Factors associated with rapid auditory processing in 6-month-olds: Risks and potential buffering factors

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Abstract

Deficits in the ability to process two or more rapidly presented, successive, auditory stimuli (rapid auditory processing, RAP) are associated with later language acquisition delay and to family history of developmental learning disorders (Choudhury, Leppanen, Leavers, & Benasich, 2007). Maternal depression (Kaplan, Bachorowski & Strouse, 1999) and exposure to ambient noise and household chaos, including television (e.g., Wachs, 1986), have also been associated with poor language acquisition. The present study measured rapid auditory processing in 78 6- to 9-month-old infants living in low-income families. Primary caregivers completed the CES-D depression scale, a family history questionnaire, a household density measure, the IT-Home, and a questionnaire on the patterns of household media use. Infants participated in auditory-visual (AV) habituation and recognition memory tasks to index RAP abilities. A preliminary linear regression analysis simultaneously entering total IT-HOME, family history of language impairment, household density, and child’s minutes of daily media exposure was significant when 70ms novelty preference score was the outcome variable, $R^2 = 0.21$, $F(4, 77) = 4.78$, $p < .01$. Regression findings suggest that exposure to background noise early in development from multiple sources, including other people and possibly even television may enhance early perceptual discrimination. Further, replicating the findings of previous studies, infants with a family history of language impairment may be at risk for future language delays. These results have important implications for predicting later language deficits and outcomes.
Introduction

Between 6 and 8 million people in the United States have some type of language impairment (NIDCD, 2010). Further, it is estimated that the prevalence rate of Specific Language Impairment (SLI) among 5-year old children is 7.42% (Tomblin, Smith, & Zhang, 1997). With the growing need to diagnose and treat language disorders, empirical measures have been developed to assess language development at an early age. One such measure is the Rapid Auditory Processing Test (e.g., Benasich and Leevers, 2002), which has been demonstrated to be a stronger predictor of later language outcome than other tests, such as a two-alternative forced-choice head turn task and a go-no-go procedure, that use similar cognitive processes (Benasich and Leevers, 2002).

Rapid Auditory Processing Test

The RAP test is an auditory-visual habituation task in which infants are familiarized to two tones—70 ms apart and 300 ms apart, depending on the test, while a picture is displayed on a screen. After the child is habituated to the tones, where habituation is defined as looking times on the last two trials that are 50% of looking time on the first two trials, a novel tone is introduced with the same picture displayed. At test, novelty preference indicates that the infant is able to discriminate between the two tones. Previous research has indicated that the RAP test with the tones 70 ms apart (RAP-70), but not the RAP-300 at 6- to 9-months of age, is an indicator of future language development. For example, event related potentials 70 ms were correlated with language outcome at 24 months; but performance on the RAP 300ms test was not predictive (Benasich, Choudhury, Friedman, Realpe-Bonilla, Chojnowska, & Gou, 2006; Benasich, Thomas, Choudhury, & Leppanen, 2002).
Relation between RAP and Family History of Language Impairment

Children who have an immediate family member who has a language impairment (FH+), are 4 times more likely than children without a history of language impairment (FH-) to develop language impairments (Benasich et al., 2002). In experiments comparing children with a family history of SLI and those without, RAP at 7.5 months was the best predictor of language outcome at 24 months (Benasich & Tallal, 2002) and 36 months (Benasich & Leevers, 2002) for both the FH+ and FH- control groups. ERP findings indicated that FH+ group responded much slower than the FH- group on the RAP 70ms test trials (Benasich, Choudhury, Friedman, Realpe-Bonilla, Chojnowska, & Gou, 2006).

Finally, the procedures from previous studies using the RAP and individuals with family history of SLI were applied to a study with 6-month-old infants who had an immediate family member with an autoimmune disorder based on the previous research indicating that a high prevalence of language-based learning disorders are found in those with autoimmune disorders and vice versa (Benasich, 2002). Findings suggested a relationship between RAP performance, family history of autoimmune disease, and language outcome at twenty-four months (Benasich, 2002). Thus, studies have demonstrated that the RAP test can be used to identify individuals, whether with a family history of SLI or autoimmune disorder or not, who will have language acquisition delays later in childhood. Specifically, studies involving the RAP test have shown that RAP scores during infancy were related to receptive and expressive language at both 16 and 24 months (Benasich & Leevers, 2002) and information processing at 16 months (Benasich, 2002). However, the RAP has not been used to identify language outcome in any other groups at risk for language delays besides those with a family medical history. A group that is especially at risk for language development delays is children growing up in poverty.
**Poverty and developmental delays**

In 2007, twenty-one percent of U.S. infants and toddlers were classified as poor (i.e., less than 100% of the federal poverty level) and 23% were classified as low-income (i.e., 100 to 200% of the federal poverty level); one child in three spends at least one year in poverty over his or her lifetime; and for more than 5% of children, poverty is chronic (i.e., lasts 10 or more years). Further, children who live in poverty, and are from culturally or linguistically diverse families, are especially at risk. Sixty-four percent of Latino infants and toddlers and 65% of African American infants and toddlers live in low-income families compared with just 31% of European American infants and toddlers (NCCP, 2007). Experiencing poverty in early childhood compared with experiencing poverty when 6 years or older is particularly detrimental due to the early and lasting negative impact on brain development (Shonkoff & Phillips, 2000).

Furthermore, children who are living in poverty are 1.3 times more likely to experience learning disabilities and developmental delays (Brooks-Gunn & Duncan, 1997; NCCP, 2007) and more likely to experience attention and emotion regulation difficulties (including ADHD), partly due to high levels of environmental noise (including media) and low levels of parent-child interaction. Moreover, children living in poverty often experience multiple biological and environmental risks (e.g., low birth weight, maternal depression, environmental toxins such as lead paint, impoverished home environments). Poverty has also been linked to lower cognitive skills (Duncan, Klebanov, & Brooks-Gunn, 1994; Korenman, Miller, & Sjaastad, 1995), language deficits (Hart & Risley, 1995; Walker, Greenwood, Hart & Carta, 1994), behavioral problems (McLeod & Shanahan, 1993), poor physical health (Klerman, 1991; Miller & Korenman, 1994), erratic or inattentive parenting (Halpern, 1993), and child abuse and neglect (Halpern, 2000).
By three years of age, poor children have vocabularies half the size of their more advantaged peers (Hart & Risley, 1995). While these early gaps may seem relatively small, there is substantial evidence that they are persistent, resistant to intervention, and widening as children progress through formal schooling. Walker and colleagues found that early language deficits linked to family socioeconomic status (SES) at age 3 predicted language development, verbal ability, and academic achievement throughout the early elementary school years (Walker et al., 1994). Over time, those children who lack cumulative high-quality language and literacy experiences continue to progressively decline while those children with more and positive early language and literacy experiences progressively improve, resulting in an ever-widening gap (i.e., Matthew effect; Stanovich, 1986). A recent Society for Research in Child Development (SRCD) Social Policy Report (Garcia and Jensen, 2009) for example, indicates that Hispanic youth, in particular, lag behind Whites and Asian Americans at all reading proficiency levels from Pre-K to 12th grade.

As the number of risk factors increases, the likelihood of poor developmental outcomes also increases. While most children cannot entirely escape factors considered to place them at-risk for poor developmental outcomes, it is generally believed that children can adequately cope with experiencing one or two factors (Garbarino, 1992; Sameroff, Seifer, Barocas, Zax, & Greenspan, 1987). However, infants that live in poverty have multiple risk factors that put them at risk for developmental language delays and impairment.

*Other risk factors for poor language acquisition*

There are many hypotheses as to why children who live in poverty are more at risk for developmental delays. Researchers posit that a high level of chaos is present in the lives of those who live in poverty. It is thought that chaos acts as a mediator between poverty and child
development, with other factors such as child temperament, age, and length of time spent in poverty contributing to the relationship (Wachs, 2010; Wachs and Evans, 2010). Using Bronfenbrenner’s bioecological theory, Wachs (2010) defines chaos, at the microsystem level, as high levels of household density and noise, high flow of people moving in and out of child’s home, and lack of stable daily routines. Applying Brofenbrenner’s theory further, Wachs and Evans (2010) theorize that chaos affects development by interfering in the proximal processes, or “the exchanges of energy between the developing organism and the persons, objects, and symbols in the immediate environment of the organism” (8) that are necessary for an organism’s development (Bronfenbrenner, 1999; Bronfenbrenner & Morris, 1998). Although research on how chaos affects the proximal processes is inconclusive, previous studies suggest that a parent’s responsiveness to infant, parental conflict, and parental emotional reactivity are mediators in the relationship between child development and chaos (Evans, Maxwell, & Hart, 1999; Evans et al., 1989; Valiente, Lemery-Chalfant, & Reisner, 2007).

However, chaos may not be completely detrimental to a normal pathway of development. As Uzgiris (1977) hypothesized in her optimal stimulation hypothesis, the relationship between stimulation and development can be shown with an inverted U curve. In other words, there is an optimal level of stimulation that is beneficial to development, and too little or too much stimulation can interfere with development. Moreover, chaos within the household, specifically greater household density, may have its advantages (Wachs and Corapci, 2003; Weisner, 2010). In non-European cultures, chaos as defined in European terms is a necessary part of life; for example, in some cultures, everyone in the family sleeps in the same room and it would be odd to put a child in his/her own room to sleep (Weisner, 2010). Since minority children are more likely to live in poverty and be exposed to higher levels of chaos as defined in European terms, it
is advantageous to take into account cultural differences when assessing chaos and its effects (Lichter and Wethington, 2010).

Additionally, although the American Academy of Pediatrics (2001) advises that children under 2 years of age should not be exposed to any television, previous research has shown that infants from low-income families are especially at risk for viewing television before this advised age. Further, these infants are not only exposed to television programs that are oriented toward children; they are present during adult-directed television as well. In an intervention study conducted by Mendelsohn, Berkule, Tomopoulos, Tamis-LeMonda, Huberman, Alvir, and Dreyer (2008) on infant television exposure in low SES households, results indicated that parents interacted with their children the most when they co-viewed television shows with educational child-directed content. In addition, the researchers found that about half of the media that infants were exposed to was not directed towards children. However, recent research suggests that television shows oriented toward children may actually help language acquisition in infants.

In a study exploring the association with type and amount of media exposure with toddler and infant communicative abilities, Linebarger and Walker (2005) found that viewing of *Arthur, Clifford, Blue’s Clues, and Dora the Explorer* was associated positively with language growth and viewing of *Blue’s Clues and Dora the Explorer, Arthur and Clifford*, and *Dragon Tales* was indicative of single and multiple word utterances at thirty months of age. The researchers hypothesized that such positive effects were found because these child-oriented programs elicited infant interaction, simulating the interactions that would usually occur between parent and child.

Finally, living in poverty is also associated with higher rates of maternal depression. In a study conducted by Vericker, Macomber, and Golder (2010), it was discovered that more than
half of parents who live in poverty have some form of depression. Additionally, 11% of infants living in poverty have a mother who is severely depressed. Maternal depression greatly affects the relationship between mother and child, especially since the first few years of life are a critical period for child development. Furthermore, previous research has shown that depressed mothers are more likely to use media as a source of entertainment for their children. Infants with depressed mothers are exposed to more television, specifically child-oriented television, during the weekdays (Bank, Calvert, Parrott, McDonough & Rosenblum, in press). Therefore, the compounded effect of living in poverty and living with a mother who is depressed increases the probability that these infants may be exposed to higher rates of media, whether adult-directed or without parent-child interaction.

Present Study

Using the RAP test as an indicator of language abilities and potential language acquisition problems, this study aimed to investigate the risk factors to language development associated with living in poverty and their links to RAP performance. Thus, we hypothesized that greater levels of household density, overall chaos, maternal depression, and media exposure would be negatively related to infant’s performance on the RAP test. Further, based on previous research conducted with the RAP test, we posited that family history of language impairment would also be negatively associated with RAP performance.

Methods

Eligibility

Prior to enrollment, participants were screened for low socioeconomic status (LSES) defined as annual income that is no more than 185% of the federal poverty threshold (FPT). For example, for a family of 4, the poverty line was an annual income of $21,000 and the family could earn no more than $38,850. Participating parents were at least 18 years of age for consent
purposes and all parents who participated in the program gave consent for their child to watch screen media at 6 months of age and exposure to a computer at 2 years of age.

**Exclusion Criteria**

In addition to the income requirements, infants were ineligible if they were diagnosed with or have a significant predisposition for certain low-incidence disabilities resulting from extreme pre-maturity (at least 8 weeks early), hemorrhagic disease, fetal alcohol exposure, or chromosomal abnormalities (e.g., Down Syndrome). Enrollment was limited to infants without any known visual or hearing impairments due to the characteristics of media and the demands of our measures. Low English Proficient (LEP) families’ other language was Spanish due to availability of alternate assessments and staff resources. Infants with speech or language delays, learning disabilities, and other high-incidence disabilities were not excluded.

**Participants**

In total, 127 infants and families were recruited into the study on a rolling basis when their infants were 6 months of age. They were recruited through a combination of flyers, radio commercials, community centers, Women and Children (WIC) clinics and word of mouth. Samples were drawn from low-income areas in Philadelphia, PA, and Washington DC. Based on the targeted areas, the Philadelphia sample was primarily LSES African American and the Washington, DC (Columbia Heights) sample was primarily LSES LEP Hispanics.

**Participant demographics**

Of the 127 eligible participants 110 participated in the RAP session. Participants who completed the RAP and were included in the analysis were 78 6- to 9-month-old children (\(M = 7\) months 17 days, \(SD = 32\) days) and their primary caregivers predominantly mothers (1 fathers and 4 were not reported; \(M\) age = 25.48 years, \(SD = 6.19\) years). The primary caregivers were
married \((n = 16)\), living with a significant other \((n = 48)\), single not married \((n = 56)\), or separated/divorced \((n = 2)\), and not reported \((n = 4)\). Of the 78 dyads, 45 lived in Philadelphia and the other 33 lived in a Washington DC. Caregiver’s education was on average at the GED level \((M = 12.01\) years, \(SD = 2.41)\) and monthly household income was reported as $1740 \((SD = $1356)\). Primary caregivers were African-American \((n = 51)\), Hispanic \((n = 20)\), mixed or other races \((n = 4)\) and not reported \((n = 3)\). Primary language spoken in the household was English \((n = 53)\) or Spanish \((n = 25)\). For missing maternal education, mean values (calculated by location) were substituted.

Ten participants were ineligible because their adjusted age was less than 6 months at the time of testing. An additional 8 were excluded because their caregivers cued during the test as indexed by speaking pointing or otherwise directing the infant toward the apparatus or 2 for technical problems during testing and finally 2 infants who did not complete the testing procedure due to fussiness.

**Materials**

**Questionnaires**

At 6 months, the primary caregiver of each infant was given several questionnaires in order to obtain a better picture of the child’s everyday life. In order to assess media exposure, each parent filled out a Media Questionnaire containing 29 questions. The Media Questionnaire provided information about the television shows viewed by the infants, hours of exposure to different types of media, parent attitudes towards media exposure, and media use in childcare settings. The average number of hours each infant spent per day was calculated using this measure. Each caregiver was also given a survey in order to obtain information about family history of language difficulties or impairments and the child’s history of ear infection.
In addition, parents were given questionnaires in order to obtain demographic information of the families involved in the study. For the purposes of this study, the Parental Demographics Questionnaire (PIB) assessed the Social Economic Status (SES) of each family, household density, and education level of the primary caregiver. Average household density was calculated by dividing number of rooms in the home by number of people residing in the home at 6 months. Three observer ratings from the Post-Visit Inventory (Dodge, Pettit, & Bates, 1994) assessing levels of home visit preparation, household cleanliness, and neighborhood noise were also included to measure chaos within the household. Each primary caregiver was given a questionnaire, the *Center for Epidemiologic Studies Depression* (CES-D), in order to assess levels of depression (Radloff, 1977). The CES-D consisted of 20 questions, assessing symptoms of depression over the week previous to filling out the questionnaire.

Finally, *The Home Observation for Measurement of the Environment-Infant Toddler Version* (HOME-IT; Caldwell & Bradley, 1984) was obtained during the first session. This measure was designed to assess the quality and quantity of stimulation and support available to a child in the home through a 45-90 minute visit when the parent and child are home and awake. The focus of the 45-item observation and interview measure was on the child in the environment as a recipient of inputs from objects, events, and transactions occurring in connection with the family surroundings. The IT-HOME was conducted in the home to assess parental responsiveness (11 items), acceptance of child (8 items), organization of the environment (6 items), learning materials (9 items), parental involvement (6 items), and variety in experience (5 items). A binary-choice (yes/no) format was used in scoring items. The alpha coefficients for the total scores were all above .90.
Procedure

At 6 months, the data was collected over a total of four visits, one of the visits during which a phone time use diary was collected is not discussed further. Visits were scheduled for a period of the day when babies were judged by their parents to be awake and alert scheduled well before they actually took place and participants were given reminder calls before each visit. During session 1, after informed consent was obtained, the Parental Demographics Questionnaire and CHAOS measure were administered to each parent. The primary caregiver in the presence of the researchers filled out these measures. Researchers also filled out the IT-HOME during this session. At session 2, another at-home visit, the Media Questionnaire was given to the caregiver of each infant. Again, the researchers were present while the survey was administered. For the fourth six months session, families were brought into the laboratory. At this session, the RAP was administered and parents were given the CES-D and the Family History questionnaire to fill out in the presence of the researchers.

Rapid Auditory Processing Task

The procedure developed by Choudhury, Leppanen, Leevers, and Benasich (2007) for the Rapid Auditory task was replicated. During session four, the RAP task was administered to the infants. Infants were either seated in the laps of their caregiver or in a highchair during these tasks. During the RAP task, visual stimuli were paired with auditory stimuli. In both tasks, all tone-pairs were 400-600 Hz complex tones. In one task, each infant was habituated to a set of complex tones presented with a black and white starburst on the screen. In this task, tone pairs were separated by a period of 70 ms. In the second task, tone pairs were presented with another abstract black and white picture and the tone pairs were separated by a period of 300 ms.
Each trial began and ended with a picture of a woman’s face, as a stimulus to acquire a baseline for looking time. The infant was seated approximately 30 inches away from the television screen. Before each task began, a light was used to draw the infant’s attention to the screen. A video camera placed above the screen recorded the infant’s face during the entire task. During the task, the recording was transmitted to a computer in the adjacent room, where a researcher watched and coded the looking patterns of the child.

Each task consisted of a pre-test, habituation, test, and post-test. The same stimulus was shown for 10 seconds during the pre-test and post-test. During the habituation trial, tone pairs were presented based on each infant’s looking time. To count looking time, the infant had to look at the screen for a minimum of 300 ms. The look was considered to be over when the infant looked away from the screen for 1.5 sec. or more. The mean looking times of the first two trials in the habituation phase was considered the baseline and set at 100%. The habituation phase was
terminated when the mean of the last two looking times was less than or equal to 50% of the baseline.

The test trial followed the habituation phase. In this trial, habituation stimuli were paired with novel stimuli in a counterbalanced form. The same visual stimulus was used throughout. Each stimuli pair lasted for 10 seconds. The presentation order of the stimuli pairs was Novel, Familiar, Familiar, and Novel. Each trial lasted 8 sec, in which each tone pair was presented six times.

Reliability for coding infant looking times on the RAP test between 3 coders, 2 from Georgetown University and 1 from the University of Pennsylvania, ranged from 81% to 94% within one second of each other.

**Results**

As the descriptive statistics in Table 1 demonstrate, the average novelty preference scores for both the RAP-70 and RAP-300 test phases exceeded chance levels of 50%. A significant novelty preference (e.g., 54% or higher) for 70ms and 300ms test trials represents the infant’s ability to discriminate between two auditory stimuli. On the RAP-70, 47% of participants (N=45) scored lower than the novelty preference criterion of 54%. Family history of language impairment was indicated by 14% of the sample. The average hours of television watched per day was just over an hour. As indicated from the high average IT-HOME and CHAOS scores, the home environment overall was stable and stimulating for the infants. Household density varied by participant, but the average suggests that the houses these infants live in are not densely populated. Finally, the CESD scores of the primary caregiver varied by participant, thus some caregivers were more at risk for depression than others.
We conducted bivariate correlations between the predictor and outcome variables. As indicated in Table 2, many of the variables correlated as would be expected. For example, monthly income was positively associated with years of education and score on the IT-HOME. The primary caregiver’s age was positively related to level of education, monthly income, number of siblings for the infant, and cohabitation with a significant other. For the cohabitation measure, whether the primary caregiver was married or not married, but living with a significant other was collapsed into one category and compared to not living with a significant other. The primary caregiver’s education level was negatively associated with household density. Also, household density was negatively associated with primary caregiver’s level of education. Interestingly, a positive relationship was found between family history of language impairment and score on the CESD. A significant correlation was found between number of siblings the
infant had and family history of language impairment as well. In addition, speaking Spanish was associated with total IT-HOME score, years of education of the primary caregiver, number of ear infections, and sex.

Furthermore, the novelty preference score for the RAP-70 was associated with demographic variables, but the RAP-300 novelty preference score was not related to any of the variables. Findings confirmed the results of previous research that history of family language impairment is negatively correlated with performance on the RAP-70 (Benasich & Tallal, 2002; Choudhury, Leppanen, Leevers & Benasich, 2007). A statistically significant correlation was also found between RAP-70 and number of siblings. Contrary to what was expected, score on the RAP-70 was positively associated with household density and hours of television exposure per day. Thus, the more people in the house and the more television viewed, the better the performance on the RAP-70.
Table 2. First order correlations between predictor and outcome variable

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<th>RAP-300 ms</th>
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<th>Ear Infection</th>
<th>CESD</th>
<th>Education</th>
<th>FH+/FH-</th>
<th>Sex</th>
<th>IT-HOME</th>
<th>Language</th>
<th>Siblings</th>
<th>Cohabit</th>
<th>Monthly Income</th>
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<td>-.09</td>
<td>.10</td>
<td>.11</td>
<td>.30**</td>
<td>.26*</td>
<td>.02</td>
<td>.12</td>
<td>0.22*</td>
<td>0.47**</td>
<td>0.35**</td>
<td>0.43**</td>
</tr>
</tbody>
</table>
† $p < 0.10$, * $p < 0.05$, ** $p < 0.01$
A linear regression analysis simultaneously entering household density, total TV minutes per day, Family History of Language Impairment, and Total IT-HOME score was statistically significant when the novelty preference score on the RAP-70 was the outcome variable, \( R^2 = 0.21, F(4, 77) = 4.78, p < .01 \). As shown in Table 3, household density and total TV minutes per day were associated with high novelty preference score on the RAP-70. Finally, family history of language impairment was related to a poor novelty preference score on the RAP-70. Just to ensure that the first order correlation pattern was correct we conducted the same linear regression with novelty preference for 300ms and habituation slope and neither regression was significant, \( R^2 = 0.01, F(4, 73) = 0.11, p > .1 \).

**Table 3.** Final Regression Model for Variables Predicting Novelty Preference at 70 ms Test

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Density</td>
<td>3.80</td>
<td>1.30</td>
</tr>
<tr>
<td>TV/Day (mins)</td>
<td>.02</td>
<td>.01</td>
</tr>
<tr>
<td>FH+/FH-</td>
<td>-5.33</td>
<td>2.49</td>
</tr>
<tr>
<td>IT-HOME</td>
<td>.28</td>
<td>.18</td>
</tr>
</tbody>
</table>

† \( p < 0.10 \), * \( p < 0.05 \), ** \( p < 0.01 \)
Table 4. Final Regression Model for Variables Predicting Novelty Preference at 300 ms Test

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Density</td>
<td>.97</td>
<td>1.96</td>
</tr>
<tr>
<td>TV/day (mins)</td>
<td>.00</td>
<td>0.01</td>
</tr>
<tr>
<td>FH+/FH-</td>
<td>.40</td>
<td>4.04</td>
</tr>
<tr>
<td>IT-HOME</td>
<td>.11</td>
<td>.28</td>
</tr>
</tbody>
</table>

† p < 0.10, * p < 0.05, ** p < 0.01

Discussion

The results indicate that greater exposure to background noise, such as household density and exposure to television, may enhance early auditory discrimination. Contrary to the belief that greater household density produces chaos, more people living together could relate to more exposure to language and communication between others. Moreover, with a large number of people in the household, the child may receive more attention. For example, if the primary caregiver is the only adult living within a household, it is likely that she will have less time to spend with the infant because of work and other obligations. However, if many adults live in one household, it is possible that an adult would accompany the infant most of the day. Recall also the theories of Uzgiris (1977) and Weisner (2010), which demonstrate that each individual has an optimal level of stimulation that benefits development, and minority individuals, who comprised most of our participants, may be habituated to a higher level of chaos than what is considered normal in a European-centered environment. Therefore, it is necessary to take
African American and Hispanic cultures into account when analyzing our results; more people living in a household may not be chaotic as represented by a European definition.

However, a confound to the relationship between household density and RAP-70 was found in the first order correlations. As Table 2 indicates, the number of siblings the infant had was negatively related to performance on the RAP-70. A possible explanation for this finding is that siblings detract from parent-infant interaction time. In addition, RAP performance was not related to the primary caregiver cohabiting with a significant other. Thus, another factor must be involved in the relationship between density and RAP-70.

Further, greater exposure to another source of background noise, television, may facilitate language development. Perhaps, contrary to the findings of Mendelsohn, Berkule, Tomopoulos, Tamis-LeMonda, Huberman, Alvir, and Dreyer (2008) on television exposure and low-income families, these children are exposed to high levels of child-directed television rather than adult-oriented television. As indicated by the results of the study by Linebarger and Walker (2005), child-oriented television can be beneficial to language development; child-directed television may act as a substitute for parent-child interaction. However, another explanation is that, instead of simulating parent-child interaction, the caregivers involved in our study actually interact with their child during television viewing to receive the full advantages of child-oriented programming as indicated by Mendelsohn et al. (2008).

In addition, the poor performance on the RAP-70 may demonstrate that this participant population is especially at risk for future language impairments. As previously mentioned, the national rate of specific language impairments in 5 year olds is 7.42% (Tomblin, Smith, & Zhang, 1997). In our sample, 14% of the participants had a family history of language impairments—twice the national prevalence rate—putting them at greater risk for future
language impairments. As shown in Table 3, family history of language impairment was negatively related to performance on the RAP test. Further, as noted, 47% of the infants scored lower than the novelty preference criterion on the RAP-70, which indicates that there may be other risk factors contributing to delay of tone discrimination than family history. For example, maternal depression was positively correlated with family history of language impairment. Also, family history of language impairment and number of siblings were negatively related. These findings may indicate that there are various risk factors linked to family history of language impairment.

Finally, as Table 2 shows, Spanish speaking is associated with multiple risk factors. Although a correlation was not found between language and performance on the RAP-70, our Spanish-speaking participants, all of whom were Hispanic, were more likely to live in a disorganized environment, receive less attention from primary caregiver, have a primary caregiver who has a low level of education, have less access to learning materials, and experience a greater number of ear infections. These correlations suggest that infants born to Hispanic immigrants may be especially at risk for future language impairments. As indicated earlier, children may be able to cope with one or more risk factors, but the presence of three risk factors may have a negative effect (Garbarino, 1992; Sameroff, Seifer, Barocas, Zax, & Greenspan, 1987). Regardless of ethnicity, the cumulative risk factors, such as maternal depression, family history of language impairment, disorganized households, and less parental attention, put our sample population at high risk for future language impairments.

Limitations

There were several limitations to the analysis of our findings. The lack of information regarding the content of television inhibited us from drawing any real conclusions about the
relationship between television exposure and RAP performance. Further, a large portion of the
participants did not score above the 54% criterion on the RAP-70. While this result may
demonstrate that our participants are at specific risk for language delays, it also may indicate that
our participant sample was too young for the test to be completely effective. Previous research
with the RAP has been conducted with infants 7 to 9 months of age while some of our
participants were as young as 6 months of age (Benasich & Leevers, 2002; Benasich & Tallal,
2002; Choudhury, Leppanen, Leevers, & Benasich, 2007). Finally, we did not start
administering the family history questionnaire until later in the project; thus, getting back in
touch with participants to obtain the necessary information was rather difficult.

Future Research

Currently, we are working on ways to further analyze our data to address the limitations
of our present data analysis. In order to obtain a better estimate of media use and the type of
media to which the infants were exposed, a detailed time use diary is being coded. We predict
that the positive association found between television exposure and RAP processing is more
likely to be associated with the child-directed television programs that have slowly paced
language and shorter phrases characteristic of parentese than with adult-directed programs, such
as sitcoms. We will also evaluate level of stimulation within the household with a quadratic
function, using the optimal stimulation hypothesis proposed by Uzgiris (1977). Additionally, to
further explore the role and structure of the households of our participants, the sibling status of
each participant and the cohabitation status of the primary caregiver must be evaluated further.
In doing so, we may be able to understand more clearly the relationship between household
density and RAP-70 scores. Finally, we are in the process of collecting and coding more
questionnaires on family history of learning difficulties. With a better idea of family history, we
will be able to more fully assess the cumulative risks for language impairments in our sample population.

Implications

Our results indicate that factors previously believed to inhibit healthy language development, mainly a large household density and greater exposure to television, may actually act as protective factors against other developmental risk factors. However, despite these surprising findings, infants born into low-income families are exposed to cumulative risk factors for developmental delays. Specifically, the Hispanic population may be at increased risk. Future programs should focus on how to intervene in low-income environments before risk factors begin to impede development.
References


