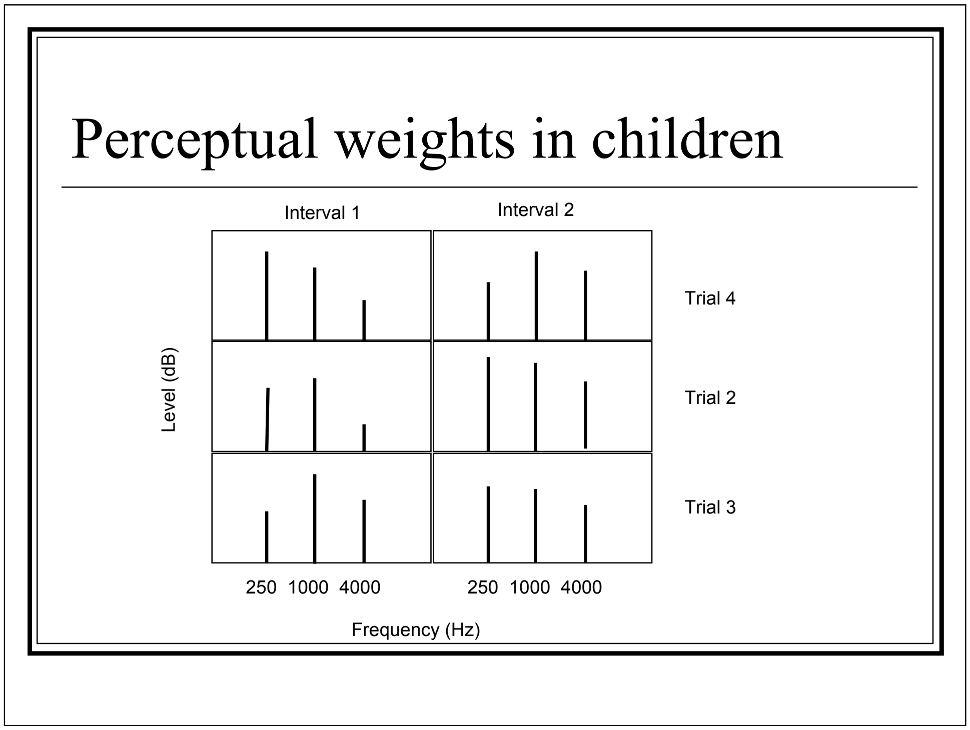
There are really two different ways that infants could be listening. In these drawings, the bank of auditory filters is shown in light line, the filter that is centered on the expected tone frequency is outline in black, and the shaded filters are the ones being monitored by the listener. I might be, as shown in the top panel, that the infant is trying to monitor the frequency around the tone, but he “misses”. We say that his listening band is wandering. So this isn’t exactly unselective; it is more like selective but not good at it. The bottom panel shows the other option. Here the baby is listening to all the filters. We would call this broadband listening. The results of several studies have made us think that infants are broadband listeners rather wandering band listeners.

When does listening become selective?



There were a couple of listening band studies of school-aged children (6+ years) that showed that they had adult like listening bands. However, recall that both infants and children show masking of tone by remote fixed-frequency maskers. That is entirely consistent with the broadband listening. So maybe kids are not as selective in their listening as we thought.

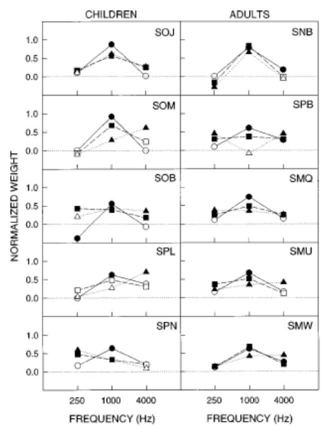
Greenberg, G. Z., Bray, N. W., and Beasley, D. S. (1970). "Children's frequency-selective detection of signals in noise," Percept. Psychophys., 8, 173-175.



Another way to look at selective listening is by measuring what are called perceptual weights. In an experiment conducted by Stellmack et al with 4.5-5.5 year old children, they calculated perceptual weights in an intensity discrimination experiment. The children were instructed to judge whether the 1000 Hz tone was louder in interval 1 than in interval 2, but tones at 250 and 400 Hz were presented at the same time. (They learned to call 250 Hz frog, 1000 Hz the happy face, and 4000 Hz the bird, and then they were told to just listen to the happy face and to ignore the frog and bird). The levels of all three tones were varied random;ly around a mean value on each presentation. If the kids were only listening to the 1000 Hz tone, then their response on that trial should only depend on the difference in the intensity of 1000 Hz tone in the two intervals, so there would be a high correlation between the intensity difference at 1000 Hz and their response, but the intensity differences at the other frequencies would not be correlated with their response. But if the kids were really listening to all three frequencies, then we would expect their response to be correlated with the intensity differences at all three frequencies. From these correlations, we can calculate a weight, which tells us how much the child was using each frequency in judging the intensities.

Stellmack, M. A., Willihnganz, M. S., Wightman, F. L., and Lutfi, R. A. (1997). "Spectral weights in level discrimination by preschool children: Analytic listening conditions," J. Acoust. Soc. Am., 101, 2811-2821.

Perceptual weights in children



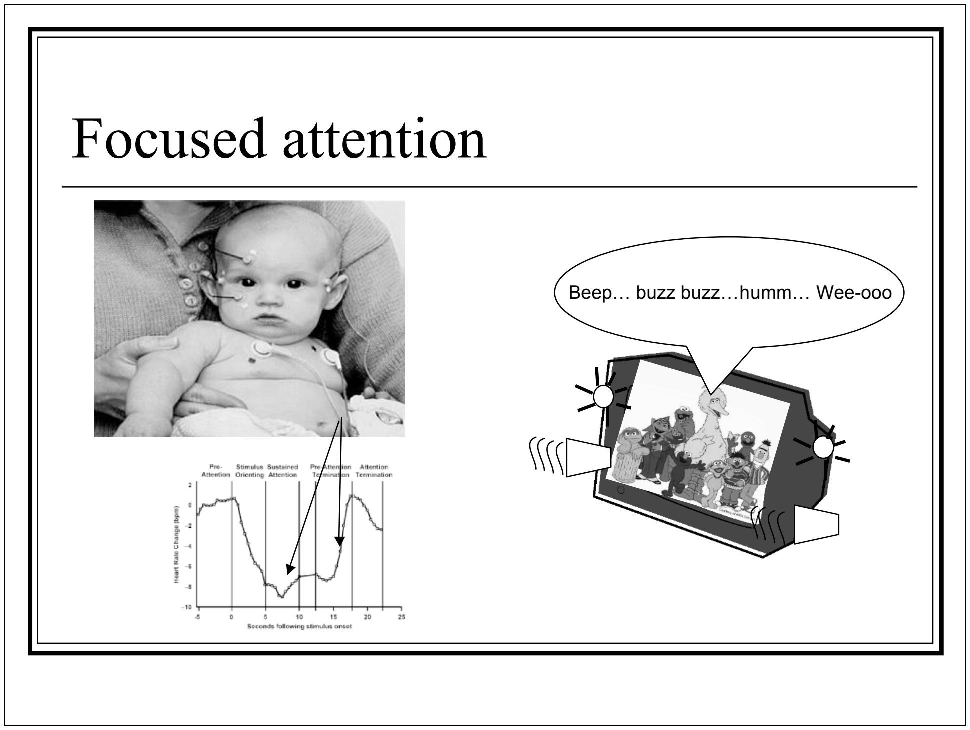
These are the results of the experiment. Each graph is for one subject. There five kids and five adults. Each graph plots the perceptual weight as a function of the frequency of the tone. Each subject was tested when the overall level of the “distracter” tones was set at 3 different values (circles, 30 dB SPL, squares, 60 dB SPL, triangles, 70 dB SPL). Remember, if the listener is just listening to 1000 Hz, then we should see a higher weight on 1000 Hz than on the other frequencies. What you’ll notice is that for both kids and adults there are a lot of conditions where the 1000 Hz tone has the highest weight, so everybody, including these kids listening for the smiley face, could listen selectively sometimes. The kids tend to be a little more selective for the lower level distracter tones; the squares and triangles (60 and 70 dB distracters) are the ones that show a pattern that’s not like an upside down V. The same thing is true of some of the adults. So these results would suggest that the kids might be a little less selective than the adults, but not much less selective than the adults.

Effects of broadband listening

- Higher thresholds for tone in noise and susceptibility to masking in general
- Broadband detection more adultlike than narrow band
- Steeper psychometric function than adults
- Sensitivity to features adults don't "hear"

Selective attention to a sound source

- Focused attention
- Dichotic listening tasks



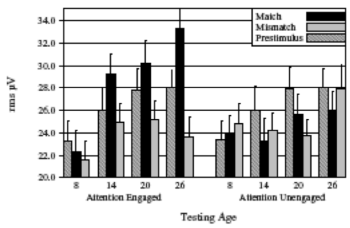
John Richards has studied the development of attention focus in infants. Remember that when infants are attending to a stimulus their heart rate goes down, as shown in the graph at the bottom of this slide, and it stays down as long as they are attending to the stimulus. It has been shown that if adults are paying attention to a visual stimulus and you flash a light in their eyes, they produce a bigger eye blink to the light flash than they would have if they hadn't been watching anything when you flashed the light. Similarly, if adults are listening to some sound and you present a loud noise burst, they produce a bigger eye blink to the noise burst than if they hadn't been listening to anything when you played the noise burst. Conversely, if an adult is watching something and you present a noise burst, the blink to the noise burst is smaller than it would have been if you hadn't been watching anything, and if you flash a light when someone is listening to something, you get a smaller eye blink than if they hadn't been listening to anything. So if you are attending to one modality, you respond more if the blink-eliciting stimulus is in the same modality and less if the blink-elciting stimulus in another modality-- so this gives us a way to confirm that the listener is attending to something.

So the baby is sitting on Mom's lap, and she's wired up to record her heart rate and her eye blinks. She can see a "TV", and next to the TV there are two lights and two little speakers.

What Richards did was to have infants watch a video or listen to some weird noises. He measured the baby's heart rate when this stimulus was presented. Their heart rates would go down, and after a short time, their heart rtes would be staying pretty low, suggesting that they are now paying attention. Now what Richards did was to either flash the lights or present a noise burst out of the speakers, and measure the infant's eye blink. He repeated the measurements at another point in time when the infant was losing interest in the video. The prediction is that the more the baby is focused on the video and/or audio, the bigger the effect on the blink should be.

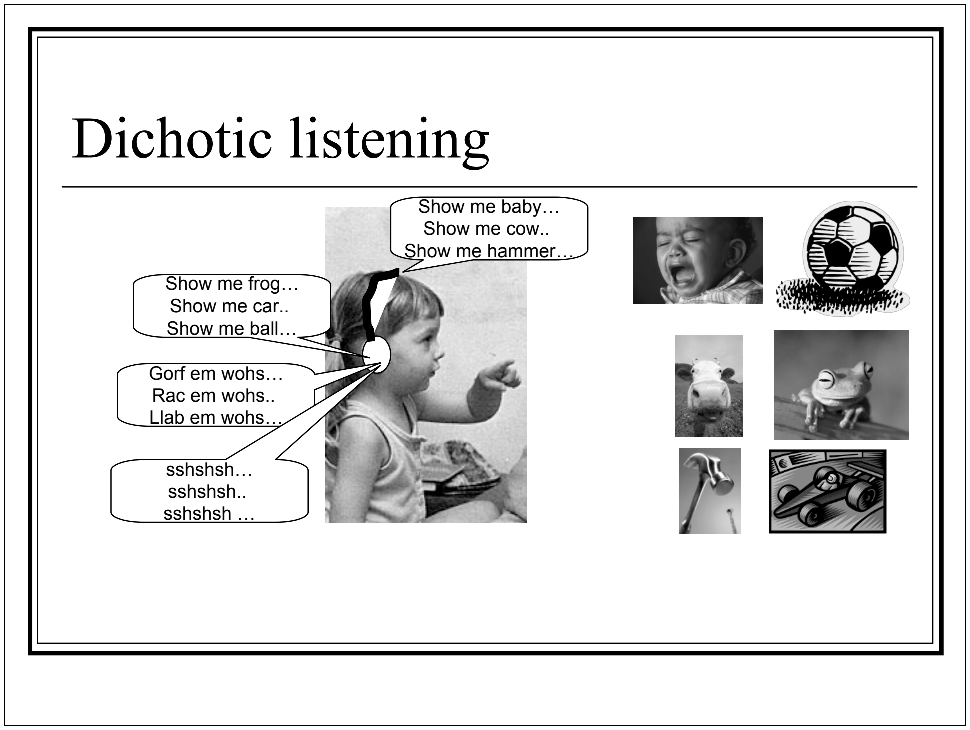
Richards, J. (2000). "Development of multimodal attention in young infants: Modification of the startle reflex by attention," Psychophysiology, 37, 65-75.

Focused attention



The results are shown here for babies aged 8 to 26 weeks. The y-axis is how big the eye blink was. “prestimulus” means the eye blink that they measured before they showed the baby the video/audio. Match means that the blink-eliciting stimulus was in the same modality as the interesting stimulus. Mismatch means that the blink eliciting stimulus was in the opposite modality from the interesting stimulus. On the left are the measures taken when the infant’s attention was engaged with the video/audio. Look at the 26-week-olds to get the idea: When the blink-elciting stimulus matched the attention getting stimulus, the eye blink was bigger than it was prestimulus, and when it mismatched the attention getting stimulus, the eye blink was much smaller . But for the younger infants this effect is smaller, and for the youngest infants, you don’t see any effect at all. It is as if they really aren’t focused on the audio/video stimulus, The right hand side of the graph shows what happens when the infant isn’t “engaged” with the audio/video. There really isn’t much of a pattern here-- this is consistent with the idea that the babies aren’t focused on anything.

Similar effects have been demonstrated in kids between 7 and 11 years of age, with the result that things are fairly mature by 7 years. At this point we don’t really know when between 7 months and 7 years kids become mature in their focused attention.



Cherry (1981) is a good example of a dichotic listening experiment with children. The idea of the experiment is that speech is being presented to both ears, and the listener is supposed to attend to one ear and ignore the other. In Cherry's experiment 5 to 8 year old children listened to a female voice saying "Show me_______" and they were supposed to point to the picture that the lady in the recording named. But of course, the same lady was saying "Show me something else" in the other ear, and the kids were instructed to only report what the lady said in one specified ear. Cherry included some other conditions to get a handle on what the kids might be having problems with. In another condition she played the same speech backward in the ear the child was supposed to ignore; this sound would be spectrally and temporally similar to speech but be meaningless. In another condition, she played white noise-- which would be different from speech in several ways.

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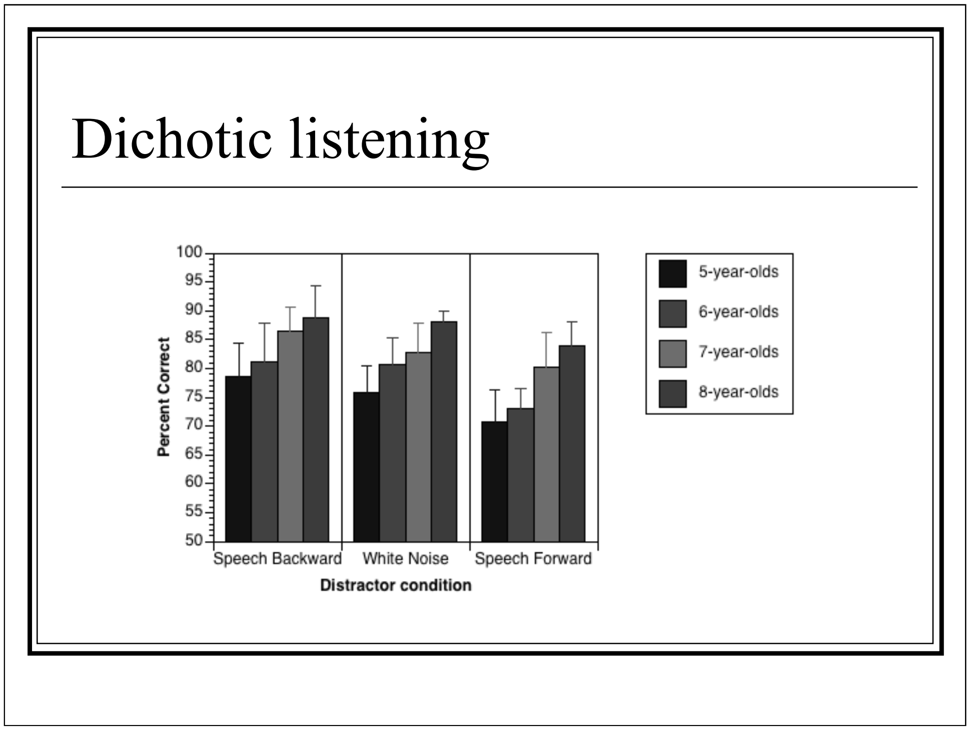
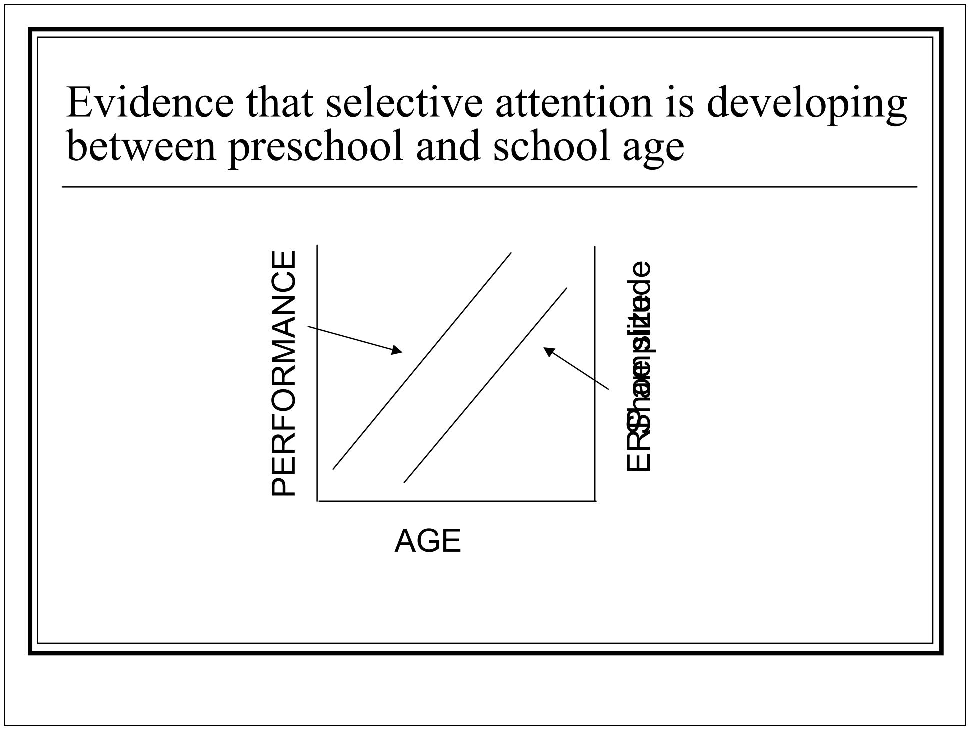
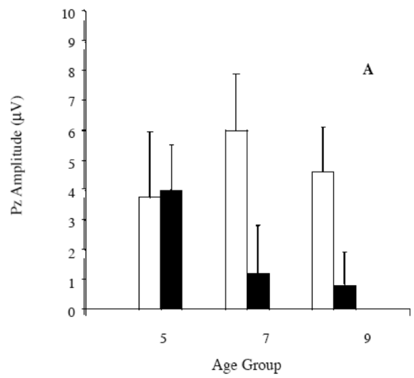


Cherry's results are shown here, percent correct at each age in each of the distracter conditions. Notice that speech backward was the easiest condition and speech forward was the most difficult condition for each age group. Also notice that in each condition, performance improves with age. But although the younger kids do worse overall, they are affected by condition in just the same way as the older kids. This gives us little basis for thinking that it is selective attention per se that is developing here-- if it were, perhaps the youngest kids would have equally difficulty with all the distracters, while the older kids did better with speech backward and white noise than speech forward, for example.



Many studies show that event related potentials-- responses to oddball stimuli or to infrequent target sounds-- change in morphology and latency with age, even through the school years, but it is not generally clear what the functional significance of these changes might be. Performance improves, evoked potential changes, but does that mean that the two are reflecting the same process?

Evidence that selective attention is developing between preschool and school age



There are a few ERP data that suggest that there are qualitative differences in selective attention between preschoolers and older kids. For example, Bartgis et al (2003) recorded P3 responses in children at 5, 7, and 9 years of age. The kids listened to a repeated 300 Hz tone, and every so often a rapid short tone sequence (250-600-250-600-250 Hz, 20 ms each tone, 0 ms ISI) was played. The kids were supposed to push a button when they heard the short tone sequence (which was the sound that a nasty rabbit makes--the child is trying to help them find the rabbit). These sounds were played to both ears; the kids were supposed to only report what was happening in one ear. A nice feature of this study is that the sounds in the two ears weren't temporally aligned (so it wouldn't be hard for the kids to segregate the sounds in the two ears. The P3 response to the rabbit target sound in each ear was recorded, and the amplitudes of the P3 response in the attended ear (white bars) is plotted here with the amplitude of the response in unattended ear (black bars). For the 7 and 9 years olds, they're seeing a big response in the attended ear, and a small response in the unattended ear; for the 5 years olds, there is no difference in the response between ears. This certainly suggests that the youngest kids are not processing the attended ear selectively. And of course, the 5-year-olds don't perform the task as well as the older kids either.

Several studies show small improvements in performance during the school years, but the consensus seems to be that these changes have more to do with being able to inhibit the incorrect response as opposed to selectively processing the stimuli initially.

Conclusions

- Newborn infants orient to sound when they are awake (which isn't often).
- Both infants and young children are immature in their ability to sustain attention to an auditory task, but this has only small effects on their thresholds.
- Infants do not listen selectively to particular frequencies; 5-year-old children can listen selectively in some conditions.
- Selective attention to a sound source improves dramatically during infancy and into the preschool years; it is fairly mature in school-aged children (at least in some conditions).

Next week we will talk about conditions under which children can look really unselective.