The topic of infant memory capacity

Although there has been this debate surrounding infant memory, it is believed that an infant's memory is formed in the same way that an adults memory is. Previous studies have shown that their memory does not develop strictly later in life as previously believed and that instead it is present from a young age, possibly at birth or in-utero (Rovee-Collier). This has been shown through tasks done with young infants which tap different memory systems in the same way in which adults process this information. (Rovee-Collier). Despite the fact that these memory systems are present in infants, it has also been found that an infant's memory increases throughout the first year or two of life so that they are able to hold longer memories and for a longer period of time (Rovee-Collier). Some of the biggest obstacles in studying memory have been due to the fact that infants are unable to give researchers explicit accounts of their experiences. Because they cannot yet speak, it has been important for researchers to determine other nonverbal ways in which infants can demonstrate that they have actually remembered something. This has been done through kicking tasks, eye tracking, and other physical traits which may demonstrate memory (Rovee-Collier). Also, another issue has risen from the general inability of older children and adults who are able to speak to verbally discuss memories from their childhood; therefore, much research has been done to determine whether they are not remembering or if the context and storage of these nonverbal memories at a young age are interfering with later verbal expressions. This too has been difficult to study as it is sometimes hard to determine whether individuals are relaying their own memories or memories that have been conditioned to them through other individuals in their lives (Rovee-Collier). Current studies have looked at many of these issues and developed experiments around them which demonstrate the capacity for infant memory.

Habituation

Because it has been found that infant memory systems are somewhat developed and capable of forming memory at birth, researchers have questioned whether infants too can form memory while still just a fetus. In the study by Ditrix, Nijhuis, Jongsma, and Hornstra called Aspects of fetal learning and memory; the researchers looked at habituation in the fetus of pregnant women. Habituation refers to a decrease in response given to a certain stimulus that has been repeatedly stimulated in the individual's presence. This phenomena is obvious from others because when the stimulus changes, there should be an immediate re-emergence of attention given to the new stimulus (Ditrix et al., 2009). Also, when the first stimulus is repeated, the individual should faster habituation to it after the first showing of the stimulus (Ditrix et al.. 2009). This study first recruited 100 pregnant women between 28 and 38 weeks of pregnancy. There was extensive exclusion criteria for the women including absence of disorder in the women, no use of mediation, no depression, no change in eating habits, and smoking less than 6 cigarettes a day, among others. Although the study began with 100 participants there were dropouts due to other complications and therefore the final

sample included 93 women. The main hypothesis of the study was that infants would habituate to a vibroacoustic stimulus which would be measured at intervals in order to show both short term and long term memory storage (Ditrix et al, 2009). At thirty second intervals, a vibroacoustic stimulus was applied to the woman's stomach and movement of the fetus one second after the stimulus was given was monitored by an ultrasound machine (Ditrix et al., 2009). The highest number of stimuli given during the test was 24, but if the fetus was still responding at the 21st stimulus, no further stimuli were given to the fetus and therefore no habituation took place. At the end of the study, the results were somewhat in line with the hypothesis. At 30 weeks gestation, almost the all of the fetuses tested demonstrated habituation (Ditrix et al., 2009). In each group, there was a significant decline in the initial stimuli versus the repeated habituation test in the first session. The results of the study demonstrated that fetuses have a short term memory for ten minutes at 30 weeks and that there is also further evidence to propose they are able to hold longer term memories for up to 4 weeks (Ditrix et al., 2009). One important aspect of these results is that it is essential to know whether the results were actually due to habituation or if they represent some type of fatigue or receptor adaptation. This is shown through the fact that when a new stimulus is presented, dishabituation should occur. One major limitation of the study in that although the study was able to demonstrate faster habituation to the first stimulus, they did not present another stimulus which would demonstrate dishabituation in order show that the results were in fact due to this phenomenon of habituation. Therefore, while the results may be clear, the researchers cannot confidently say that the results were specifically due to habituation and not another process. Another limitation of the study is that there may not have been enough participants to give the study the power it needs because unpaired statistics often need more participant cases in order to reach a higher level of significance (Ditrrix et al, 2009). Therefore, in order to increase the power and validity of the statements regarding long-term memory storage, it would be important to conduct further information to confirm these results (Ditrix et al., 2009).

Although there have been many studies that demonstrate the fact that fetus have the ability to form memory in the womb such as the one done by Ditrix et al., very few studies have demonstrated the persistence of fetal memory into infant life. The study done by Gonzalez-Gonzalez et al. helps to show the link between these two life stages (2006). This is important to study because it is believed that fetal memory can actually serve some functions in terms of parental attachment to the mother and also recognition of the infant's mother. Therefore, it is essential to know whether fetal memory stays intact after birth because it could have a potential effect on these variables. The present study consisted of forty-one pregnant women who were 38 to 40 weeks pregnant who had an absence of both medical and obstetric disorders, not toxic habits and cephalic presentation (Gonzalez et al., 2006). Through the method of the study, the fetus was stimulated using an artificial larynx repeatedly every minute for a maximum of 24 stimuli. This is the same method used in the Ditrix et al. study along with others as it has been shown to lead to habituation. This study determined habituation when the fetus stopped responding to four repeated stimuli. This test is different from the Ditrix et al. study because the researchers presented these stimulations every 48 to 72 hours until the

fetus was delivered and then one or two days after delivery, the habituation assessment took place. The results of the study demonstrated that all of the fetuses showed a positive response to the stimulus presented after birth. Also, infants that were stimulated while in the womb habituated earlier than infants who were not previously exposed to the stimulus (Gonzalez et al., 2006).This provides some evidence that fetal memories are able to persist into infant life. Furthermore, it demonstrates that not all infants have the same capacity for memory formation. In general, the longer it took the fetus to habituate in the first part of the study, the longer it took the infant to habituate after birth. This study went more into depth than the Ditrix et al. study although both used many of the same methods. One limitation of this study and others which study habituation is the fact that there were very few participants and therefore this may decrease the power of the overall study. Previous studies also demonstrated this problem (such as the Ditrix et al. study) and many contained more participants than this study did. It is important that further research be done to rule out any errors that occurred within this study and increase the validity of the results. Another limitation is the fact that after the initial presentation, some fetus were given more presentation of the stimulus than others before they were born (Gonzalez et al., 2006). This may introduce another variable of repetition or priming effects that were not accounted for within the study. A major strength of this study that was not included in the Ditrix et al. study was that the researchers used the process of dishabituation in order to rule out other effects that may cause the fetus to stop responding.

Repetition and Priming Effects

The study involving habituation by Gonzalez et al. may involve some limitations and confounding variables, but it also demonstrates other aspects of infant memory that are important to explore: repetition and priming effects. There have been many studies done which involve these variables, yet after many years of research, the exact process involved in the encoding, storage and retrieval of memories still remains largely unaccounted for (Turati, 2008). This study consisted of three separate experiments. The first one looked at the effect of an interfering stimulus on a newborn's memory for a specific geometric pattern and the second one looked at the effect of further exposing the infant to the geometric pattern in order to reduce the loss of recognition which occurs after interference (Turati, 2008). For experiment 1, the study consisted of 65 infants, 30 boys and 35 girls, all of which were 1-3 day old healthy, full-term infants. The stimulus that was used during the study was hexagonal and X-shaped white geometric figures that had a black background. The first phase consisted of habituating the infants to a flickering LED light and then projecting the geometric shape to the infant and then recorded how long the infant remained fixed on the shape (Turati, 2008). The distracter shape was then presented and at the end of this test the results showed that the infant preferred the control more than the interference condition. These findings demonstrated that when a distracter stimulus is introduced between a habituation and test phase, this causes inhibition of the infant's recognition response. In the second experiment, 31 subjects were used (17 girls and 14 boys) and the experiment had a similar set-up to that of the first. One difference was that before the test phase, they re-presented the

familiar stimulus for 15 seconds. The results of this part of the study showed that when the infant's memory was inhibited by a distracter stimulus, it could be reactivated through a reminder stimulus of the previously forgotten stimulus (Turati, 2008). This is significant because it demonstrates the importance of the repetition priming effect in memory storage which this study shows is present at birth. One limitation of this study is that the preference of the infant to the novelty stimulus may just be due to the fact that the infant has become familiarized with this stimulus. Another criticism is that the distracter may cause the infant to habituate to the stimulus and therefore they would be unable to show a reaction response (Turati, 2008). Further studies should be done in order to rule this out. Another important aspect of the study that should be further explored is whether during the repetition priming part of the study, if the infant needs to be exposed to the previous stimulus in full or if a partial reminder of the stimulus would show the same results. The importance of this study is that it shows infants have the capacity for memory storage and that this storage has the potential to be enhanced through repetition.

Another study that looks at the impact of repetition on early childhood memory involves an apparatus that is very much a part of our society: the television. The previous study looked at the effect of distracters and the impact of repetition while this study by Barr, Muentener, Garcia, Fujimoto, and Chavez effects of imitation caused by repetition. Television is a very prevalent part of our lives today and it has been shown that the amount of exposure in infants is high (Barr et al.. 2007). This study builds off previous studies by Bandura et al. (1963) which demonstrate the fact that children were more likely to show aggressive acts after they watched them on television. The authors of this study wanted to see if this effect could be seen in young infants also. This is important to look at because previous studies have not determined the effect of repetition in infant television programming as much of what they are watching are often repetitions of specific shows. Similar to the Turati et al. (2008) study, this research was also broken down into multiple experiments. The participants in the first experiment consisted of 108 full-term, healthy infants (58 girls and 50 boys). The infants were assigned to one of three groups which were a live administration given three times, a video given six times or a baseline control condition. 24 hours after the infant was exposed to the live session or recorded videos, a researcher returned and presented the stimuli presented in the demonstration stage in front of the child. The results show that there was no significant difference between the individuals exposed to the live versus recorded sessions but that they both had much higher levels of imitation than the control group whom was not exposed to the test stimuli. The second experiment looked at only 21 month olds and seeks to determine whether there was a video deficit present in these infants who have been exposed to more recorded television that may not be in younger infants. This part of the study employed 12 infants who were 21 months-old. The results of this part of the experiment again showed that infants who were exposed to the live and recorded situations showed a significantly higher score than the control group which again demonstrates repetition effects (Barr et al. 2007). One interesting finding was that the infants who were shown the video three times had a significantly lower score than the infants who were shown the live demonstration three times (Barr et al, 2007). This

shows that repeated exposure really can increase the imitation of the desired action. The last part of the study wanted to determine if infants as young as 12 months could imitate stimuli from television after deferred imitation as previous studies claim that 14 months is the youngest age at which infants can do this (Barr et al., 2007). This part of the research used 36 full term, healthy 12 month-old infants and the results again demonstrated that the infants had much higher imitation scores than the baseline with no difference between live and recorded administrations. One limitation of these experiments by Barr et al (2007) is that there may be some perceptual coding issues. For example, it may be that it is harder to transfer the 2D images on the television from the 3D images that are presented in front of the infant and therefore may explain why this video deficit is occurring. Seeing the stimuli in the 3D demonstration may make it easier for deferred imitation to occur in the same medium of 3D presentation (Barr et al 2007). Further research should employ more technology in order to separate these effects from the results. Also, the presentation of the stimuli by the different researchers varied across the participants and therefore this could have had some effect on the results. It is important that future research make the live administrations more uniform across the different presentations. Despite these methodological issues, this study shows that there is an important role of technology in infant learning and memory and shows infants do have the capacity to remember the things that they see on television (Barr et al. 2007). This finding is also significant in terms of videos and programs designed to improve infant intelligence that may carry onto later life outcomes.

Another article by Defrancisco and Rovee-Collier (2008) explores the effects of priming on young infants and how it can lead to the re-emergence of once forgotten memories. The fact that infants can “forget” may serve to demonstrate that they were able to form the memory in the first place. This is an important concept because in order for memories in infancy to affect later life outcomes, these memories need to be remembered and retained within the individual. In order for a memory to be properly retrieved the cues needs to match the cues from the original exposure with the memory. In this study, 138 infants were used. Similar to the other studies that have been discussed, these infants were all full-term and healthy. This is an important aspect of the studies because having infants that are not healthy or properly developed may have the potential to eschew the results. The method of this study followed previous studies conducted by Rovee-Collier which use a train task and a mobile task depending on the age. The infants were trained and tested with the mobile which was hand-painted and therefore the infant had no previous exposure to it (Defransisco&Rovee-Collier, 2008). Their ankles were connected to a string which attached to the mobile and each time the infant kicked, the mobile moved. The train task was only used on infants 6 months and over as it was not appropriate for 3 month-olds. The procedure of the study consisted of three different phases in which the infants received training sessions that were given a day apart. After a week, they received a reactivation treatment and after another day a long-term retention test. The first part of the training began with a nonreinforcement period followed by a reinforcement period and then again another nonreinforcement period. The first experiment looked at how a reactivated memory could be retrieved by a cue that was very broad (Defransisco&Rovee-Collier, 2008). This answers one of the

limitations presented in a previous study by Turati (2008) which did not demonstrate this in the study. For the 9 month-old infants in this study, it was found that they showed a level of significant retention whether they were tested with a different train in the same environment or with the same train in a different environment. For the 12 month-olds, similar results were collected. For the second experiment in the study, the researchers looked at whether 9 and 12 month-old infants could be primed with a different cue in the same environment or the same cue in a different environment when they were tested with the original cue in the original environment after 24 hours. The 9 month-olds showed remembering when they were primed with a different cue in the same environment but not when they were primed with the original cue in a different environment (Defransisco&Rovee-Collier, 2008). This was the opposite for the 12 month-olds. These findings show that by the end of the first year, the environmental constraints on remembering certain stimuli are probably less than any time before. This study shows how infant memory is present but also ever changing as the infant grows and matures (Defransisco&Rovee-Collier, 2008). Moreover, as infants grow older, the amount of time that a cue can be remembered increases with this age increase. Also, the more time that has passed between the first cue and later reminders of the cue increases the likelihood that the cue will not be remembered. The results demonstrate the importance of repetition in strengthening infant memory (Defransisco&Rovee-Collier, 2008). One limitation of this study is that there was not consistency in the variation between the different locations of the study. In order to improve the accuracy and generalizability of the study, it would be important to keep this variable stable throughout the study. Also, as is true with the other studies, the sample size may be too small on some of the individual experiments due to the fact that some could only be performed with infants of a certain age.

Deferred Imitation

Many studies, such as one previously discussed involving television cues have looked into the idea of deferred imitation as a way to determine memory in infants (Barr et al., 2007). Although this was part of the study they seemed to focus more on the effects that priming can have on this. A study done by Goertz, Kolling, Frahsek, Stanisch, and Knopf (2007), used the deferred imitation task in order to assess declarative memory in 12 month-old infants. In this study infants were shown a series of objects and watched (but did not physically touch) the demonstration of how the objects were used. They were then given these props at some point later and observed as to whether the target action is repeated. A task like this would show that the infant remembered how the objects were previously used and that they both acquired the information and chose to voluntarily retrieve and use this information (Goertz et al., 2007). For this study 24 children (9 girls and 15 boys) were included whose ages ranged from 11 months and 15 days to 12 months and 15 days. As with all previous studies, this is a severe limitation of the study in that the results may not hold the same power as a study that included more infants would. The results of this study showed that the tin can, cup and knife and drum used as the action items were spontaneously performed more often than the toy pig and mouse were (Goertz et al., 2007). This study showed that it is possible to study

declarative memory in infants toward the end of the first year of life. Because these infants are actively choosing to manipulate the object in the way that they chose, this demonstrates that it is in fact declarative memory that is being shown. Although the authors did not discuss this, Barr et al. demonstrated this idea too, that the infants that were repeating the items viewed on the television and live performance were probably doing so using declarative memory (2007). This is a difficult concept to grasp as most people believe that declarative memory is mostly verbal; however, this is not the case as shown by the studies done with the 12 month-olds in which speech is not fully developed. Despite this, through their nonverbal actions, they are able to demonstrate the fact that they have retained a memory through repetition of actions previously seen.

Another example that uses similar procedures to the study by Goertz et al. is from an article called The influence of training views on infants' long-term memory for simple 3D shapes by Kraebel, West and Gerhardstein (2007). This study used the demonstration of 3D objects in order to show that infants can process these shapes and then recognize them at a later time. The first experiment used 3 month-old infants and sought to see if after 24 hours that infant was able to remember a less complex object. The conditions that they used for the re-exposure was whether the infant was presented with the same view of the image or a different view. Fourty-two infants were used for this portion of the study and they were all screened using the same variables (Kraebel et al, 2007). They were shown either red bricks or red cylinders and these objects were hung on mobiles above the infant. As with the kicking studies by Rovee-Collier, these experimenters also used the same type of kicking frequency to determine recognition of the objects. For two days the infants were exposed to the mobiles for 15 minutes each for a total of 30 minutes of viewing time. The results of the study showed that the infants were able to remember to the shape even after the 24 hour delay. Not only does this demonstrate the presence of memory functioning, but it also leads to the conclusion that infants are able to process 3D shapes (Kraebel et al, 2007). Furthermore, because they were able to distinguish the two shapes, this evidence suggests that their memories are well-developed enough to contrast the objects. This study has is important because it demonstrates infants capacity for long-term memory retention which was previously thought to not be able to occur in infants this young. Along with every other study that has been previously mentioned, one of the most significant issues with infant studies is the sample size. Because it is difficult to secure a large number of infants to participate in the study and the fact that it is also a costly procedure, all of the studies lack in this area.

The topic of infant memory has been researched a great deal over the past few decades. Previous views such as infantile amnesia are being discounted through the numerous studies which show that infants do in fact have the capacity for memory formation even at very young ages. Although the debate has lessened, specific aspects of infant memory are still largely unknown. There have been studies which explored these different aspects of memory; however, there is a need for future studies which can further demonstrate evidence for these memory processes. For these future studies, it is essential that the sample sizes be expanded in order to increase the

validity of the results. Moreover, more uniform practices between the participants need to be employed so that the most accurate results are obtained. Overall, infants are much more cognitively able to form memories than was previously thought.