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Comparison of video and toy reinforcers to motivate infants/toddlers for hearing tests

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COMPARISON OF VIDEO AND TOY REINFORCERS TO MOTIVATE INFNATS/TODDLERS FOR HEARING TESTS

by

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Abstract: Comparison of the effectiveness between Video and toy reinforcer types to motivate infants/toddlers for hearing tests. No significant differences were found between a age groups or gender. Toy reinforcers were found to produce on average 2 more threshold estimates compared to video reinforcers. Variety, color, and animation of animals may have attributed to this difference.

ABSTRACT

Purpose: To compare the effectiveness of toy and video reinforcers to motivate infants/toddlers in the 16 month to 24 month old age range; evaluate if there is a difference in the number of head turns.

Design: 85 children were recruited from St. Louis Children's Hospitals' Audiology/Otolaryngology out-patient population. Children were assigned to receive either video or toy reinforcement.

Results: 41 were tested with video reinforcers and 44 were tested with the toy reinforcer. Mean number of responses with the video reinforcer was 3.4 and was 5.4 with the toy reinforcer. The average number of responses obtained with video and toy reinforcers in each age group was not significant. There was no significant difference between males and females. Although no statistical difference was shown due to a small number of subjects, there appeared to be a trend showing as hearing loss increased in dB the number of responses decreased.

Conclusions: The results of this study differed from Schmida, Peterson, and Tharpes' 2003 findings. The difference may be related to the wide variety of toy reinforcers used in the current study. The toy reinforcers were all very brightly colored, moved, and made noise. All of these factors may have made the animals much more interesting to the children where as video clips may be much more common place today.

Since the early days of audiology, clinicians and researchers have recognized the need for accurate diagnostic testing in infants and young children. We now have evidence that infants with early diagnosis and intervention before 6 months of age perform much better on tests of language than those diagnosed at a later age (Yoshinaga-Itano 1998).

ABR, OAE, SSEP and Immittance tests are the cornerstone of UNHS and early diagnosis. However, it is behavioral testing that allows us to truly see the infant or child's volitional, functional response to sound and to confirm the diagnosis. Young children and infants are limited in their ability to perform behavioral tests due to short attention spans and limited interest in many audiologic test stimuli. Through the years a variety of behavioral hearing tests have been tried to evaluate hearing in infants and young children.

Initially, clinicians relied on eliciting startle responses or behavioral responses to loud stimuli. Froding (1960) reported eye blinks (APR- auropalpebral reflex) to be the most reliable auditory response seen in infants and the APR can be seen in an awake or sleeping infant in a response to a loud sudden stimulus. Northern and Downs (1974) reported that APRs can be reliably elicited with broad band noisemakers at 50-70 dB SPL in infants 3 to 7 months old. These stimuli and responses do not allow for frequency specificity or threshold determination.

Behavioral Observation Audiometry (BOA) is administered by presenting calibrated stimuli and observing the infant or child's response. One or two clinicians observe the infant or child to see whether behaviors such as eyes widening, eye blinks, and brow and head movement occur in a timely manner after the stimulus is presented (Eisenberg 1976). BOA can also be administered with loud stimuli to observe a startle response. Responses to less intense stimuli include; eye widening, blinks, and brow and head movement (Eisenberg 1976). Responses to less intense stimuli are variable and test-retest reliability for BOA is on the order of 40 to 50 dB HL for 4 to 7 month olds and 30-40 dB for 7 to 9 month olds (Northern and Downs 1978). BOA is no longer in widespread use, but is still employed when special circumstances arise, such as the assessment of children with brain damage, autistism and/or physical disability.

Dix and Hallpike (1947) developed a “Peep-show” procedure to test children under the age of six. The Peep-show apparatus consisted of a wooden box with a viewing hatch. A picture can be seen through the viewing hatch when illuminated. The child can illuminate the box and see a new picture by pushing the button, but must wait until a signal light goes on. Once the child catches on to this idea, an auditory signal is combined with the signal light. After several trials, the signal light is omitted. The child demonstrates he can hear the signal by pushing the button to see the picture right after the auditory signal is given. Most children over the age of three performed this task quite easily. Testing four frequencies took no more than fifteen minutes. Dix and Hallpike (1947) noted that the child is less likely to show signs of boredom or fatigue if the pictures are frequently changed. They tested thirty-one children ranging in age from two to seven. The Peep-show was found to be considerably more accurate observing responses to drums, pitch-pipes and the spoken voice. The researchers concluded that great skill and experience were not required, the apparatus was simple, the responses of the child were straightforward, and the procedure was fairly quick.

Although Dix and Hallpike hoped the Peep-show procedure would have a great impact on pediatric audiology, clinics had difficulty using the procedure for children under the age of three. As Hodgson (1984) pointed out, most three-year olds are able to be tested satisfactorily using play audiometry (CPA), which was developed in by Barr (1955). The child listens for the tone and is taught to perform an action (e.g., dropping a ball in a bucket) in response to the tone. Play audiometry can be successfully taught to most three-year olds, and even some two-year olds can be conditioned with play audiometry (Thompson 1989). Thompson and Weber (1974) found that the success rate for conditioning a child under 30 months and obtaining detailed auditory information was limited. However, if two-year olds were proficient with play audiometry, than CPA was more successful in obtaining more information than with VRA (Thompson et al. 1989).

Suzuki and Ogiba (1961) took advantage of the orienting reflex and observed that infants would turn toward the source of a strange visual or auditory stimulus. They developed a procedure known as Conditioned Orienting Reflex Audiometry (COR). Instead of illuminated pictures, they used illuminated dolls to reward the child. Two speakers (one to the left of the child and one to the right) were used in this procedure. The dolls were located under each speaker. To begin testing, the child was placed in the lap of an assistant about 50 cm back, facing the equipment. A test tone was presented at 30- 40 dB above the estimated threshold and the dolls were illuminated a second later. This visual stimulation caused the child to turn his or her head and look toward the dolls. The combined tone and light stimulus lasted about four seconds; they were extinguished simultaneously. The tester repeated this process with the opposite speaker, getting the child to look toward the other side.

This procedure was repeated until the tester felt the child was conditioned-- i.e., the child looked toward the dolls before they were illuminated. Suzuki and Ogiba defined a “true response” as a quick turn of the head toward the stimulus that occurs within 0.5 to 1.5 seconds of the stimulus onset. Once the subject was conditioned, the tester decreased the tone, until the child’s threshold was reached. Suzuki and Ogiba (1961) recommended starting at 30 to 40 dB above estimated threshold for each frequency or stimulus tested. They warned that to be accurate, the tester must learn to recognize a true head turn from random movements. Suzuki and Ogiba (1961) found that test time (for four frequencies) for ages three years to one year ranged from three to five minutes.

Suzuki and Ogiba (1961) tested 250 children using the COR procedure. They successfully tested only 13 of 29 (44.8%) children under one year. Satisfactory results were found for 63 of 74 (85.1%) children who were one-year old, and for 87 of 99 (87.8%) children aged two years. Suzuki and Ogiba (1961) observed that children three years and above responded well at the beginning of the test but soon lost interest. Test-retest reliability of COR evaluated by comparing hearing thresholds obtained in initial testing with those in a second test three to fifteen days later was within 5 dB for 53 of 60 (88.3%) children (Suzuki and Ogiba, 1961).

One problem with COR is that the test is administered in a sound field environment, making ear specific information difficult to obtain (Suzuki and Ogiba 1961). In addition, Liden and Kankkunen (1969) found it to be less successful with hard of hearing children. However, the use of calibrated stimuli and conditioned responses paved the way for modern-day visual reinforcement audiomtery (VRA).

Liden and Kankkunen (1969) modified COR and developed a new method called visual reinforcement audiometry (VRA). The authors compared it with COR on 120 children with normal hearing and, more importantly, 985 children with hearing loss. The children ranged in age from 3 months to 6 years. The main differences between VRA and COR were as follows:

1) COR requires a localized response, but VRA does not.
2) Reinforcement for VRA consisted of slides projected onto frosted glass versus illuminated dolls used for COR.
3) For VRA an insert ear phone and an external muff were placed on the “non-test” ear.
4) VRA did not require a strict head turn response. A variety of responses were accepted—e.g., an intense expression on the child’s face, movements of the head and shoulders, eye-widening, forehead wrinkling, looking toward the speaker, immediate head turn, a statement that he/she had heard the stimulus, pointing to the window. Responses were judged by the examiner.

For VRA the children sat in the lap of a parent in the center of the room. Testing began with a 500 Hz tone in the right speaker at 30 to 40 dB above estimated threshold. Once the child was conditioned to provide a response, the level of the tone was gradually reduced to determine a threshold. The session ended with COR. Linden and Kankkunen made no mention of the effects this testing order could have had on results. No counterbalancing or breaks between sessions were mentioned.

Of the 935 children tested with VRA, the technique was considered successful (ability to elicit responses to auditory stimulation) for 925 (99%) of the children. For COR, the tester was able to elicit responses in approximately 80% of the children ages one to three. Thresholds obtained with VRA were on average 10 dB lower than those obtained with COR. There was no significant difference in success between VRA and COR for children under one year of age, with both methods yielding thresholds between 30-40 dB (Liden and Kankkunen 1969).

Moore, Thompson, and Thompson (1974) used VRA and explored the effects of various reinforcers with 48 normal-hearing subjects from 12 to 18 months of age. From least to most successful were social reinforcement, simple visual reinforcement (a blinking light), and complex visual reinforcement (an animated toy animal). A response was defined as a head turn in the direction of the speaker immediately after the stimulus was presented. It was concluded that complex reinforcement results in significantly more localization responses than all other reinforcers. Although visual and social reinforcers were not combined in this study, the authors hypothesized that in a clinical setting they would most likely complement each other (Moore, Thompson, Thompson 1974).

Tangible Reinforcement Operant Conditioning (TROCA) is another method of reinforcement used in evaluation of children. The child pushes a bar on a dispenser in response to a sound stimulus, emitting candy, nuts or small coins. The correct response coupled to the stimulus results in reinforcement (Lloyd, Spradlin and Reid 1968). Fulton, Gorzycki, and Hull (1982) further evaluated reinforcement options with TROCA. Responses were individualized to the subject, and rewarded after each detection response. The authors defined reinforcement as “an event that increases the probability that the proceeding action will reoccur under the same set of antecedent conditions and hypothesized that individualizing the reinforcer would improve testing outcomes.” Reinforcements included cereal, raisins, baby food, ice cream, cola, juice, milk, tokens with pictures on them, parent smiles, and small trinkets. Auditory responses were obtained with 7 of 12 subjects (9 to 25 months of age). Test-retest thresholds were within 10 dB 92.4 % of the time and within 5 dB 73.9% of the time (Fulton, Gorzyki, and Hull 1982).

VRA has been proven to be a successful method for testing infants particularly in the 8-12 month age range (Moore, Wilson, and Thompson 1977). VRA has been shown to be less effective for the two-year old age group because they typically have very short attention spans, habituating quickly to the stimuli. Unfortunately, the next level of testing, play audiometry, is too advanced for most two year old children (Primus and Thompson 1985). Thompson, Thompson, and Vethivelu (1989) compared VRA, VROCA, and standard play audiometry with 62 children between the ages of twenty-four to twenty-seven months. Results revealed that none of the methods was clearly superior to the others, but some tests did have advantages for testing the difficult two-year old population. Results were as follows: If the child could be conditioned, play audiometry does provide the most information in a test session; however only 68% of the children could be conditioned. In contrast, 100% of subjects could be conditioned for VRA. The disadvantage for VRA in this age group was rapid habituation. Thompson, Thompson, and Vethivelu (1989) conclude that VRA appears to be the safest method to use due to the majority of two-year old's ability to readily condition to the task.

Thompson, Thompson and McCall (1992) found that habituation occurred readily in one to two-year olds, but using two reinforcers led to more responses before habituation than use of a single reinforcer. Furthermore, they reported that a short break led to at least five additional responses in the next testing session for one-year old infants. Two year olds were found to habituate faster than one-year olds and did not perform as well even after a break. Two-year olds are a difficult-to-test population (more so than one year olds), and often only minimal auditory information is able to be collected.

Recently, video clips have been introduced as a reinforcer (Schmida, Peterson, and Tharpe 2003). Instead of an animated toy, a moving video image is presented on a screen as a reward. It was anticipated that the video images would be more rewarding to children aged 19 to 24 months than the conventional mechanical toy reinforcers. However, children of this generation are frequently exposed to video images and therefore may be more interested in a three dimensional toy (Schmida, Peterson, and Tharpe 2003). Werner and Kopyar (1994) measured the length of time two to twelve-month old infants spent looking at video tapes and animated toys. They found that infants tended to look longer at a videotape than a mechanical toy. Werner and Kopyar (1994) also estimated auditory sensitivity of the infants with both the mechanical toy and video reinforcer. Infants older than three months had higher hearing sensitivity when a mechanical toy was used. Children younger than three months had the opposite results, i.e., higher hearing sensitivity when video clips were used. Werner and Kopyar (1994) concluded that the reinforcer can affect hearing sensitivity, and children of different ages are affected differently by the type of the reinforcer.

The work of Schmida, Peterson, and Tharpe (2003) was the primary impetus for the current study. These authors compared video reinforcement with mechanical toy reinforcement for forty normal- hearing children (twenty-two boys and eighteen girls) between the ages of nineteen and twenty-four months. The conventional reinforcer group was rewarded with an animated mechanical chicken. The video reinforcer group was rewarded with video clips fro, *The Adventures of Elmo in Grouchland*. Two audiologists, each with over fourteen years of experience, completed the testing. One examiner presented the tones and the other sat with the child to provide distraction and keep the child facing forward. Stimulus tones were presented at 35 dB from 125 to 8000 Hz. The response criterion was counted as a “true response” if a 90 degree head turn toward the reinforcer was observed. The number of head turns prior to habituation and response consistency were counted (Schmida et al. 2003). Thirty-two of the children continued with the task until habitation occurred. Significantly more head turns for the video reinforcer (15.5 head-turns) than the conventional reinforcer (10.8 head-turns) were documented.

Schmida, Peterson, and Tharpe (2003) suggest that the additional four responses obtained with the video VRA may permit the audiologist in a clinical situation to obtain one or two more responses. From another perspective, 30% of children in the video reinforcement group demonstrated twenty or more head turns whereas only 5% in the conventional group had twenty or more head turns. In addition, the false positive rate was lower with the video reinforcement compared to conventional reinforcement. Schmida, Peterson, and Tharpe (2003) hypothesized that the complexity, dynamic nature, and luminosity of the video clips may be more visibly appealing to a child (Schmida et al. 2003).

It should be noted that the Schmida et al. (2003) study was conducted in a well-controlled environment with normal-hearing children. What most clinicians want to know is if video reinforcement results in more frequency thresholds. In a clinical environment with children with hearing loss, would these results be replicated? The purpose of the current study was to compare video VRA with conventional VRA (mechanical toys) in a clinical setting (i.e., encompassing both normal-hearing infants and infants with hearing loss). Questions to be answered included the following:

1. Did video VRA enable the audiologist to obtain more threshold estimates than animated VRA?
2. Within the 16 to 24-month age range is there an age effect or gender effect?
3. Do normal hearing infants provide more threshold data than those with hearing loss?

Method

The study " Comparison of video and toy reinforcers to motivate infants/toddlers for hearing tests" was approved by Washington University's School of Medicine Human Studies Committee.

Subjects

The subjects were 85 infants 16 to 24-months of age. Subjects were recruited from the Audiology/Otolaryngology out- patient population. If a patient was within the age range of the study, the parent/guardian was approached by the receptionist to participate. If informed consent was obtained by the audiologist, the infant was enrolled. Eighty-five subjects were enrolled, and conditioned for VRA and were included in the analysis.

Procedures

Eight audiologists participated in the testing, each having five to thirty years of experience. Four of the audiologists were assigned odd days to begin testing first using video reinforcers and even days to first begin using toy reinforcers and vice versa for the other four audiologists. If the chosen type of reinforcer did not motivate the child, the audiologist noted this on the audiogram terminating the research portion of the session and switched to the alternate. Only data obtained with the assigned visual reinforcer was included for analysis.

Testing was done in one of three sound suites using either a Grason Stadler Instrument-61 or the Madsen Orbiter-922. Booth A reinforcers included the video clips from Scooby Doo, Sesame Street, Shrek, and Baby Einstein. There are approximately 220 video clips from which to choose. Toy reinforcers in Booth B included a puppy, elephant, Panda, pig, bunny, and kangaroo. Toy reinforcers in Booth C include an elephant, donkey, pig, bunny, penguin, and puppy. A complete description of the animated toys may be found in Appendix A.

Each infant sat on the parent’s lap in a chair in the middle of the room. Loud-speakers were situated at a 45-degree angle to the left and right of the subject. An assistant stayed in the room to keep the subject’s attention focused to the midline between trials. The tester presented the stimuli (speech, warble tones, or narrowband noise). The infant/child was conditioned to respond to stimuli with a head turn at supra-threshold levels. Depending on group assignment, head turns were reinforced by either a three dimensional animated stuffed toy or animated video images. The audiologist first obtained a speech awareness threshold either with earphones, inserts or in the soundfield. Individual frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz were then obtained either through ear phones or through the soundfield. This sequence of frequency specific stimuli was determined by the audiologist based on case history information.

Results

A multi-varied ANOVA was used to analyze the following: differences in the number of threshold estimates between the AVRA and VVRA groups (reinforcer type), differences among the age groups (16 to 18 months, 19 to 21 months and 22 to 24 months), differences due to gender, and for infants/toddlers with hearing loss versus those with normal hearing and/or unilateral hearing loss.

Of the 85 infants/toddlers who participated, 44 were assigned to the AVRA group and 41 to the VVRA group. The AVRA group produced an average of 5.4 (standard deviation = 2.5) thresholds and the VVRA group produced an average of 3.4 (standard deviation = 2.5) thresholds (see figure 1). A statistically significant difference was found for reinforcer type ($p = .0002$). In contrast to the original hypothesis, AVRA produced more thresholds than VVRA.

There was no statistically significant difference in the mean number of thresholds among the three age groups (see figure 2). In the 22 to 24 month age range AVRA (7 subjects) produced 3.4 more thresholds than VVRA (11 subjects). In the 19 to 21 month age range AVRA (14 subjects) produced 1.9 more thresholds than VVRA (14 subjects). In the 16 to 18 month age range AVRA (23 subjects) produced 1.4 more thresholds than VVRA (16 subjects). Given the variability of the performance of infants and toddlers, additional subjects would be needed to make a definitive statement with respect to age.

Gender interactions between reinforcer types were not significant. With VVRA the females had an average of 3.2 thresholds and the males an average of 3.6 thresholds. With AVRA the females had an average of 5.7 thresholds and males an average of 5.2 thresholds.

As shown by the scatterplot in figure 3, the data collected is consistent with the hypothesis that the more hearing loss the infant demonstrated, the fewer thresholds obtained, however this cannot be supported statistically due to the small number of subjects with hearing loss and the great variability of the normal hearing infants/toddlers. Of the 63 infants/toddlers with normal hearing, six provided 10 or more threshold estimates. In contrast, of the 22 infants/toddlers with hearing loss (i.e., pure tone average greater than 20 dB HL), only one had 6 threshold estimates and all of the others had 5 or fewer threshold estimates.

Discussion

The purpose of this study was to compare the number of threshold estimates in VRA testing when using a toy reinforcer versus a video reinforcer with children between the ages of 16 to 24 months. Based on Schmida et al (2003), it was hypothesized that using the video reinforcement would result in more threshold estimates than reinforcement with animated toys. In actuality, results were the opposite of the hypothesis, with AVRA providing significantly more thresholds than VVRA. Approximately two more threshold estimates were obtained with conventional toy reinforcement. In addition to being a statistically significant difference, two thresholds is clinically significant when testing infants and toddlers, permitting a more complete audiogram.

Once explanation for obtaining significantly more thresholds with animal VRA versus video VRA is the number of animated toys. Six animals were in each of the animated VRA booths. Schmida, Peterson, and Tharpe (2003) used only one animal, an animated chicken. In addition,the toy reinforcers used in our study may have resulted in significantly more head turns because of the variety of animals used, their dynamic nature and their bright colors (see appendix A). Anecdotally, a survey of seven pediatric audiology facilities indicated a range from one animated toy to three animated toys on each side. Two of these centers had VVRA available in addition to AVRA.

A second explanation for the AVRA producing more thresholds than VVRA was alluded to by Schmida et al (2003). They suggest that the animals may have also been more interesting than the videos because television is so common for children these days. The moving brightly colored animals may be more of an oddity, attracting the child’s attention more readily. In addition, perhaps the selected video clips may have not been the optimal clips for the current age group. Future research is needed to determine how to optimize the video clips.

In addition, the use of VVRA in addition to and/or in combination with AVRA may allow infants/toddlers to perform accurately for a longer session and provide more threshold estimates. The visual uncertainty and novelty of not knowing whether a VVRA or AVRA reinforcer will be used may sustain infant attention longer than either technique alone. Further research is needed using a combined approach.

As in the Schmida et al. (2003) study, the current study also did not find a significant gender effect for the number of thresholds obtained with AVRA vs VVRA. With respect to age, no statistical difference between reinforcer types was found for the age groups studied (i.e., 16 to 18 months, 19 to 21 months and 22 to 24 months. However, a definitive statement with respect to age cannot be made given the small number of subjects in some of the age groups (e.g., N=7 for 22 to 24 months of age).

However, this conclusion cannot be currently made without a more adequate number of subjects in each age group.

There was no significant difference in the mean number of thresholds obtained between infants/toddlers with hearing loss and those with normal hearing. However, the data trend was consistent with the hypothesis that those infants/toddlers with hearing loss provided fewer threshold estimates than those with normal hearing. Again, a larger sample size is needed before a definitive statement can be made.

Appendix A

Animals in Booth A include: On the right side is a brown puppy. This puppy has a red ribbon around its neck and barks while nodding its head.

On the left side is a rooster. It is very bright orange and red with different textures. It cock-a-doodle-doos and nods it's head while wagging its tail.

Animals in Booth B include: On the right side a brown puppy with a black collar barks while wiggling back and forth, moving its head and wagging its tail.

A bright yellow elephant moves its trunk up and down; its body moves up and down. It makes an elephant noise.

A black and white panda bear with a blue collar bangs on red, white, and blue drums.

On the left side a pink pig wiggles and snorts.

A pink bunny with a bright red nose and colorful collar bangs on blue drums.

A brown kangaroo with a polka-dot collar hops up and down.

Animals in Booth C include: On the right side a Pink bunny with a red, white, and blue collar bangs on drums.

A black and white penguin with a red hat and red and white scarf waddles.

A brown dog with a leather collar barks and wiggles.

On the left side is a pink elephant with a red white and blue collar that bangs on drums.

A brown donkey with a pink nose wiggles its tail.

A pink pig snorts and wiggles.

Figure 1

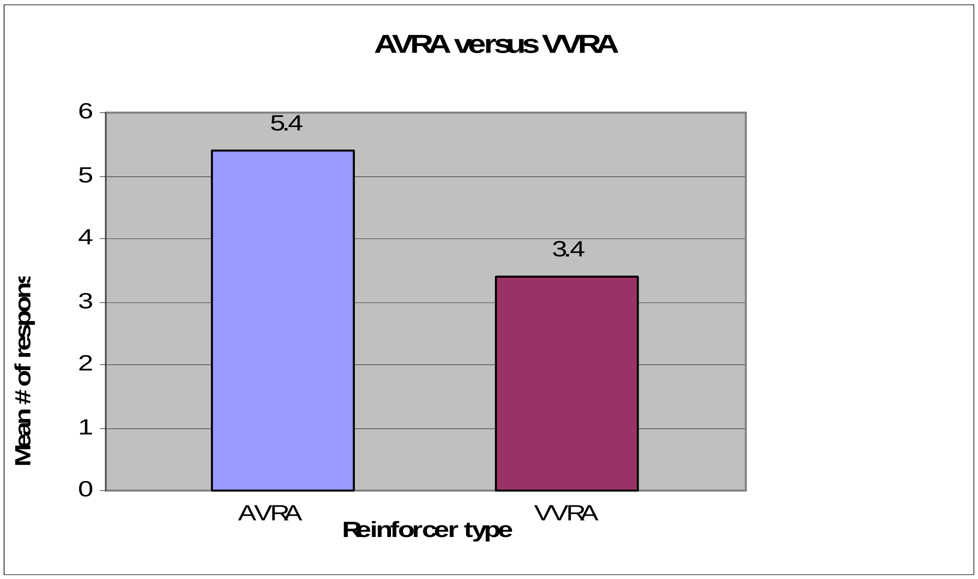

AVRA versus VVRA
6
5
4
3
2
1
0
5.4
3.4
Mean # of respons
AVRA
VVRA
Reinforcer type

Figure 2

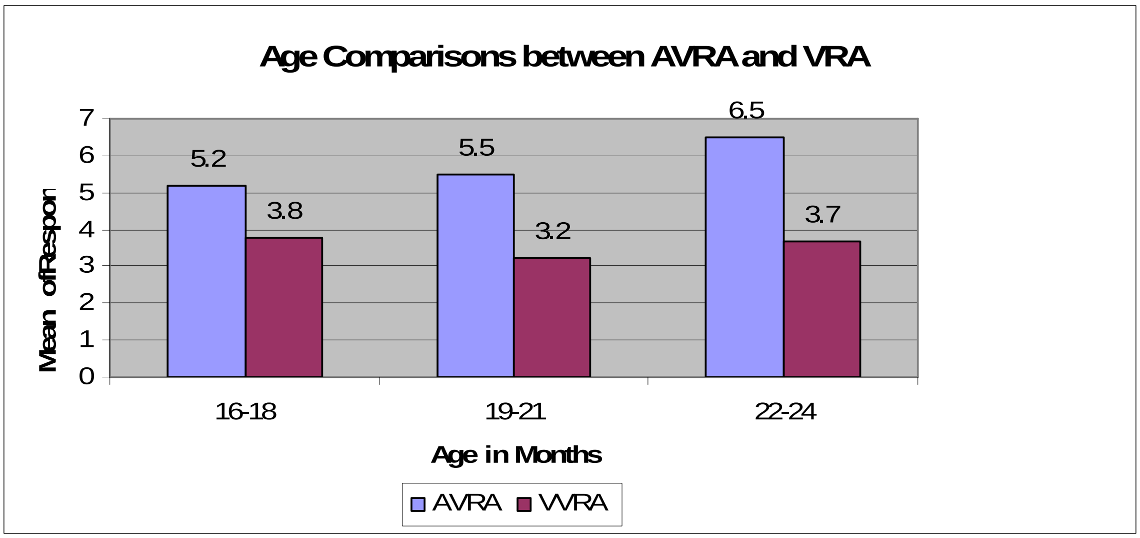
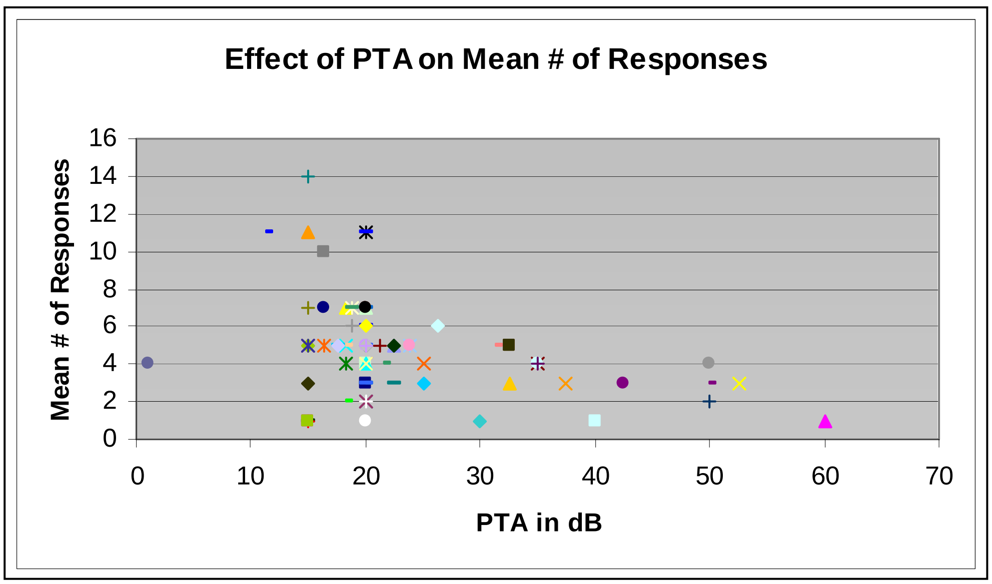

Age Comparisons between AVRA and VRA
Mean of Respon
7
6
5
4
3
2
1
0
5.2
3.8
5.5
3.2
6.5
3.7
16-18
19-21
22-24
Age in Months
AVRA
VVRA

Figure 3


Effect of PTA on Mean # of Responses
Mean # of Responses
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
70
PTA in dB

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