Literature Review of the Effects of Multiple Talker Information

on Speech Perception Across the Lifespan

Lindsey M. Mancuso

Louisiana State University

Literature Review of the Effects of Multiple Talker Information

on Speech Perception Across the Lifespan

Speech perception is the process by which sounds of language are heard, interpreted, and understood by the brain. Research in speech perception seeks to understand how listeners recognize speech sounds and use this information to understand spoken language. Current studies of speech perception suggest that a given speech signal contains two pieces of information for the listener: linguistic information and talker information. The linguistic information involves the way sounds are produced as a result of phonetic, prosodic, and semantic characteristics. For instance, /di/ and /du/ audibly share the same phoneme /d/, but the acoustic signal corresponding to the /d/ in both cases differs substantially due to the vowel following the phoneme (Liberman et al., 1967). On the other hand, the talker information involves the way sounds are produced as a result of a particular speaker's vocal tract size and shape, different speaking rates, age, gender, and individual dialect (Mullennix, Pisoni, & Martin, 1988).

Speech perception in terms of the multiple talker environment is not frequently studied. There are a few studies (e.g., Jusczyk, Pisoni, Mullennix, 1992; Magnuson and Nusbaum, 2007; Ryalls ad Pisoni, 1997), but there is not enough clear evidence to suggest the total effects that occur to a listen that is listening to stimuli presented by varying speakers. The research is lacking in terms of the effects of multiple talker environment on the speech perception of a listener. Most of these studies of speech perception of listeners are conducted in a lab setting and are not representative of the everyday speaking and listening environment. In many natural settings, more than one speaker talks to the listener, and this multiple talker scenario is not often accounted for in speech perception studies. Because it is not accounted for, we do not really know the effects multiple talker information can have on a given listener. The second factor

limiting current speech perception is the lack of different age groups studied. Of the few speech

perception studies that examined the effect of multiple talker information on the listener,

generally the studies only looked at infants (Jusczyk, Pisoni, Mullennix, 1992) or college-aged

adults (Magnuson and Nusbaum, 2007.) These studies have presented valuable information in

the field of speech perception involving those specific age groups but fail to paint a full picture

of what is occurring throughout the entire development of a listener in terms of talker specific

speech perception. Because these studies lack to paint the full picture, there is a lack of studies of

the effects of multiple talker information involving the developmental gap between infancy and

adulthood. For example, few studies address the effects seen on toddlers and school-aged

children. A lack of knowledge surrounding this developmental time period makes gaining a

developmental theory of speech perception across the lifespan nearly impossible. Along with

these early developmental gaps, there are also insufficient numbers of studies involving the

elderly. The gap involving older adults must be filled to successfully gain a full understanding of

the processes occurring during a listener's exposure to multiple talker environments throughout

the entire lifespan. The importance of filling these developmental gaps cannot be overstated as a

full understanding of the effects of multiple talker information on listener's speech perception

across the lifespan could potentially have theoretical and clinical implications, such as the way

people with hearing loss are treated. This literature review examines select studies exploring the

effects of multiple talkers on the perception of speech across the lifespan.

Studies of Talker-Specific Speech Perception Across the Lifespan

As previously stated, there is a need for further studies across the lifespan that explore the

effects of multiple talker information on human speech perception. More studies have been

conducted with infants and with young adults than with any other age group, so this review will help to highlight these developmental gaps in the literature.

It is essential to have knowledge of infant speech perception because it is the crucial time period when infants are acquiring language. All other ages following infancy are important to be studied as well because it will help researchers to have a better understanding of the full developmental picture of talker specific speech perception. We cannot make the assumption that speech perception remains stable across the lifespan, so further study is needed.

Infant Studies on Talker Variability

One infant study by Jusczyk, Pisoni, Mullennix (1992) looked at how stimulus variability in speech production would affect 2-month-old infants' speech perception and memory of sounds. In particular, they looked at the affect of multiple talkers on the perception of speech by the infants in terms of discrimination abilities. In their study, the HAS procedure was used to test 72 infants' responses to the contrast between /b/ and /d/ in a single talker condition and in a multiple talker condition. Both groups heard the stimuli /b^g/ or /d^g/, but one group heard the stimuli produced by a single talker and the other group by a set of 3 male and 3 female talkers. The results indicated that the infants in both groups could detect a phonetic change from one utterance to the next, and therefore, perceived a difference in the linguistic information. The infants in the single talker change condition readily detected a change in talker voice during the test phase. These results indicate that infants have the ability to discriminate between voices of the same gender within a single talker environment. However, in the multiple talker change condition, the infants did not display evidence of being able to discriminate a difference between speakers from the habituation to the test phase (Jusczyk et al., 1992). However, these results also suggest that discriminating a group of talkers from a different group of talkers may be too

difficult of a task for the infants to complete. If discrimination between groups of talkers is

difficult for 2-month old infants, then there is a possibility that the speech being perceived by the

infants is being negatively effected by the multiple talker environments. Having to cope with the

difficult task of discriminating between speakers could potentially effect the processing

occurring during the perception of speech. The infant is forced to deal with the extra pieces of

multiple talker information and make adjustments for those different environments.

        Jusczyk et al. attempted to better understand infant's abilities to discriminate between

different speakers by evaluating the time it took the infants to habituate to the phonetic stimuli in

the different conditions. The infants in the multiple talker condition took significantly longer

than the infants in the single talker condition to become habituated to the phonetic stimuli

(Jusczyl et al., 1992). Therefore, these results suggest that the greater the variability in talker

information, the longer the infant's interest will be sustained when listening to the stimuli. The

infants' sustained interest suggests that the variability of information could have affected the

development of the perceptual representation of the sounds the infants heard. The variability of

the speaker presenting the same phonetic stimuli could possibly have effected how the infant

encoded information, thus explaining why it took the infants longer to habituate to the sound.

This information suggests that the infants' speech perception was affected by the multiple talker

information. This study's results are important to understanding the effects of multiple talker

information on speech perception because it provides insight into the way talker information

effects the way infants perceive speech. Because it took the infants longer to habituate to the

stimuli presented in the multiple talker environment and because the previous study

demonstrated infants inability to discriminate between the different speakers, it is possible that

multiple talker information is perceived differently than information in a single talker

environment. This difference could be due to the infant having to compensate for the extra pieces of information contributed by the different talkers. Again, further research is needed before we fully understand the processes of speech perception in terms of multiple talker information's effects on infants.

Another way to examine the effects of multiple talker information on the speech perception of infants is to examine the way other cognitive processes are affected as a result of speech perception. For example, the manner in which speech is perceived could ultimately affect the way information is processed and retained in memory. Intheir second study, Juscyzk et al. also looked at the way the perception of speech in multitalker environments affects infants' memory. The stimuli/ b^g/ or /d^g/ were presented to a group of 60 infants in either a single or multiple talker environment. A two-minute delay period was put between the habituation phase and the postshift phase of the stimuli exposure. Results showed an increase in sucking due to phonetic change for the single talker environment but not for the multiple talker environment during the postshift phase. Results suggest that infants were capable of retaining some information about the given sounds for a period of two minutes because they were able to detect the difference between stimuli played during the habituation and postshift periods in the single talker condition. These results suggest that speech perception was not negatively impacted at all or enough to effectuate the memory of the infants since they were able to detect the difference still. The study also demonstrated infants' inability to successfully retrieve the linguistic informatics frm their memory while in the multiple talker environment. When the infants were exposed to different talkers providing the same linguistic information, they were unable to detect the difference between stimuli. These results could be caused by the infant's perception of speech within the multiple talker environment. The infants had to adjust to the talker variability while perceiving

the sounds and attempt to encode the information to memory. Their success in completing the task within the single talker condition and their unsuccessful completion of the task during the multiple talker condition suggests that multiple talker information hampers the way speech is perceived by infants. The infants in the multiple talker environments performed poorly in comparison to infants in single talker environments on all tasks studied. This information gives some insight into the early development of speech perception in regards to multiple talker environments, but more research must be conducted to further support these claims and to gain an even better understanding of speech perception across the lifespan.

Toddler Studies on Talker Variability

We have a general understanding of the way infants perceive speech from multiple talkers (Jusczyk, Pisoni, & Mullennix 1992) but much less research describes what is happening in toddlerhood. In order to understand the full developmental picture, we cannot skip over this age group, as children of this age group are undergoing continuous language development. One of the only studies that examined the effects of multiple talker information on the speech perception of toddlers is by Ryalls and Pisoni (1997). Specifically, they examined the effects of talker variability on toddler word recognition. The study looked at the detection and discrimination of individual phonemes rather than words. Although the basics of learning language involve these single sounds, everyday speech is presented in words. For this reason, examining word recognition in toddlers is more realistic to the everyday environment stimuli and was more developmentally appropriate for this age group.

In their study, Ryalls ad Pisoni (1997) found that young children's word recognition performance was negatively affected by talker variability. The stimuli consisted of 50 phonetically balanced, monosyllabic words for the children to identify in either a single or

multiple talker condition. Children's word recognition was poorer in the multiple talker

environment in terms of correct identification of words, just as the infant's discrimination skills

were negatively effected in the multiple talker environment. These results show a developmental

trend from infancy to young toddlerhood. This trend shows that both infants and toddlers

performed poorer in term of speech perception tasks in a multiple talker environments than

compared to the single talker environment.

One weakness with this study in terms of using it to understand the developmental picture

of speech perception across the lifespan is that it only looks at word recognition. Word

recognition tasks involve repeating back the word that is presented auditorily and does not

necessarily demonstrate how the child is processing or perceiving the information. It gives some

insight into how speech is being perceived but does not provide the clearest evidence into the

processes that are occurring. Still, more research is needed among this age group in order to

understand the full developmental picture.

Elementary Age Studies on Talker Variability

After conducting research of the available literature, no studies were found involving the

effects of multiple talker information on the speech perception of school-aged children. There is

very little speech perception research involving this age group in general. One study looked at

the speech perception of this age group, but it did not look at the effects of a multiple talker

environment. Metsala, Stavrinos, and Walley (2009) conducted a study that examined the effects

of lexical factors on children's spoken word recognition over the course of a year. The study

looked at a group of first and second graders and a group of third and fourth graders and found

that the older children made more improvements in terms of word repetition than the younger

aged children across the year. Other results indicated that all the children identified the words

with less input as the year progressed. Although this study did not involve a multiple talker

condition, the study is one of the few that examine speech perception in school-aged children.

The results suggest that children's speech perception processes improve with age, and this is

congruent with the toddler study by Ryalls & Pisoni (1992) that showed the older toddlers

completing the speech perception task more successfully than the younger toddlers. Because the

older children in the Metsala et al. (2009) study made more improvements in terms of word

repetition when compared to the younger children, this could suggest that with age, people learn

to adjust for differing listening environments and can improve their perception of the speech in

those environments. Again, there is no research on the effects of multiple talker information on

this age group, so none of this information can be used to fill the developmental gap that exists in

terms of the effects of multiple talker information on speech perception. In order to have a full

understanding of the development of speech perception throughout the lifespan, studies must be

conducted with all age groups. There is also a gap in the time period from school-aged children

to early adulthood. The age group of adolescence is not one examined in terms of multiple talker

information and its effect on speech perception. Again, in order to improve the theory of speech

perception, we need to know the whole developmental lifespan of speech perception processes.

We do not age from toddlerhood to early adulthood so finding out what happens in this age gap

could provide new information in the field of speech perception.

Adult Studies on Talker Variability

Majority of the studies that examine the effects of multiple talker information on adults'

speech perception involve the young adult population. Knowledge of speech perception abilities

during this point of is not limited to the ages of 18 to 25 years. There are middle aged and older

adults that could be looked at as well. Either way, studies of talker specific speech perception

with the adult population should be further studied because the results would tell us how multiple

taker information affects the understanding of a speech signal for this age group.

A study done by Magnuson and Nusbaum (2007) looked at a group of 23 college students

and the effects that talker variability had on their perception of speech. The adults were put into

different groups, some heard either a single male or female talker, and other groups heard stimuli

that consisted of a group of two females, two males, or a male and a female. The stimuli

consisted of the vowels /i/, /I/, /a/, /æ/, /U/, and /u/. Results showed a higher amount of correct

responses in the single talker condition than in the multiple talker condition. There was also more

"false alarms" and slower response times in the multiple talker condition compared to the single

talker condition (Magnuson & Nusbaum). These results suggested that with each changing

speaker, contextual tuning had to be restarted for the listener and this process slowed the

recognition process. As per these results, adults' reaction times to the tests were much slower

when the stimuli had been presented in an environment with more than one speaker alternating

speaking roles. Accuracy on the tests was decreased, as well, as compared to in the single talker

environment. These results demonstrated that perception is effected when stimuli is presented by

multiple talkers. The adults performed slower and with less accuracy in the multiple talker

condition. These results are congruent with the findings of other multiple talker studies

conducted on other age groups. Infants and toddlers both performed better on speech perception

tasks in single talker environments rather than in the multiple talker environments. These

findings suggest that it is more difficult for the listener to deal with multiple talker information as

compared to single talker information, regardless of age. These findings can be applied to the

understanding of speech perception across the lifespan because all the age groups from infancy

to adulthood exhibited similar speech perception skills when comparing the single talker to the

multiple talker environment. No matter what age, people tend to perform better in terms of speech perception tasks when information is presented in a single versus a multiple talker environment.

Another study that looks at speech perception in regards to multiple talker environments is Sommers and Barcroft (2006). This study was done with 60 young adult participants who were split up into single and multiple talker groups, but within those groups, different speaking styles were used. These styles included: normal voice, whisper, nasalization, excited tone, childlike intonation, and elongated speech. During the study, the participants were exposed to a set of words chosen from a list of 144 highly familiar monosyllabic words. The participants had to identify the words during the task. A given participant received one set of words in the single speaking style condition and one set of words in the multiple speaking style condition. The study found that similar to talker variability, speaking style variability also reduced identification performance relative to the single talker condition. These results strengthened the argument made by previous studies (Sommers, 1996; Luce & Pisoni, 1998), that accommodating for varying sources of variability, such as multiple talker information, has an affect on the perception of important acoustic features of speech for adults. From the single talker condition to the multiple talker condition, there was a significant decrease in spoken word identification and speech perception, and the pattern was consistent across all 6 different speaking styles. These results can be applied to the knowledge of speech perception development across the lifespan, as it provides further evidence of the processes occurring during the age of early adulthood.

In another study, Goldinger, Pisoni, and Logan (1991) looked at multiple talker environments and its effect on adults' memory capabilities. They conducted the study with 160 college students. The subjects heard a list of words produced by either one speaker or a group of

alternating speakers and had to repeat back the list of words in the same exact order. Words from the single talker lists were recalled more accurately than words in the other condition. The results suggest that multiple talker information has a perceptual consequence for the listener. As variability in talker occurs, the listener's processing resources are reduced and thus effect the listener's rehearsal of items. This information is important because it gives us more information about the processes that may be occurring during the perception of speech in multiple talker environments for this age group. Further research is needed within this age group and with older aged adults to develop the full picture of speech perception development across the lifespan.

A study by Yonan and Sommer (2000) examined the ability of various age groups to use talker information as an aid for spoken word identification. Participants identified novel words spoken by familiar and unfamiliar talkers, and results showed that memory of talkers' voices were significantly lower in older than in younger listeners. These findings suggest that speech perception is definitely effects in terms of age, but we need to do more research to find out why.

There are few studies involving the effect of multiple talker information on the speech perception of elderly adults. At this age, there are general declines in the system. Hearing and brain function may begin to deteriorate, so knowledge of speech perception abilities during this age could enable the best rehabilitation services to be provided to this age group. Also, knowledge about this age group would fill the developmental gap missing and make the theories of speech perception more applicable to the entire developmental lifespan and not just particular groups.

Filling the Developmental Gap

Future Directions

Clinical implications. There is a gap in the literature in terms of the effect of multiple talker information on listeners across the lifespan. Why is it so important to fill this developmental gap? It is crucial to develop a better understanding of speech perception trends across the lifespan and to have a better understanding of how people are learning, processing, and storing language. Clinical applications could be implemented in terms of second language learners or to establish evidence-based practice listening techniques for toddlers with hearing losses. If we had a better understanding of the processing occurring during perception of speech for specific ages in terms of normal development, then we would have a better idea of how to deal with abnormal development. Second language users could be taught in a more sufficient way if we knew the best way and environment for information to be perceived. Children with hearing loss could receive better therapy services for those same reasons. Once we have an understanding of development of speech perception across the lifespan in terms of what is normal, better aid can be given to those with abnormal development. It is crucial to learn what speech perception processes occur for people in order to develop the best techniques to educate and provide intervention to those who struggle with speech perception.

The aforementioned studies all indicate that interesting trends occur between infancy and adulthood. It is known that multiple talkers affect retrieval speed for linguistic information in both adults and infants (Jusczyl et al., 1992). When both the infants and adults were placed in discrimination tasks, reaction time was relatively longer for groups exposed to multiple talker information than the groups who heard the stimuli given by one person. This information demonstrates that some important developmental processes occur in terms of speech perception in between the infancy and adult stage, and this information gives way to clinical applications. If both groups were able to retrieve the information at about the same speed, this suggests that

adults and infants are using similar speech perception processes. With this known information, new clinical practices can be implemented to better serve the speech perception of those particular age groups.

Another study suggests the clinical implications of filling this developmental gap. Barcroft, Sommers, Tye-Murray, Mauze, Schroy, and Spehar (2011) examined the way knowledge of speech perception could be applied to the clinical setting. A group of 69 adults were trained using either single or multiple talkers to determine which method of auditory training would lead to the most transfer-appropriate gains. The objective of the study was to develop evidence to support auditory training programs that would best meet patients' expectations of benefit and to provide benefit in specific situations that patients most wanted to improve their understanding of spoken communication (Barcroft et al.). Results showed that participants in the multiple talker group scored slightly worse than the single talker group prior to any auditory training; however, after training, the multiple talker group scored higher. These results indicated that participants who received auditory training from only one talker improved their discrimination of the talker's speech more so than participants who had been trained by more than one speaker. The results also suggested that people trained in the multiple talker group would be able to improve their discrimination of multiple talker speech and that the single talker group would not have improved discrimination in an environment with more than one speaker. Both of these results propose that it is possible to tailor auditory training to meet an individual's needs (Barcroft et al.). Being trained in a particular environment improves performance in that particular environment; however, more information is needed on which method of training would be most beneficial in general for people. This knowledge will only come once the entire developmental lifespan of speech perception has been studied and is further understood.

Another study by Tye-Murray, Sommers, Mauze, Schroy, Barcroft, and Spehar, (2012) looked at patient-based evaluations of perceived benefits of auditory training programs with single or multiple talkers providing training. On average, both groups of adults reported enjoyment in the auditory training program, and high enjoyment rates are a predictor of high compliance and completion rates. There was no major difference between both groups' opinions of the auditory training, but the general consensus was that both were helpful and on average seemed to make the patient relatively confident (Tye-Murray et al.). This study varied from other studies that have thus been looked at because no general trend was found when comparing both talking environments. The study did show benefits of aural rehabilitation techniques on patients' personal view of self and self-efficiency, though. Because there is not a lot of evidence to support which technique is the most beneficial for adults or for any other age group for that matter, further studies must be conducted across the lifespan. With more knowledge of trends seen across the lifespan in terms of speech perception, more effective clinical techniques can be used to help clients.

Theoretical implications. As new information is gathered involving the effects of multiple talker information on the speech perception of listeners across the lifespan, new theoretical implications are likely to occur. All of the current studies indicate that people, regardless of age, perform better on speech perception tasks in single talker environments rather than multiple talker environments. This general trend, although not supported by evidence from all age groups, could be applied to many speech perception theories to help strengthen the argument that they make. For example, the general auditory approach claims that listeners perceive the acoustic signal itself rather than using the speakers' vocal tract gestures to perceive speech like in the direct realist approach (Viswanathan, Magnuson, & Fowler, 2010). The general trend, discussed

earlier, relates back to these theories and supports what they propose. In terms of the general auditory approach, the listeners in the single talker environment were able to focus on one acoustic signal and therefore performed better than the listeners in the multiple talker environment. Also, the studies discussed were all conducted in a lab with computer generated speech or speech played through a microphone, so no visual cues were able to be used during the studies. The lack of visual cues available makes relating this general trend back to the direct realist approach difficult. In future studies, if actual speakers were to speak to the listeners in single or multiple talker environments, then it would be obvious if visual cues were being used to aid in the perception of speech in varying environments.

Conclusion

All of the literature reviewed within this document suggests that multiple talker environments have some kind of impact on the speech perception of listeners. There is a developmental gap that needs to be filled in order to gain a full understanding of the processes of speech perception occurring throughout the lifespan. People, regardless of age, listen to linguistic information in multiple talker environments, so it is crucial to know what processes are occurring during their spoken language processing. The effects of multiple talker information on speech perception across the lifespan needs to be further studied in order to develop the most beneficial techniques for clinical implications and to improve speech perception theories. The studies of the effects of a multiple talker environment on the speech perception of all age groups is only beginning, and much more is needed in order to fill the developmental gap that still exists.

References

Barcroft, J., Sommers, M. S., Tye-Murray, N., Mauze, E., Schroy, C., & Spehar, B. (2011).

> Tailoring auditory training to patient needs with single and multiple talkers: transfer-

> appropriate gains on a four-choice discrimination test. *International Journal of Audiology*

> 802-808. doi: 10.3109/149920227.2011.599868

Goldinger, S. D., Pisoni, D. B., & Logan, J. S. (1991). On the nature of talker variability effects

> on recall of spoken word lists. *Journal of Experimental Psychology, 17*(1), 152-162.

Jusczyk, P. W., Pisoni, D. B., & Mullennix, J. (1992). Some consequences of stimulus variability

> on speech processing by 2-month-old infants. *Cognition 43*, 253-291.

Liberman, A. M., Cooper, F. S., Shankweiler, D. P., & Studdert-Kennedy, M. (1967). Perception

> of the speech code. *Psychological Review*, 74(6), 431-461.

Luce, P. A., & Pisoni, D. B. (1998). Recognizing spoken words: The neighborhood activation

> model. *Ear Hear*, 19, 1–36. 7

Magnuson, J. S., & Nusbaum, H. C. (2007). Acoustic differences, listener expectations, and the

> perceptual accommodation of talker variability. *Journal of Experimental Psychology,*

> *33*(2), 391-409. doi: 10.1037/0096-1523.33.2.391

Metsala, J. L., Stavrinos, D., & Walley, A. C. (2009). Children's spoken word recognition and

> contributions to phonological awareness and nonword repetition: A 1-year follow-up.

> *Applied Psycholinguistics, 30*(1), 101-121. doi:10.1017/S014271640809005X

Ryalls, B. O., & Pisoni, D. B. (1997). The effect of talker variability on word recognition in

> preschool children. *American Psychological Association, 33*, 441-452.

Sommers, M. S. (1996). The structural organization of the mental lexicon and its contribution to

age-related changes in spoken word recognition. *Psychological Aging, 11,* 333–341.

Sommers, M. S., & Barcroft, J. (2006). Stimulus variability and the phonetic relevance

hypothesis: effects of variability in speaking style, fundamental frequency, and speaking

rate on spoken word identification. *American Institute of Physics, 119*(4), 2406-2416.

Tye-Murray, N., Sommers, M. S., Mauze, E., Schroy, C., Barcroft, J., & Spehar, B. (2012).

Using patient perceptions of relative benefit and enjoyment to assess auditory training

American Academy of Audiology, 23(8), 623-624.

Viswanathan, N., Magnuson, J., & Fowler, C. (2010). Compensation for coarticulation:

disentangling auditory and gestural theories of perception of coarticulatory effects in

speech. *Journal Of Experimental Psychology: Human Perception And Performance,*

36(4), 1005-1015.

Yonan, C. A. & Sommers, M. S. (2000). The effects of talker familiarly on spoken word

identification in younger and older listeners. *Psychology and Aging,* 15(1), 88-99. doi:

10.1037/0882-7974.15.1.88.