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ABSTRACT

Two experiments tested Hasher and Zacks' (1984) age-invariance hypothesis of frequency memory, which proposed that frequency memory is fully developed when a minimal level of physiological maturation is reached (by two or three years of age). Participating in the first experiment were 24 subjects at each of three ages: 8 years, 11 years, and young adults. In the second experiment, there were 24 subjects at each of 4 ages: 6 years, 8 years, 11 years, and young adults. In both studies, children and adults heard atypical action statements, presented as many as seven times, either in list format or embedded in script-like stories. In the first experiment, frequency estimates were higher for actions presented in list format, and age differences were found between 8- and 11-year-old children and adults. In the second experiment, frequency estimates were unaffected by the presentation format, and age differences were found only between 6-year-old children and adults. Results from both experiments suggests that frequency memory is fully developed by 6 years of age. Overall, results supported the age-invariance hypothesis and provided novel support for the Script-Pointer-Plus-Tag theory of script memory. (MM)

A Developmental Evaluation of Frequency Memory for Actions Presented in Lists and Scripts

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Abstract

In two Experiments, Hasher and Zack's (1984) age-invariance hypothesis of frequency memory was tested. Children and adults heard atypical action statements, presented as many as 7 times, either in list format, or embedded in script-like stories. In Experiment 1 frequency estimates were higher for actions presented in list format, and age differences were found between children, 8- and 11-years old, and adults. In Experiment 2, frequency estimates were unaffected by the presentation format, and age differences were only found between 6-year old children and adults. Overall, these results support the age-invariance hypothesis, and provide novel support for the Script-Pointer-Plus-Tag theory of script memory.

A Developmental Evaluation of Frequency Memory for Actions Presented in Lists and Scripts

Frequency memory, or memory for how often events occur, is proposed to be fundamental to the development of many higher-order cognitive processes including recognition, classification, categorization, scripts and schemata, reading, and decision making (Hasher & Zacks, 1979, 1984). The essential contribution of frequency memory to both cognitive and social development provides a functional rationale for Hasher and Zack's theory that frequency information is encoded automatically.

Hasher and Zacks (1984) describe a body of research that demonstrates encoding of frequency information jointly meets six necessary criteria for automaticity. Included in these criteria is that "encoding of this information will be invariant across a wide range of ages" (p. 1373). Specifically, Hasher and Zacks propose that when a minimal level of physiological maturation is reached, by age two- or three-years, frequency memory is fully developed.

Research prompted by this hypothesis is paradoxical because it supports three mutually exclusive conclusions: a) frequency memory is age-invariant (Hasher & Chromiak, 1977; Hasher & Zacks 1979; Sanders, Zembar, Liddle, Gonzalez, & Wise, 1989, Exp. 2), b) frequency memory is fully matured by the early elementary-school years, the modified age-invariance hypothesis, (Lund, Hall, Wilson, & Humphreys, 1983; Sanders, Zembar, Liddle, Gonzalez, & Wise, 1989, Exp.1), and c) frequency memory varies with age (Ellis, Palmer, & Reeves, 1988; Ghatala & Levin, 1973).

Two general observations can be derived from these studies. First, the hypothesis that frequency memory varies with age is more likely to be supported when pre-study instructions include specific test details. Second, an effect of age is more likely to be found in an analysis of discrimination, than in an analysis of accuracy. Each of these observations will be discussed in turn.

When pre-study instructions include test details, participants are likely to engage in strategic encoding. Several studies have shown that, for adults, strategic encoding of study stimuli improves judgements of frequency (Fisk & Schneider, 1984; Greene, 1986; Greene, 1988, Jonides & Naveh-Benjamin, 1987). Because the quantity, and the quality, of memory strategies improves with age (Schneider & Pressley, 1989) this finding is especially cogent when designing a developmental study of frequency memory. In two of the three studies that reported results consistent with the age-variance hypothesis, participants were instructed to prepare for a frequency test (Ellis et al., 1988, Exp. 1; Ghatala & Levin, 1973). Age differences reported in these studies may be due to differences in frequency memory; however, this interpretation can not be distinguished from the equally parsimonious explanation that the results reflect age differences in selection and/or execution of strategies.

When studies that allow strategic encoding of study stimuli are omitted, there is very little support for the hypothesis that frequency memory varies with age. In fact, the one study that remains to support this hypothesis reported no age differences in mean frequency estimates. Age differences were only reported in an analysis of discriminability, a correlation between actual and estimated frequency, (Ellis et al., 1988, Exp.2).

As noted above, age differences in frequency memory are more likely to be observed in an analysis of discriminability than in an analysis of accuracy. Specifically, all six experiments that support the age-invariance or modified age-invariance hypotheses reported analyses of mean estimates, median estimates, or proportion correct. Conversely, all three experiments that support the hypothesis that frequency memory varies with age reported age differences in an analysis of discrimination scores. Furthermore, two of these studies reported no age differences in analyses of accuracy as measured by mean frequency estimates (Ellis et al., 1988, Exp.2; Ghatala and Levin, 1973).

Jonides and Naveh-Benjamin (1987) argued that there are three sample statistics that must be included in a complete analysis of judgements of frequency. Mean frequency estimates describe accuracy, variance of frequency estimates describe reliability, and the slope of the frequency estimates, as a function of actual frequency, describe sensitivity to the frequency range. According to Jonides and Naveh-Benjamin, all three measures are necessary in order to adequately reflect performance in a test of memory for frequency.

This conclusion was based on a discussion of adult's frequency memory. It is not certain that the measures are similarly meaningful when interpreting results from a developmental study of frequency memory. Specifically, variability of estimates may measure a process that is independent of frequency memory. Previous studies have found that adult's frequency estimates are influenced by their previous judgements (Hockley, 1984), while children's frequency estimates are not (Ellis et al, 1988, Exp. 1). Perhaps, adults are more consistent in their judgements of frequency because of their tendency to associate current and previous judgements. It seems prudent, therefore, to consider accuracy of estimates, and sensitivity to the range of frequencies to be more interpretable measures of the development of frequency memory than variability of estimates.

In a developmental study of frequency memory, it is important to effect incidental encoding of frequency information, and to select dependent measures that provide the information necessary to analyze accuracy of estimates, sensitivity to the range of frequency, as well as reliability of frequency estimates. There is no developmental study of frequency memory that has done this. This was one objective of Experiment 1.

Experiment 1 also introduces a novel presentation paradigm designed to investigate the development of frequency memory for action statements that are, perhaps, more personally engaging. To do this, stories that activate script memory were used as the vehicle for presenting the critical stimuli. Script memory is a unique memory store that represents the sequence of actions for personally-experienced routine events (eg., going grocery shopping). A script develops when an event recurs. Once scripted, the event is represented in memory as a single abstract representation for the sequence of actions that constitute the event, and is activated when we think about the event, or when we hear a story that describes the event (Abelson, 1981).

In the script memory literature, two types of actions are distinguished, typical and atypical (Nelson. 1986). Typical actions are ones that occur each time the event is experienced, and so are included in the scripted representation of the event. For instance, the typical actions likely to be included in the script for going grocery shopping are; walk in, get a cart, select the groceries, pay, and leave. The typical actions contained in a script exist in memory as a single unit. Thus, when a story activates a script, all typical acts are expected, and will be inferred if not presented.

Atypical actions are not included in the script of a routine, because they may not occur each time the event is experienced, and because they are unimportant to the routine (Hudson, 1988). For instance, 'looking at the clouds' may not occur each time you go grocery shopping, but, even if it did, 'looking at the clouds' is unrelated and unimportant to the grocery shopping routine. According to the Script-Pointer-Plus-Tag theory of script memory, when an atypical action is presented in a story that activates a script, its memorial representation is a "tag" that is externally associated with the script (Nelson, 1986). Thus, when atypical actions are retrieved, the process involves accessing the "tags" associated with recently activated scripts.

In Experiment 1, 8-year olds, 11-year olds and adults were presented with "atypical" action statements, an equal number presented 0, 1, 2, or 4 times. The action statements were presented either in a conventional list format, or they were embedded in script-like stories. Following presentation of the stimuli, all participants completed the same frequency test.

Experiment 1

Method

<u>Subjects</u>. Twenty-four participants at each of three ages, 8 years old (mean age 8 years, 4 months), 11 years old (mean age 11 years, 6 months), and young adults, participated in this experiment. Data from one 8-year old was replaced because minimum attention to the stories was not attained. Half of the participants at each age were randomly assigned to the story condition and half to the list condition.

<u>Design and Materials</u>. This was a 2 x 3 x 4 mixed design. The between-subjects variables were condition (script vs list presentation), and age (8 years-old, 11 years-old, and young

adult). The within-subjects variable was frequency (0, 1, 2, 4).

There were two stories based on each of the following events: visiting a physician, visiting a dentist, grocery shopping, clothes shopping, eating at McDonald's, and eating at Pizza Hut. Each story was approximately 150 words long and included either 2 or 3 atypical actions. Examples of the stories are given in Appendix 1.

The atypical acts included in this study were pre-tested by six 8-year-olds and six undergraduates, who did not participate in the experiment. Judges listened to 38 action statements and reported whether they never (1), sometimes (2), or always (3) think about the action when they think about an activity. Judges were instructed to consider one of the experimental activities (health-care, shopping, restaurant) as the context within which to rate the items. The 16 actions presented in Appendix 2 were selected (mean ratings given by children and adults were 1.16 and 1.38 respectively).

The atypical actions were divided into four equal groups and each group was randomly assigned to a frequency. Two story sets were used to partially counter-balance frequency. Atypical actions assigned to frequencies 0, 1, 2, and 4 and integrated into stories in set one, were assigned to frequencies 4, 2, 1, and 0 and embedded into stories in set two. Each story contained either 2 or 3 different atypical actions. Repetition of actions was always presented across stories. Two presentation lists were created to match the presentation of atypical actions in the script and list conditions.

Procedure. Participants were tested individually. Those in the script condition listened to 14 pre-recorded stories each followed by a related question and then a 5-second pause during which the participant answered the story related question. Next participants received a list of 16 statements (12 "old" and 4 "new" actions), each followed by the numbers 0, 1, 2, 3, 4. They were instructed to circle a number that corresponded to their judgement of its presented frequency. The order of test items was arranged so that each quarter of the test list contained one item from each actual frequency.

To monitor attention, each story was followed by a related question. Participants whose accuracy on these questions was below 75% were replaced. An example of the questions follows each of the sample stories in Appendix 1.

Order of story presentation was random with two restrictions. First, in each third of the story set, one story from each of the three activities was presented. Second, each atypical act was repeated in a segment of the story set that corresponded to its frequency. For instance, if an item was presented four times, it occurred once in each quarter of the story set.

Participants in the list condition listened pre-recorded action statements and rated each one for typicality (the same instructions and rating scale as were used to pre-test the actions for typicality). The actions were presented in groups of two or three, and before each group, an activity was named. This was the activity within which participants were to rate that group of actions. Following instructions, participants were given up to three practice trials before the experimental list began. When participants were comfortable with the instructions, the list of 34 actions was presented (4 actions repeated each of 1, 2, and 4 times plus 3 recency and 3 primacy actions). Order of presentation was identical to the order of actions presented to participants in the script condition. Following list presentation, participants completed the same frequency test given to participants in the story condition.

Results

An analysis of variance was performed on mean frequency estimates, median frequency estimates, and variance of estimates, with age and condition as between-subjects variables and frequency as a within-subjects variable. Because of the relatively small number of observations at each frequency level (4 observations), macro-subjects were created for the analysis of the variances of the frequency estimates. Participants were arranged into groups of three, and the variance of frequency estimates was calculated from the newly formed macro-subject. Finally, the slope of mean frequency estimates for each participant was entered into an analysis of variance with age and condition as between-subjects variables. Scheffe's post hoc tests were used to interpret the significant effects.

Mean Estimates. Mean frequency estimates by age, condition, (script vs. list), and frequency are presented in Figure 1. There were significant main effects of frequency, F (3, 198) = 630.75, MSe = .30, age, F (2, 66) = 14.82, MSe = .42, and condition, F (1, 66) = 44.49, MSe = .42. These main effects were qualified by the interactions of age x frequency, F (6, 198) = 9.5, MSe = .30. condition x frequency, F (3, 198) = 23.14, MSe = .30, and age x frequency x condition, F (6, 198) = 3.67, MSe = .30.

Frequency estimates increased as a function of presented frequency. Children's mean frequency estimates were larger when the stimuli were presented in list format than when they were presented in script format. The frequency x age x condition interaction was reliable because at frequency of 4, in the story condition only, mean frequency estimates of both child groups were equal and smaller than mean frequency estimates of adults.

Median Estimates. Figure 2 displays the median estimates by age, condition, and frequency. There were main effects of frequency, F (3, 198) = 560.23, MSe = .19, age, F (2, 66) = 8.79, MSe = .31, and condition, F (1, 66) = 32.98, MSe = .31. Once again, these main effects were qualified by the interactions of age x frequency, F (6, 198) = 12.19, MSe = .19, and condition x frequency, F (3, 198) = 17.77, MSe = .19. The frequency x age x condition interaction approached significance, *F* (3, 198) = 1.81, MSe = .19, p = .10.

Frequency estimates increased as a function of presented frequency, and for both groups of children, median frequency estimates were higher in the list condition than in the script condition. When the script and list conditions were analyzed separately, age differences were only significant at frequency of 4. In the list condition, at frequency of 4, median estimates of 8-year old participants were smaller than median estimates of 11-year old participants and adults (median estimates of 11-year old children and adults did not differ). In the script condition, at frequency of 4, median estimates of 8- and 11-year olds were equal and smaller than median estimates of adults.

Variance of Estimates. In the analysis of variance of estimates there was a main effect of frequency, *F* (3, 54) = 20.07, MSe = .10, and an interaction of age x condition, *F* (2, 18) = 6.62, MSe = .09. In the script condition, the variance of estimates of 11-year olds were larger than the variance of estimates of either 8-year olds or adults. In the list condition, variance of estimates of 8-year old children were larger than variance of estimates of either 11-year olds or adults. Mean variance of estimates by condition and age are given in Table 1.

Table 1
Variance of Estimates
By Age, Condition, and Frequency

	Presented Frequency				
	0	1	2	4	Mean
Script					
8 years	.25	.52	.57	.96	.57
11 years	.72	.56	.82	1.30	.85
Adults	.23	.35	.96	.52	.52
Mean	.40	.48	.78	.93	.64
List					
8 years	.11	.64	.76	1.11	.65
11 years	.00	.40	.82	.47	.42
Adults	.23	.31	.91	.77	.55
Mean	.11	.45	.83	.78	.54

Slope: Mean slope values of frequency estimates as a function of actual frequency by age and condition are presented in Table 2. In this analysis there were main effects of age, *F* (2, 66) = 16.73, MSe = .05, condition, *F* (1, 66) = 10.83, MSe = .05, and an interaction of age x condition, *F* (2, 66) = 7.43, MSe = .05. In the script condition, the slopes of mean frequency estimates of both groups of children were equal and smaller than the slope of mean frequency estimates of adults. In the list condition there were no age differences.

Table 2
Means Slope Values
By Age and Condition

	8 years	11 years	Adults	Mean
Script	.459	.545	.827	.610
List	.619	.807	.759	.728
Mean	.539	.675	.793	.669

Discussion

Of particular interest were the interactions of age with condition and frequency. In the list condition, at frequency of 4, median estimates of 8 year old children were smaller than median estimates of 11 year old children and adults. There were no effects of age in the analyses of mean frequency estimates, or slope of estimates.

In the script condition, for actions presented 4 times, mean and median frequency estimates, of grade 3 and grade 6 children were equal, and both smaller than mean and median frequency estimates of adults. The slope of mean frequency estimates of grade 3 and grade 6 children were equal and smaller than the slope of adult estimates.

Overall, results from the list condition support the age-invariance hypothesis, while results from the script condition support the hypothesis that frequency memory improves with age. Interestingly, the effect of age was only apparent at the presented frequency of 4. In Experiment 2, the highest presented frequency was increased to 7 to explore age differences over a wider range of presented frequencies. A second objective of Experiment 2 was to examine frequency memory over a greater range of ages. Accordingly, a group of 6-year-olds was included in Experiment 2.

Experiment 2

Method

Subjects. There were 24 participants at each of four ages, 6 years old (mean age 5 years, 11 months), 8 years old (mean age 8 years, 3 months), 11 years old (mean age 11 years, 3 months), and young adults. Half of the participants at each age were randomly assigned to the script condition and half to the list condition. Six 6-year-olds were replaced because two children did not meet the minimum criterion for attention, and four children had corrected recognition scores that were at or below 0. Three 8-

year olds were replaced for the same reasons (one child did not meet the minimum requirement for attention and two children had corrected recognition scores that were at or below 0).

Design and Materials. This was a 2 x 4 x 5 mixed design. The between-subjects variables were condition (script vs. list), and age (6 years old, 8 years old, 11 years old, and young adults). The within-subjects variable was frequency (0, 1, 3, 5, 7).

There were two stories from each of the following events: grocery shopping, clothes shopping, toys shopping, eating at McDonald's, eating at Pizza Hut, and eating at Dairy Queen. Each story was approximately 170 words in length and contained 4 atypical actions.

To monitor attention, each story was followed by a related question. Participants who correctly answered fewer than 75% of the questions were replaced. Examples of stories and related questions are given in Appendix 3.

The 15 atypical acts included in this study were selected from the pool generated for Experiment 1 (mean typicality rating of the actions used in Experiment 2 were 1.17 and 1.34 from children and adults respectively). They were divided into five equal groups and randomly assigned to a frequency (0, 1, 3, 5, or 7). To partially counter-balance frequency, there were two story sets. The atypical acts assigned to frequencies of 0, 1, 3, 5, 7 and embedded into stories in set one, were assigned to frequencies 5, 7, 0, 3, 1 and embedded into stories in set two.

Procedure. Participants were tested individually. Those in the script condition listened to 14 pre-recorded stories, each followed by a related question. Next, participants received a randomly ordered list of 15 actions (12 'old' and 3 'new'), each followed by the numbers 0 through 7. Participants circled a number beside each item that corresponded to their judgement of its presented frequency.

Order of story presentation was random with the following constraints. First, in each half of a story set, one story from each of the six events was presented. Second, between repetitions of an atypical action, at least one story that did not present that item intervened.

Participants in the list condition were asked to listen carefully to a list of actions, no mention was made of a subsequent test. The list contained 54 action statements, 3 repeated each of 1, 3, 5, and 7 times, plus 6 primacy and recency items. Order of list presentation was random with the constraint that at least five unrelated items separated repetitions of an action statement. List presentation was followed by the same frequency test given to script-condition participants.

Results

Data was analyzed in the manner described in Experiment 1.

Mean Frequency Estimates. Mean frequency estimates by age, condition, and frequency are in Figure 3. There was a main effect of frequency, F (4, 352) = 359.75, MSe = .92. Mean judgements of frequency increased as a function of presented frequency. There was no significant effect of age, F = 1.10.

Median Estimates. Median estimates by age, condition, and frequency are reported in Figure 4. There was a reliable effect of frequency, F (4, 352) = 261.58, MSe = 1.40 and an interaction of age x condition, F (1,88) = 2.95, MSe = 3.65. Median frequency estimates increased across the presentation frequencies 0, 1, 3, and 5. At frequency of 5, and only for the 6-year old children, median frequency estimates were larger in the list condition than in the script condition.

In the script condition, median frequency estimates of 6-year old children were smaller than median frequency estimates of adults. There were no effects of age in the list condition.

Variance of Estimates: There were two main effects, age, F (3,24) = 6.07, MSe = 3.77, and frequency, F (4,96) = 33.87, MSe = 1.87. Variance of estimates of adults and 11-year olds were equal and smaller than variance of estimates of 6- and 8-year olds, who did not differ from each other. Variance of estimates by age, condition, and frequency are displayed in Table 3.

Table 3
Variance of Estimates
By Age, Condition, and Frequency

	Presented Frequency					
	0	1	3	5	7	Mean
Script						
6 years	.028	2.125	4.458	4.320	4.729	3.182
8 years	.223	.729	3.472	4.507	4.722	2.731
11 years	.028	.306	1.458	2.465	3.014	1.454
Adults	.868	1.299	2.198	3.0209	3.5209	2.181
Mean	.139	.625	1.417	2.079	2.834	1.419
List						
6 years	1.896	3.820	4.549	4.847	3.827	3.788
8 years	.056	2.264	3.860	4.632	3.202	2.803
11 years	.486	1.646	3.458	1.657	1.986	1.847
Adults	.125	1.070	1.854	1.985	4.049	1.817
Mean	.317	.903	1.604	1.748	2.236	1.362

Slope of Estimates. The slope of estimates by age and condition are given in Table 4. There were no reliable effects.

Table 4
Slope of Frequency Estimates as a Function of Presented Frequency By Age and Condition

Script		List	
6 years	.494	6 years	.632
8 years	.635	8 years	.599
11 years	.663	11 years	.654
Adults	.649	Adults	.732
Mean	.610	Mean	.654

Discussion

In the list condition, there were no age differences in the analyses of mean frequency estimates, median frequency estimates, or slope of mean frequency estimates. In the script condition, median frequency estimates of six-year-olds were reliably smaller than median frequency estimates of adults. However, there were no age differences in the analyses of mean frequency estimates, or slope of mean frequency estimates as a function of actual frequency. In general, results support the hypothesis that frequency memory is age-invariant.

General Discussion

Results from Experiments 1 and 2 suggest that frequency memory is fully developed by age 6 years. The list conditions of Experiments 1 and 2 support Hasher and Zack's age-invariance hypothesis, and advance the literature in two ways. First by using action statements as the stimuli. Studies that support the age-invariance hypothesis, presented participants with lists of words, pictures, or letters. In Experiments 1 and 2, it was found that children and adults are also equally accurate in judging the presented frequency of action statements. Second, children and adults were observed to be equally sensitive to the range of frequencies, as measured by the slope of mean frequency estimates.

Results from the list and script conditions of Experiments 1 and 2 are consistent with previous studies that have analyzed accuracy and reliability of frequency estimates (Ellis et al., 1988; Ghatala & Levin, 1976). Judgements of frequency provided by children and adults were equally accurate (mean estimates), however, young children (6- and 8-year olds) were less reliable in their frequency judgements than were 11-year olds and adults. As discussed in the introduction, reliability of estimates may measure something that is independent of frequency memory. For instance, it may reflect age differences in the tendency to connect current and previous frequency estimates (Ellis et al, 1988, Exp. 1, Hockley, 1984). Thus, accuracy of estimates is a more interpretable measure of frequency memory.

An important outcome, that is currently being investigated, is the different age effects observed in the script conditions of Experiments 1 and 2. Specifically, age differences in accuracy and sensitivity to the range of frequencies were found between both 8- and 11-year old children and adults in Experiment 1 but not it Experiment 2. Similarities across experiments help to dismiss some explanations. Story presentation and testing format of Experiments 1 and 2 were identical, so age differences found between children and adults in the script condition of Experiment 1 could not have been due to age differences in: a) memory deficits following dissimilar encoding and retrieval cues, or b) information loss between study and test, or c) interference, or d) test difficulty.

One possible explanation relates to the activities described in the stories of Experiments 1 and 2. In Experiment 1, participants heard stories about going shopping, going to a restaurant, and going to a health-care professional. In Experiment 2, health-care stories were not presented. It is possible that children do not have a 'script' for going to a health-care professional. And, if the health-care theme is scripted for adults, but not for children, the adults in Experiment 1 may have had an encoding and/or retrieval advantage.

The Script-Pointer-Plus-Tag theory of script memory describes this advantage. According to this theory, an atypical action that is presented in a story that activates a script is represented in memory as a tag that is externally associated with the script. Accordingly, several "tags" associated with a single script may exist in memory as a kind of list. The atypical actions presented in the health-care stories of Experiment 1 may have been represented in memory as a 'list' for adults but not for children. Given the evidence that frequency memory for actions presented in a list is age-invariant, it is expected that when stimuli is tagged to a script, performance on a frequency test will not vary with age.

This suggests that performance on a frequency test is age-invariant when the stimuli is presented in lists, or embedded in script-like stories. However, frequency memory may vary with age when the stimuli is embedded in non-scripted stories. To test this, a study that examines age differences in memory for the frequency of actions presented in familiar and unfamiliar script-like stories, is in progress.

A second possible explanation for the different developmental patterns across experiments relates to the array of stories presented. In Experiment 1, participants heard action statements repeated across stories that described three distinct routines. In Experiment 2, they heard actions repeated across stories that described two discrete routines. Perhaps, the children in Experiment 1 had difficulty retrieving the critical information across three discrete scripts. Research that examines frequency memory for atypical actions presented across and within script-like stories is in progress to test this possibility.

Results from the script conditions of Experiments 1 and 2 contribute novel support for the Script-Pointer-Plus-Tag theory of script memory. First, children and adults were able to access the frequency of atypical actions independent of the frequency of script-like stories. Second, in many conditions, performance on the frequency test was similar when the stimuli were presented in lists or embedded in script-like stories. These findings are consistent with the Script-Pointer-Plus-Tag theory. Atypical actions presented in a script-like story are externally tagged to the script, and represented as a kind of associated list of actions. Experiments 1 and 2 show that this 'list' of atypical actions is independently accessible, and that frequency memory for actions represented as a list of 'tags', is not different from frequency memory for actions that were presented in list format.

In conclusion, Experiments 1 and 2 contribute to our understanding of the development of frequency memory and introduce new directions for future research. Results from participants in the list conditions provide very strong support for Hasher and Zacks age-invariance hypothesis. Judgements of frequency from 6-, 8-, 11-year old children, and adults were equally accurate and sensitive to the range of frequency of action statements presented as many as 7 times. Results from participants in the script conditions provide less consistent support for this hypothesis. In Experiment 1, age differences in accuracy, and sensitivity to the range of frequencies were reported between children and adults. In Experiment 2, there were no age differences in accuracy of frequency estimates, or sensitivity to the range of frequencies, between 8-year olds, 11-year-olds, and adults. Current research is examining if age differences reported in Experiment 1 were due to differences in the strength of the scripts activated by the stories, or to age differences in the ability to retrieve information across discrete scripts.

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FIGURE 1

MEAN FREQUENCY ESTIMATES

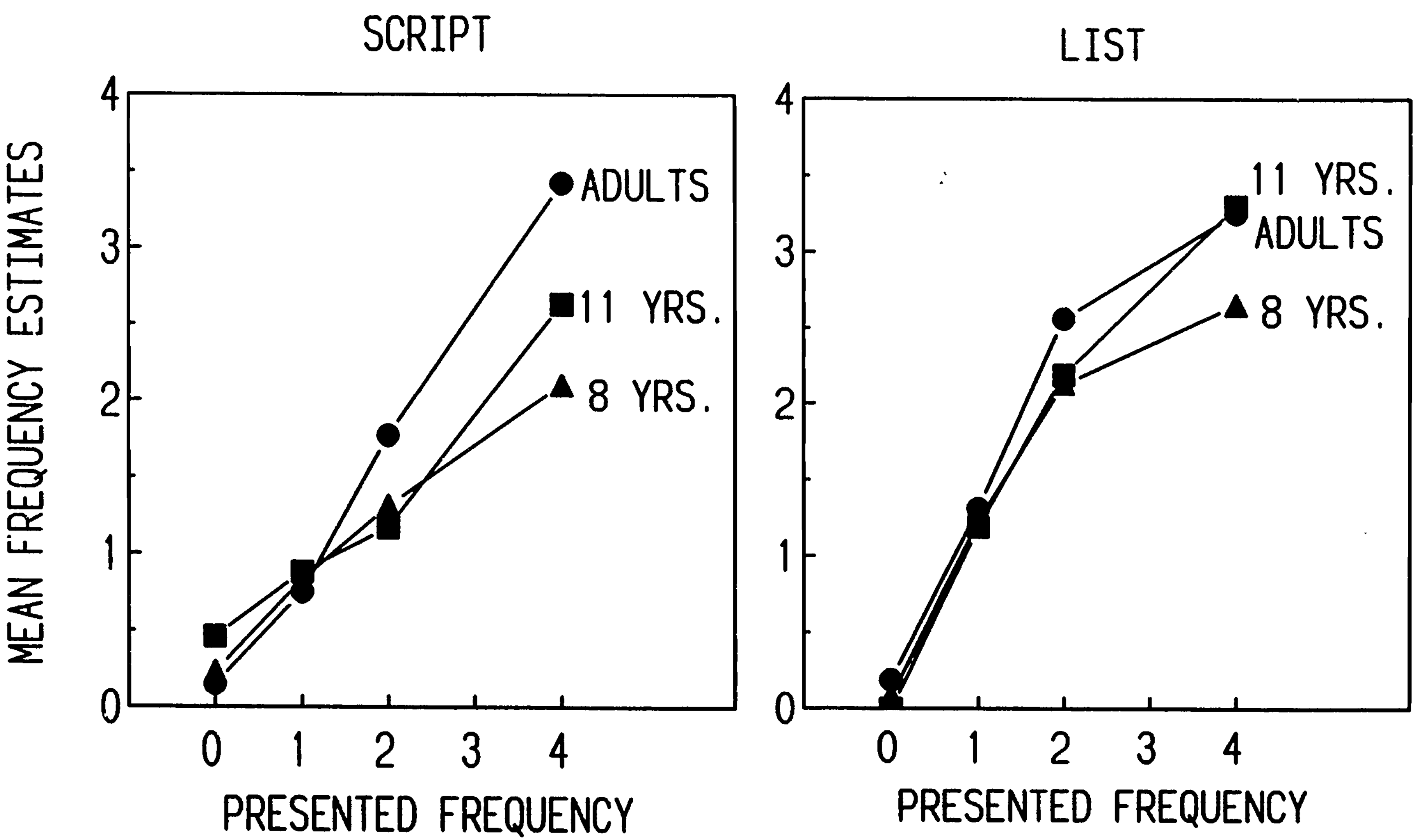


FIGURE 2

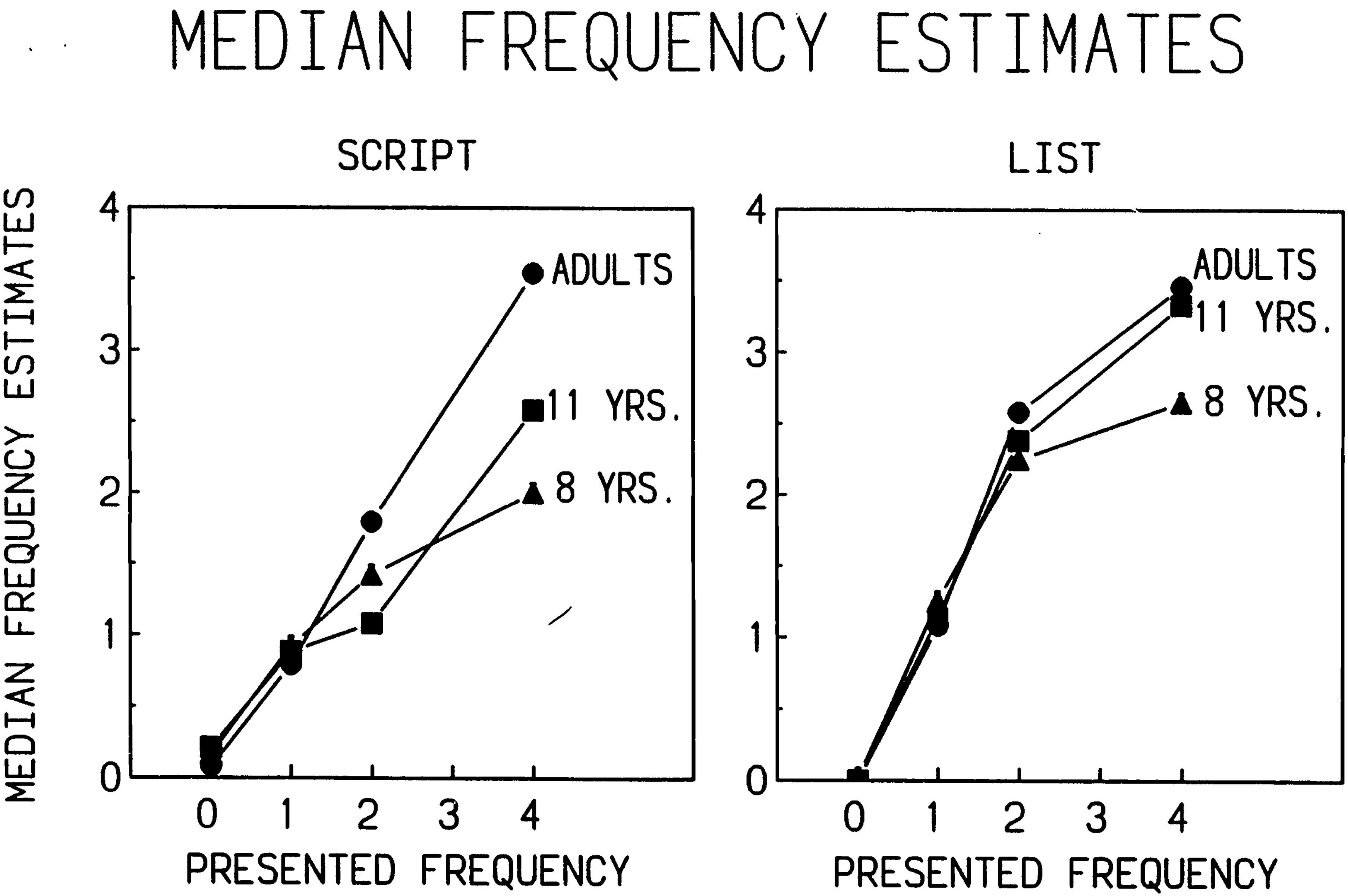

MEDIAN FREQUENCY ESTIMATES
SCRIPT
LIST
MEDIAN FREQUENCY ESTIMATES
ADULTS
11 YRS.
8 YRS.
PRESENTED FREQUENCY
0
1
2
3
4

FIGURE 3

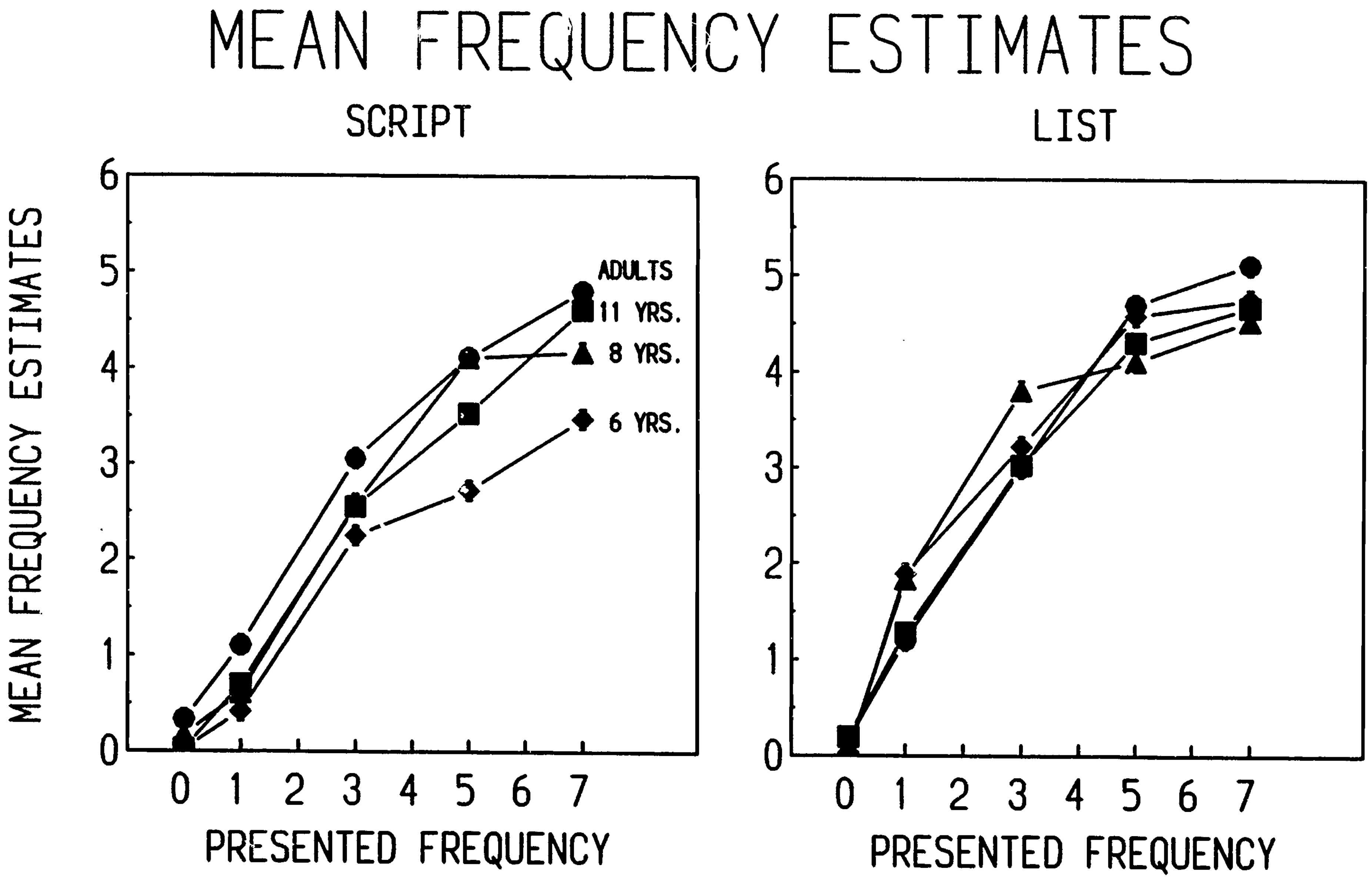
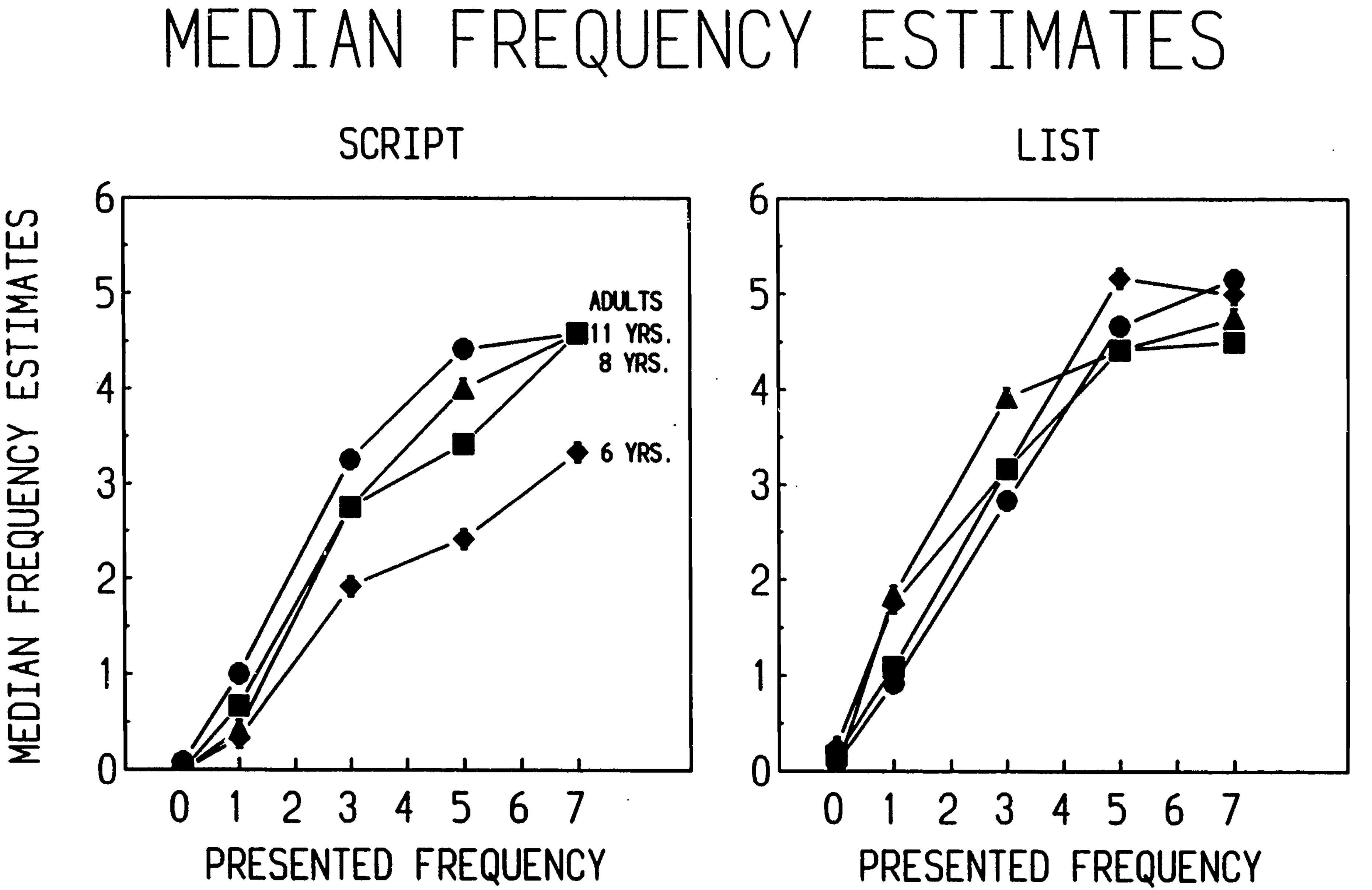

MEAN FREQUENCY ESTIMATES
SCRIPT
LIST
MEAN FREQUENCY ESTIMATES
ADULTS
11 YRS.
8 YRS.
6 YRS.
0
1
2
3
4
5
6
PRESENTED FREQUENCY
0 1 2 3 4 5 6 7

FIGURE 4


MEDIAN FREQUENCY ESTIMATES
SCRIPT
LIST
MEDIAN FREQUENCY ESTIMATES
0
1
2
3
4
5
6
ADULTS
11 YRS.
8 YRS.
6 YRS.
0 1 2 3 4 5 6 7
PRESENTED FREQUENCY
0 1 2 3 4 5 6 7
PRESENTED FREQUENCY

Appendix 1

Experiment 1 Stories

Going to Pizza Hut

Samuel's favourite food in the whole wide world is pizza. So, when his Mom and Dad asked him if he would like to go to Pizza Hut for supper it is not very surprising that he ran to the car before he had a chance to say "yes". They drove to the restaurant and parked the car. Samuel and his parents walked into the restaurant and waited for someone to show them to a table. They sat down and looked at the menu. Samuel <u>sang a song</u> while he waited for their food. When the waiter brought them their pizza Samuel ate 3 pieces very quickly. When they had all finished they walked to the front of Pizza Hut. Samuel <u>scratched his elbow</u> while his father paid for the pizza. Then they left the restaurant to go home.

What is Samuel's favourite food?

Going Grocery Shopping

Every Saturday morning Allyson and her mother go grocery shopping. This Saturday was no different. When Allyson's mother told her that it was time to go <u>she stepped on a mat</u> and went to the car. They drove to the store and parked the car. When they got into the store Allyson picked a cart and then she and her mother went up and down the isles and selected the groceries. Allyson's mother always had a list of things to buy and she looked at it a lot. Allyson was allowed to choose one treat for herself. Today she <u>blinked her eyes</u> and choose a box of crayons. When they finished picking all of the food they went to the cashier and waited in line. Then Allyson and her Mom picked up the groceries and went home.

What treat did Allyson choose?

Going to the Doctor

Daniel knew that it was time for his annual check-up at the doctor but he wasn't sure that he really wanted to go. He got into the car and sat quietly while his mother drove to the office. They walked into the office and his mother went to the secretary's desk to say that they had arrived. While Daniel sat in a chair and waited for the doctor to call his name he <u>looked at the ceiling</u> then he read a book. The doctor looked in Daniel's throat, eyes and ears. Then the doctor told Daniel that he was very healthy and very cute. Daniel <u>laughed to himself</u> when he and his mother left the doctors office to go home.

What did Daniel do while he waited for his turn?

Appendix 2

Atypical Acts

Waved to a friend

Looked at the clock

Sang a Song

Tapped Fingers

Kicked a Stone

Tied Shoes

Looked at the clouds

Scratched Elbow

Blinked Eyes

Nodded Head

Combed Hair

Heard a Baby Cry

Stretched Legs

Looked at the ceiling

Laughed to self

Stepped on a Mat

Appendix 3
Experiment 2 Stories

Going Grocery Shopping

Adam loved to go grocery shopping with his mother because she usually let him choose one treat. When his mother asked him if he would like to go he said "yes" right away. Adam scratched his elbow when he and his mother got into the car to drive to the grocery store. They walked into the store and Adam choose the cart. He looked at the clock when he saw his mother's very long grocery list. They went up and down each of the aisles to select the groceries. After Adam choose a book for his special treat he nodded his head and went to the cashier. While he waited in line Adam looked at the ceiling. When they got to the front of the line Adam's mother paid for the groceries and they left to go home.

Why does Adam like to go grocery shopping with his mother?

Going to McDonald's

When Karen came home from school her mother asked her if she would like to go to McDonald's for supper. It had been a long time since Karen had been to McDonald's so she was very excited about going and said "yes" right away. They drove to McDonald's and parked the car. When they went into McDonald's Karen looked at the ceiling then she went to the line to wait. When it was time for Karen and her mother to order their food Karen nodded her head and asked for a Big Mac, french fries, and apple juice. Karen blinked her eyes when her mother paid for the food. They went to a table to sit and eat their supper. When they were finished Karen and her mother cleared the table. Karen looked at the clouds when they left McDonalds to go home.

What did Karen order to drink?