Stormy Weather:

A Front-end Evaluation

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EXECUTIVE SUMMARY: INTRODUCTION

This report presents the findings from a front-end evaluation for *Stormy Weather*, a major traveling exhibition on severe storms. This exhibition is being developed through a collaboration among the Smithsonian Institution Traveling Exhibition Service, National Museum of Natural History, St. Louis Science Center, and National Severe Storms Laboratory, National Oceanic and Atmospheric Administration (NOAA).

The purpose of conducting a front-end evaluation is to better understand visitors' perceptions and their baseline knowledge regarding a particular subject--in this case, severe storms. The goals of the evaluation were outlined in the Request for Proposal and were clarified during an initial meeting between the evaluators and representatives from participating institutions. The evaluation goals were to determine:

- differences between natural history museum visitors and science center visitors regarding demographic and group composition data (gender, age, education level, permanent residence, and group size and type)

- differences between natural history museum visitors and science center visitors regarding ratings of interpretive strategies (computer-based programs versus informational text, for example)

- visitors' memories, thoughts, and baseline knowledge about the three categories of severe storms--thunderstorms, blizzards, and hurricanes

- sources from which visitors obtain information about weather and their baseline knowledge about weather indicators

- visitors' ability to read weather maps and understand satellite and Doppler radar imagery

- visitors' baseline knowledge regarding safety measures that should be taken during severe weather and their ability to recognize a severe storm approaching.

EXECUTIVE SUMMARY: STANDARDIZED QUESTIONNAIRE

DEMOGRAPHICS

- Slightly more women than men were attracted to natural history museums and science centers (53 percent and 47 percent, respectively). There was little difference between natural history museums and science centers regarding gender composition.

- Science centers attracted slightly older visitors (mean=39.10 years) than did natural history museums (mean=37.39 years), but the difference is not statistically significant.

- Science centers attracted more 6-12 year olds than did natural history museums (63 percent and 55 percent, respectively), and natural history museums attracted more 13-20 year olds than did science centers (27 percent and 20 percent, respectively). Generally, more than half of the children who visited these types of institutions were 6-12 years of age.

- Natural history museum visitors are more educated than science center visitors.

- Natural history museums attracted more visitor pairs than did science centers (42 percent and 22 percent, respectively), and science centers attracted more groups composed of three or more visitors than did natural history museums (78 percent and 58 percent, respectively). This difference is significant.

- For both institutional types, there were more groups composed of adults and children than any other group type, but science centers attracted more adult/children groups than did natural history museums (74 percent and 53 percent, respectively). In addition, natural history museums attracted more adult pairs than did science museums (26 percent and 13 percent, respectively). These differences are statistically significant.

- Science centers attracted visitors with more children per visiting group than did natural history museums.

RATINGS OF INTERPRETIVE STRATEGIES

Respondents were asked to rate nine interpretive strategies on a seven-point scale ranging from "Don't like at all" (1) to "Like very much" (7).

Adult Respondents

- The three highest-ranked strategies for natural history museums and science centers were "live demonstrations," "things to handle/touch/manipulate," and "objects or artifacts."

- For "video programs," computer games," and "activities for small groups," science center respondents' mean ratings were significantly higher than natural history respondents' mean ratings.

- More science center respondents rated "live demonstrations" and "things to handle/touch/manipulate" high (7, on a scale from 1 to 7) than did natural history museum respondents.

- Women rated "objects or artifacts," "activities for small groups," and "things to listen to" significantly higher than did men.

- More women rated "live demonstrations" and "things to handle/touch/manipulate" high (7, on a scale from 1 to 7) than did men.

- Older respondents rated "objects or artifacts," "video programs," "dioramas," and "activities for small groups" higher than did younger respondents.

- Younger respondents rated "computer games" higher than did older respondents.

- For ages 14-34, more respondents rated "things to handle/touch/manipulate" high than rated it low. For ages 35+, more respondents rated the strategy low than rated it high.

- Adults visiting alone and adults visiting with children rated "video programs" and "computer games" higher than adult pairs.

Adults Responding for Children

- The three highest-ranked strategies for natural history museums and science centers are "things to handle/touch/manipulate," "computer games," and "live demonstrations," although the ranking varies with institutional type. Science center respondents ranked "computer games" second and "live demonstrations" third, and natural history museum respondents ranked "live demonstrations" second and "computer games" third.

- Science center respondents rated "activities for small groups" higher for children than did natural history museum respondents (5.16 and 4.68, respectively).

- Natural history museum respondents rated "things to listen to" higher for children than did science center respondents (5.11 and 4.54, respectively). Natural history museum respondents also rated "informational text/panels" higher for children than did science center respondents (4.07 and 3.42, respectively).

- More science center respondents rated "computer games" high for children than did natural history museum respondents.

Adult Ratings versus Child Ratings (According to Adult Respondents)

<u>Natural History Museums:</u>

- Adults rated "things to handle/touch/manipulate" and "live demonstrations" higher for children than they did for themselves.

- Adults rated "computer games" and "activities for small groups" higher for children than they did for themselves.

- Adults rated "objects or artifacts" and "informational text/panels" higher for themselves than they did for children.

Science Centers:

- Adults rated "things to handle/touch/manipulate" higher for children than they did for themselves.
- Like the natural history museum sample, adults rated "computer games" and "activities for small groups" higher for children than they did for themselves.
- Adults rated "objects or artifacts," "things to listen to," and "informational text/panels" higher for themselves than they did for children.

EXECUTIVE SUMMARY: IN-DEPTH INTERVIEWS

In Part III of the study, major findings from in-depth interviews with adults and children are presented. Eighty adults (14 years and older) were interviewed at four sites in summer 1994: National Museum of Natural History (NMNH), St. Louis Science Center (SLSC), Miami Museum of Science (MMS), and California Academy of Sciences (CAS) in San Francisco. Forty children (8-13 years old) were interviewed at two sites in summer 1994: National Museum of Natural History and St. Louis Science Center. Interview data fell into two categories: knowledge of storms and experience with storms. A brief outline, using headings from the interview guide, follows:

Knowledge of Storms

What are different types of storms?
What do these storms [thunderstorm, hurricane, blizzard] have in common?
What is different about these storms [thunderstorm, hurricane, blizzard]?
What is a storm?
What is happening on this weather map from one day this summer?
What do meteorologists measure to predict the weather?
What are definitions for the five basic indicators used to predict the weather?
What is happening in this picture [GOES (Geostationary Operational Environmental Satellite) visible image]?
What is happening in this picture [GOES infrared image]?
What is happening in this picture [Doppler radar image]?

Experience with Storms

What is the last storm you remember?
What was most memorable about that storm?
What words or phrases are true when thinking about storms?
How did you find out about today's weather?
What does it have to look like outside to know a severe storm is approaching?
What actions do you take if a severe storm is approaching?

In general, regional differences among respondents did not emerge in the knowledge-based questions but were more of a factor in the experience-based questions.

KNOWLEDGE OF STORMS

The first group of questions focus on respondents' knowledge of storms. These questions address the *Stormy Weather* exhibition team's keen interest in discovering what knowledge, ideas, and misconceptions visitors will bring to the exhibition. Team members also wondered if storm knowledge would vary by region.
What Are Different Types of Storms?

- Regional differences were not a factor in the amount or quality of knowledge respondents had about storms. Hurricanes were mentioned most often by adult interviewees, followed by rain/thunderstorms/monsoons. The most prevalent response among children was rain/thunderstorms/monsoons, followed by tornadoes.

What do These Storms [Thunderstorm, Hurricane, Blizzard] Have in Common?

<u>Adults</u>

- Adult interviewees overwhelmingly described how storms affect people's lives. Considerably more than half of adults, when thinking of what thunderstorms, hurricanes, and blizzards have in common, talked about the terrible toll storms take on life and property as well as the ways storms affect day-to-day existence.

- Slightly more than one-third of adult interviewees talked about the elements and qualities of weather that storms share. These visitors did not talk in scientific terms but described storm elements (e.g., wind, rain, and lightning).

- A few interviewees were slightly more sophisticated in their responses and described atmospheric conditions they thought were common to all storms.

- Finally, a few interviewees described the commonalities of storms in miscellaneous ways--the release of energy that occurs during storms, their connection to nature, their predictability, and the length of time they last.

<u>Children</u>

- Child interviewees, like adults, saw storms primarily in terms of their impact on human life.

- Less than one-quarter of children discussed the elements of weather that storms had in common.

- Finally, a few children described the common characteristics of storms in miscellaneous ways--their connection to nature and the ways they form.

What Is Different about These Storms [Thunderstorm, Hurricane, Blizzard]?

<u>Adults</u>

- When shown photographs of a thunderstorm, hurricane, and blizzard, the majority of the adults differentiated among the storms by describing the different temperatures, seasons, or regions of the country or world in which the storms tend to be found.

- Slightly more than one-third of adult respondents described differences in terms of different elements of weather (e.g., wind, snow, rain) associated with each storm.

- When some interviewees looked at the images, they discussed the levels of impact on people's lives.

- Finally, a few interviewees spoke about differences in miscellaneous ways--the length of time they last, how storms form, predictability of storms, and colors generated by storms.

<u>Children</u>

- The majority of child interviewees talked about the different elements of weather (e.g., wind and rain) of each storm type.

- More than one-quarter of the children described differences in region, tied to characteristics of the landscape, that distinguish one storm from another.

- Finally, a few children discussed differences in temperature or season in which certain storms are experienced.

What Is a Storm?

<u>Adults</u>

- Almost half of adults described storms as something natural that just happens. These people thought of storms as either more violent forms of nature or more severe forms of weather; a sense of inevitability ran through both types of responses.

- Less than one-quarter of interviewees defined storms as a mixing of various elements (e.g., temperature, clouds, and humidity).

- Some interviewees described storms as being determined by temperature. These respondents talked about temperature as either a clashing of different temperatures or a change in temperatures.

- Some respondents defined storms in terms of air pressure. These respondents talked about pressure as either a clashing of different pressures or a change in pressures.

- A few respondents defined storms as they did in the above two questions--in terms of weather elements (e.g., thunder, wind, and rain).

- A few interviewees defined storms in terms of how they affect people's lives.

- Finally, a very small number of interviewees defined storms as complex cycles of events.

<u>Children</u>

- Slightly more than one-third of children interviewed defined storms by the elements of weather (e.g., rain and snow) present.

- One-quarter of the children saw storms as natural events. Like adults, these young respondents saw storms as inevitable facts of life.

- Some children saw storms as events that affect people's lives.

- A few children attempted to explain why storms happen and described a clashing of temperatures or other elements.

- Finally, one child discussed storms as a cycle of events.

What Is Happening on This Weather Map from One Day This Summer?

Interviewees were given a weather map from the *Washington Post* from one day in July 1994 and were asked to interpret what they saw. Four major weather indicators were illustrated on the map: temperature, precipitation, high- and low-pressure systems, and warm and cold fronts. Evaluators looked for how many indicators respondents discussed and how they explained what they saw on the map.

<u>Indicators</u>

Adults

- Adult interviewees were almost evenly divided between those who discussed one or two indicators and those who discussed three or four, with a few more in the latter category. Many adults were not confident in their responses; there was a sense of hesitation and guessing in many of the responses.

Children

- Child interviewees talked about the weather map in a fashion similar to the adults: approximately half of these young respondents identified one or two weather indicators, with the other half discussing three or four indicators. Children were similarly hesitant and unsure of their responses. Their language tended to be simple; most children needed continuous probing to encourage them to talk about all elements of the map.

<u>Explanations</u>

Adults

- Approximately half of adults interviewed offered explanations for how the symbols depicted on the weather map interacted to create storms or weather events. The explanations fell into five categories:

    - A warm front meets a cold front
    - High pressure creates good weather, low pressure creates bad weather
    - Cold fronts bring rain
    - High pressure meets low pressure
    - Complex cycle of factors.

  The first two categories were most common, with only a few respondents offering explanations in the last three categories.

Children

- One-quarter of child interviewees offered explanations for the symbols depicted on the weather map. They explained the weather phenomena in three ways:

    - Warm air meets cold air
    - High pressure creates good weather, low pressure creates bad weather
    - High pressure meets low pressure

  The most prevalent response was that storms are formed when warm air meets cold air.

What Do Meteorologists Measure to Predict the Weather?

- The most prevalent response among adults and children was barometric pressure, followed by temperature. The third most frequently mentioned response by adults was humidity/moisture. Among children, it was rain/precipitation.

What Are Definitions for the Five Basic Indicators Used to Predict the Weather?

<u>Temperature</u>

- Ninety-six percent of adults and 98 percent of children understood temperature.

<u>Wind Speed</u>

- Ninety-three percent of adults and 80 percent of children understood wind speed.

<u>Wind Direction</u>

- Unlike wind speed and temperature, there is a discrepancy between adult and child knowledge regarding wind direction. Thirty-nine percent of adults and only 3 percent of children understood wind direction.

Relative Humidity

- Very few adult and no child respondents understood relative humidity to indicate the amount of water air can hold at a given temperature. "Moisture/wetness in the air" was the most prevalent response among adults; and "don't know" was most prevalent among children.

Barometric Pressure

- Even though two-thirds of the adults attempted to define barometric pressure, few were confident about their response. Eighty percent of the children said they did not know the meaning of barometric pressure.

What Is Happening in This Picture [GOES Visible Image]?

- Respondents were shown a GOES visible image of a hurricane. There is a substantial difference between adult and child knowledge regarding this image. More than half of adult respondents and 15 percent of child respondents knew that the photograph represented a satellite image of a hurricane.

- Adults correctly identified the storm depicted in the image twice as often as children. More than 80 percent of adults and almost 40 percent of children recognized a hurricane in the photograph.

- Sixty-eight percent of adults and 38 percent of children thought the image was produced by either a satellite or a camera in space.

What Is Happening in This Picture [GOES Infrared Image]?

- Respondents were shown a GOES infrared image of a hurricane. Significantly less adults and children were able to identify a hurricane in the infrared image than in the GOES visible image discussed above. Fewer adults and children were also able to identify satellite technology in the infrared image than in the GOES visible image.

- Twice as many adults as children correctly identified the storm in the photograph. Fifty-six percent of adults and almost one-quarter of children recognized the image of a hurricane.

- More than half the adults and more than half the children thought a satellite or a camera in space was used to produce the image. Several adults, in conjunction with various imaging techniques, also mentioned infrared technology.

What Is Happening in This Picture [Doppler Radar Image]?

- Respondents were shown a Doppler radar image of thunderstorms. Two adults and no children correctly identified the image.

- Sixteen percent of adults and children together identified thunderstorms in the photograph. The most prevalent response among adults was "precipitation"; the most prevalent among children was "temperature."

- Ten percent of adults and 3 percent of children mentioned Doppler radar as the means of creating the image. More than half of children thought the image was created on a computer. Nearly half of adults associated the image with satellite technology. Respondents often used the words radar and satellite interchangeably.

EXPERIENCE WITH STORMS

The remaining questions relate to respondents' experiences with various storms. In this section of the report, the region where data were collected is more relevant than in the previous section, "Knowledge about Storms." Although demographic data were not collected for each interview, some obvious regional differences did emerge in the data.

- Interviewees at the Miami Museum of Science talked about hurricanes more often than did interviewees from the other three sites. Children interviewed at the St. Louis Science Center talked about tornadoes more than did other children and more than most of the adults, including those interviewed in St. Louis.

What Is the Last Storm You Remember?

- Almost half of adult interviewees mentioned hurricanes as the storm they remembered most. Although a greater proportion of adult respondents from Miami talked about hurricanes, these storms were discussed by adult respondents at all four sites. Blizzards and floods were mentioned by few respondents. More than half of child interviewees talked about thunderstorms as the storm they remembered most. Blizzards, floods, and tornadoes were mentioned by few children.

- Approximately three-quarters of adults and three-quarters of children discussed storms either they or their families experienced directly.

What Words or Phrases Are True When Thinking about Storms?

To get a sense of respondents' general thoughts and feelings about storms, adults and children were given cards with various words and phrases on them. They were asked to sort the cards into two piles: those that are true when they think about storms and those that are not true. The phrases offered to children varied slightly from those offered to adults. Some options were simplified to make them more understandable to children.

- Adult and child responses to this question were similar. Both groups thought storms were a natural phenomenon and quite dangerous. More adults and children thought storms were hard to understand than easy to understand. The fewest number of adults and children thought of storms as freak occurrences.

How Did You Find Out about Today's Weather?

Respondents were asked the sources they used to find out about the weather.

- Television was the most common source for both adult and child respondents. Children were more likely than adults to go outside and check for themselves. Home instruments, weather radio, and computers were the least-used sources for obtaining information about the weather. Of those respondents who use weather radio, none mentioned NOAA specifically.

What Does It Have to Look Like Outside to Know a Severe Storm Is Approaching?

<u>Adults</u>

- More than half of adults talked about changes they saw in the sky--colors, rain, wind, or lightning. These respondents tended to group weather elements together when they talked about approaching storms. They usually did not talk about only rain, only wind, or only dark skies. When discussing these changing weather elements, it was usually in the context of tornadoes and thunderstorms. Such responses were most prevalent among interviewees in Washington, D.C., St. Louis, and San Francisco. Few respondents in Miami discussed changing weather elements as a sign of a storm.

- Some adult respondents answered that they rely on television or radio reports to warn them of an approaching storm. More respondents from Miami said this than respondents from the other three cities.

- A few adult respondents at all sites but Miami talked about miscellaneous ways they detect an approaching storm--counting seconds between thunder and lightning, major occurrences (e.g., windows blowing out), and animal responses.

Children

- Almost all child respondents from both data collection sites talked about looking outside for darkening skies, wind, and rain as a way to know a storm is coming. These young respondents talked mostly about thunderstorms, although a few discussed tornadoes.

- A few children, mostly in St. Louis, indicated that they rely on television and radio reports to warn them of storms. These respondents mostly discussed tornadoes.

- A few children at both sites talked about needing to see certain cloud forms to know a tornado was heading their way.

What Actions Do You Take If a Severe Storm Is Approaching?

- Nearly all adult respondents at the four data collection sites and child respondents in Washington, D.C. discussed thunderstorms. Seventy-five percent of adults in San Francisco talked about this storm type as well. Hurricanes were of top concern to 75 percent of adults in Miami but of relatively little concern to adults and children at other sites. Snowstorms were discussed infrequently by adults and children at all sites.

Thunderstorms: Adults

- Of adults discussing thunderstorms, most talked about finding shelter or, if they were outside, finding low ground.

- One-quarter of adults discussing thunderstorms described things to avoid if they were caught outside.

- One-quarter of adults discussing thunderstorms talked about safety measures they would take to protect themselves in their homes.

- And a few adults talked about needing supplies or needing to evacuate.

Thunderstorms: Children

- Like adults, most children talked about needing to seek shelter. Many of these respondents had direct experience with thunderstorms and tornadoes and were reporting actions they had once taken.

- One-quarter of young respondents described needing to get supplies.

- Some children talked about what to do if they were caught outdoors in a thunderstorm.

- And a few child respondents described safety measures to take indoors.

Hurricane: Adults

- Of adults who discussed hurricanes, two-thirds described a need to secure their homes.
- One-half of adult respondents who discussed hurricanes talked about needing to stock up on supplies.
- Some respondents discussed the need to evacuate if necessary.
- And a few adults talked about the general need to find a safe place to be.

Hurricanes: Children

- Two children provided minimal comment about hurricanes.

Blizzards: Adults

- Most adults talked about the need for adequate supplies.
- Others discussed staying indoors and protecting electric sources.

Blizzards: Children

- Of the few children who discussed this storm type, half talked about needing supplies.
- The other half talked about staying indoors.

Part I:

Introduction

INTRODUCTION

This report presents the findings from a front-end evaluation for *Stormy Weather*, a major traveling exhibition on severe storms. This exhibition is being developed through a collaboration among the Smithsonian Institution Traveling Exhibition Service, National Museum of Natural History, St. Louis Science Center, and National Severe Storms Laboratory, National Oceanic and Atmospheric Administration (NOAA).

The purpose of conducting a front-end evaluation is to better understand visitors' perceptions and their baseline knowledge regarding a particular subject--in this case, severe storms. The goals of the evaluation were outlined in the Request for Proposal and were clarified during an initial meeting between the evaluators and representatives from participating institutions. The evaluation goals were to determine:

- differences between natural history museum visitors and science center visitors regarding demographic and group composition data (gender, age, education level, permanent residence, and group size and type)

- differences between natural history museum visitors and science center visitors regarding ratings of interpretive strategies (computer-based programs versus informational text, for example)

- visitors' memories, thoughts, and baseline knowledge about the three categories of severe storms--thunderstorms, blizzards, and hurricanes

- sources from which visitors obtain information about weather and their baseline knowledge about weather indicators

- visitors' ability to read weather maps and understand satellite and Doppler radar imagery

- visitors' baseline knowledge regarding safety measures that should be taken during severe weather and their ability to recognize a severe storm approaching.

In response to these goals, the research design combined quantitative and qualitative instruments--a standardized questionnaire and an open-ended interview guide (see Appendix A). Since *Stormy Weather* will focus on severe weather (and severe weather differs according to geography) and be exhibited in natural history museums and science centers across the United States, data were collected in different regions of the United States at two natural history museums and two science centers. The four participating museums were:

National Museum of Natural History (NMNH), Washington, D.C.

St. Louis Science Center (SLSC), St. Louis, Missouri
Miami Museum of Science (MMS), Miami, Florida
California Academy of Sciences (CAS), San Francisco, California

All data were collected during a four-week period in summer 1994. From mid-July through mid-August, every Thursday, Friday, and Saturday, data were collected at one of the participating sites.[1] Each week data were collected at a new site.

STANDARDIZED QUESTIONNAIRE

Visitors responded to basic demographic questions (gender, age, education level, permanent residence, size of visiting group, and type of visiting group) and a lengthy question about the kinds of interpretive strategies they like in a museum or science center. This question (number 3 on the questionnaire; see Appendix A) listed nine strategies and asked respondents to rate each one on a seven-point scale ranging from "Don't like at all" (1) to "Like very much" (7). If respondents were visiting with children, they were asked, in addition, to rate each strategy according to what their children might like. Adults responded to this question for their children because children experience and see things in extremes, not in gradations, and gradations are important and necessary for analyzing rating scores.

Evaluators recruited eligible respondents (over 17 years of age) at high traffic areas in each museum using a continuous random sampling method. In museums that had a slow, but steady, number of visitors entering the data collection area, evaluators intercepted every third visitor. In museums that had a high number of visitors entering, evaluators intercepted every tenth visitor. The standardized questionnaire was completed by 743 respondents.

When visitors declined to participate in the study, evaluators recorded their gender and approximate age. The refusal rate was 15 percent. A chi-square analysis showed no difference between the refusal and respondent samples regarding gender; however, a t-test showed a significant difference in the mean ages of the two samples. The mean age of respondents was 37.88, while the mean age of refusals was 41.03. Those who declined to participate in the study were significantly older than respondents ($p=.010$). This finding suggests that the standardized questionnaire findings may not accurately reflect the demographics and opinions of older visitors.

Data Analysis

[1]The instruments were pretested on a Wednesday at the National Museum of Natural History, the first data collection site. Following a few minor changes to the questionnaire, actual data collection started and continued through Saturday. By Saturday, however, so much of the data had already been collected that only a small sample was needed to meet quotas for the project. Therefore, the National Museum of Natural History sample is biased toward weekday visitors.

Percents[2] were calculated for all categorical variables, and summary statistics, including the mean (average), median (half above and half below), and standard deviation (spread of scores; ±) were calculated for interval and ratio variables. To answer specific questions about the relationship between natural history museum visitors and science center visitors, cross-tabulation tables were computed to show the joint frequency distribution of the two samples. Chi-square (x^2) analysis was used to test the significance of the relationship of the two samples. T-tests and analysis of variance (ANOVA) were used to compare the mean scores of the rating scales of natural history museum samples and science center samples. For all statistical tests, the significance level was set at $p \leq .05$.[3]

All findings regarding the standardized questionnaire are presented within a natural history museum/science center framework. That is, data from the two natural history museums were combined into one data set, and data from the two science centers in another. The two data sets were then analyzed so comparisons between natural history museum respondents and science center respondents could be made and discussed. All the findings are described in the body of this report and summarized in tables.[4]

Findings from each of the four institutions are presented in Appendix B.

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[2]The percentages that are presented do not always equal 100 percent due to rounding.

[3]Setting the probability level (p) of significance at $\leq .05$ means that there is a 95 percent probability that the relationship being explored exists; that is, in 95 out of 100 cases, there really would be a relationship between two variables (age and interpretive strategy, for example). Likewise, there is a 5 percent chance that the relationship does not exist; or in 5 out of 100 cases, a relationship is due primarily to chance.

[4]Tables that report findings from statistical calculations include standard computations. Each table reports the value, whether it be a chi-square (x^2), t-test (t), or ANOVA (F), degrees of freedom (a calculation dependent on the number of rows and columns in a table; df), and p value, which is explained in the above footnote.

IN-DEPTH INTERVIEW GUIDE

An interview guide was developed to collect descriptive data regarding visitors' knowledge about and experience with severe weather as detailed in the evaluation goals. Planning team members thought it would be useful to hear how visitors talked about and described various types of storms and weather indicators, as there is likely a difference between scientific and novice explanations. They also wanted to hear how visitors talked about their personal experiences with storms. Two interview instruments were designed--one for adults (14 years and older) and one for children (8 to 13 years old).

The two interview guides were alike except for question 5, which asked visitors to sort descriptive words and phrases into two piles (words and phrases that were true for storms, and ones that were not; see question 5 in Appendix A). The words for children were simpler. For example, "predictable" was used for adults, and "easy to see coming" was used for children.

Interviewees were asked thirteen general questions and countless probing questions. Many of the questions had supporting visuals, such as a weather map and a satellite image of a hurricane (see Appendix A) to help visitors talk about a potentially difficult subject or one about which they may have known very little. Conversation between the evaluator and visitor was extensive. Interviews ranged from 10 to 30 minutes and generated more than 400 pages of conversational data.

Interviewees were selected in much the same manner as questionnaire respondents. A total of 120 interviews were collected: 80 adult interviews (20 at each site) and 40 child interviews (20 at NMNH and 20 at SLSC). Respondents' familiarity with Doppler radar was tested in November 1994. A total of 120 interviews were collected about Doppler radar: 80 adult interviews (40 at NMNH and 40 at SLSC) and 40 child interviews (20 at NMNH and 20 at SLSC). All interviews were tape-recorded and later transcribed to facilitate analysis.

Agreeing to participate in an open-ended interview commits a considerable amount of time from the visitor, thus, the refusal rate for this portion of the study was 35 percent--quite a bit higher than that for the standardized questionnaire. A chi-square analysis showed no difference between the refusal and interviewee samples regarding gender; however, a t-test showed a significant difference in the mean ages of the two samples. The mean age of interviewees was 30.71, while the mean age of refusals was 38.27. Those who declined to be interviewed were significantly older than interviewees ($p=.007$). This finding suggests that the interview data may not accurately reflect older visitors' knowledge of and experience with storms and severe weather.

Data Analysis

Two content analyses were conducted--one with the adult data and one with the child data. The transcripts were reviewed several times, and recurring categories and ideas were noted. With each reading, categories became better defined and articulated. All data were reviewed again so visitors' responses could be placed under the most appropriate category. All categories emerged from the data (they were not preconceived), although they were naturally tied to the specific questions asked of visitors. The findings in the body of the report are presented question by question in the qualitative tradition. Categories are presented and described and selected quotations are provided to support the categories and analysis. In cases where it made sense to quantify responses, tables are used to summarize the information.

LITERATURE REVIEW: DIFFERENCES BETWEEN NATURAL HISTORY MUSEUMS AND SCIENCE CENTERS

The *Stormy Weather* exhibition will travel to natural history museums and science centers. Planning team members wondered if visitors to natural history museums and science centers differed and, if so, in what ways. As stated earlier, the standardized questionnaire analysis focused on differences between natural history museum visitors and science center visitors, but it was thought that a literature review would provide additional support to the data, as would findings from visitor surveys conducted at natural history museums and science centers around the United States.

A literature review conducted at the Smithsonian's Museum Reference Center did not reveal any references that focused on visitors to either natural history museums or science centers. The Association of Science-Technology Centers was also contacted, and while staff there were intensely interested in such information, they had little to offer.

Finally, Randi Korn and Associates began contacting natural history museums and science centers in an effort to collect recent visitor survey data (within the last five years). This effort yielded few results, due both to the scarcity of current survey data at many institutions and to the difficulty of reaching a staff person via the telephone. Each institution required a minimum of four phone calls, only a few of which were returned. A total of four natural history museums and five science centers sent usable demographic information. Since each natural history museum/science center designed its own survey, visitors were asked a variety of questions. Demographic questions (gender, age, education, and ethnicity) were almost always asked, but response categories varied. Thus, direct comparisons were difficult to make.

All the details of this part of the project data and a brief summary of participating institutions' data are provided in Appendix C.

The remainder of this report presents the findings from the standardized questionnaire (Part II) and interviews (Part III). Part IV provides recommendations based on the findings from both parts.

Part II:

Standardized Questionnaire

STANDARDIZED QUESTIONNAIRE FINDINGS

A total of 743 questionnaires were collected at the four participating institutions. The sample size collected at each institution is presented in Table II.1.

Table II.1.
Sample Size per Institution

Institution	Number of Surveys
California Academy of Sciences	200
St. Louis Science Center	197
National Museum of Natural History	195
Miami Museum of Science	151
Total	743

DEMOGRAPHICS

Slightly more women than men were attracted to natural history museums and science centers (53 percent and 47 percent, respectively). As shown in Table II.2, there was little difference between natural history museums and science centers regarding gender composition.

Respondents were asked to record their age in years so means could be calculated (see Table II.3). Continuous age data can also be organized categorically (see Table II.4). Science centers attracted slightly older visitors than did natural history museums, but the difference is not statistically significant.

Table II.2.
Gender in Percent

Gender	Natural History	Science	Total
Female	54	53	53
Male	46	47	47

Table II.3.
Mean Ages of Respondents

	Natural History	Science	Total
Mean	37.39	39.10	38.19
Median	38	38	38
±	12.50	11.56	12.10

Table II.4.
Age in Categories in Percent

Age Categories	Natural History	Science	Total
14-24	17	10	13
25-34	25	27	26
35-44	33	36	34
45-54	17	16	17
55+	09	12	10

Respondents who were with children were also asked to record the age in years of each child. Natural history museums attracted slightly older children than did science centers, as shown in Table II.5. This difference, however, is not statistically significant. Table II.6 shows children's ages categorically. Science centers attracted more 6-12 year olds than did natural history museums (63 percent and 55 percent, respectively), and natural history museums attracted more 13-20 year olds than did science centers (27 percent and 20 percent, respectively). Generally, more than half of the children who visited these types of institutions were 6-12 years of age.

Table II.5.
Mean Ages of Children Accompanied by Adult Respondents

	Natural History	Science	Total
Mean	9.31	8.95	9.10
Median	9.00	9.00	9.00
±	4.50	4.10	4.30

Table II.6.
Age Categories of Children Accompanied by Adult Respondents in Percent

Age Categories	Natural History	Science	Total
Under 5	18	18	18
6-12	55	63	59
13-20	27	20	23

Adult respondents were asked to indicate their highest level of education from a list of seven options. Table II.7 summarizes those findings. More science center visitors than natural history museum visitors had a high school diploma only (17 percent and 11 percent, respectively), but slightly more natural history museum visitors than science center visitors had "some college/associate degree" (28 percent and 25 percent, respectively) and "college graduate/bachelor's degree" (26 percent and 24 percent, respectively).

To determine if these differences were statistically significant, the seven options had to be collapsed into three because too few respondents fell into the "grade school" and "some high school" options. A chi-square analysis (see Table II.8) shows that natural history museum visitors are more educated than science center visitors (p=.005).

Table II.7.
Education Level of Respondents in Percent

Education Level	Natural History	Science	Total
Grade school	00	02	01
Some high school	01	02	02
High school	11	17	14
Some college/ associate degree	28	25	27
College graduate/ bachelor's degree	26	24	25
Some graduate work	09	08	09
Graduate degree	24	22	23

Table II.8.
Education Level (Collapsed) of Respondents in Percent

Education Level	Natural History	Science	Total
High school or less	12	21	16
Some college/ bachelor's degree	54	49	52
Some graduate work/ graduate degree	34	30	32

x^2=10.738; df=2; p=.005

Most respondents who completed the standardized questionnaire reside in the United States (91 percent). There was little difference between natural history museum respondents and science center respondents regarding residence, as shown in Table II.9.

Natural history museum respondents represented 38 states including the District of Columbia, and science centers represented 32 states including the District of Columbia. The whole sample represented 42 states including the District of Columbia. Visitors to the two natural history museums represented nearly twice as many foreign countries as the two science centers (22 and 14, respectively).

Table II.9.
Residence of Respondents in Percent

Residence	Natural History	Science	Total
United States	90	92	91
Foreign	10	08	09

Table II.10 suggests that the state in which participating institutions are located does not always determine the state in which most respondents reside. Two-thirds of the respondents from the MMS resided in Florida (66 percent), and over half of the respondents from the CAS resided in California (54 percent). Only 20 percent of the respondents from the NMNH were from nearby Virginia and Maryland (2.6 percent were from the District of Columbia).

The top three resident states for each institutional type are shown in Table II.11.

Table II.10.
Participating Institutions and Residence of Respondents in Percent

CAS		MMS		NMNH		SLSC	
California	54	Florida	66	Virginia	11	Missouri	48
Georgia	03	Puerto Rico	03	California	10	Illinois	16
Texas	03	New York	03	Maryland	09	Indiana	09

Table II.11.
Top Three Resident States in Percent

Natural History		Science		Total	
California	32	Florida	29	California	18
Virginia	06	Missouri	27	Florida	15
Maryland	04	Illinois	10	Missouri	13

SIZE AND TYPE OF VISITING GROUP

Science centers attracted larger visiting groups than did natural history museums, as shown in Table II.12. Natural history museums attracted more visitor pairs than did science centers (42 percent and 22 percent, respectively), and science centers attracted more groups composed of three or more visitors than did natural history museums (78 percent and 58 percent, respectively). This difference is significant (p=.000).

The difference in group size is also evident in Table II.13, which reports the mean group size.

Table II.12.
Number of Visitors in Visitor Groups in Percent

Number of Visitors	Natural History	Science	Total
1-2	42	22	33
3-4	35	47	41
5+	23	31	27

x^2=31.004; df=2; p=.000

Table II.13.
Mean Visitor Group Sizes

	Natural History	Science	Total
Mean	4.57	5.37	4.95
Median	3.00	4.00	3.00
±	8.80	8.20	8.60

Respondents were also asked to indicate from a list of five options the one that described their group type. For both institutional types, there were more groups composed of adults and children than any other group type, but science centers attracted more adult/children groups than did natural history museums (74 percent and 53 percent, respectively). Also, as noted above and shown again in Table II.14, natural history museums attracted more adult pairs than did science museums (26 percent and 13 percent, respectively). These differences are statistically significant (p=.000).

Table II.14.
Group Type in Percent

Group Type	Natural History	Science	Total
Adults and children	53	74	63
Adult pairs	26	13	20
Several adults	11	08	10
Adults alone	08	03	06
Tour group	02	02	02

x^2=38.812; df=4; p=.000

Respondents were asked to record the number of children in their group, and, as expected, science centers attracted visitors with more children per visiting group than did natural history museums (see Table II.15). In fact, nearly half of natural history museum respondents did not come with any children (46 percent), compared to one-quarter of science center respondents (25 percent). Thirty-three (33) percent of natural history museum respondents and 58 percent of science center respondents were with two or more children. These differences are statistically significant (p=.000).

These differences are also reflected in the mean number of children per visitor group, as shown in Table II.16.

Table II.15.
Number of Children per Visitor Group in Percent

Number of Children	Natural History	Science	Total
None	46	25	36
One	21	18	19
Two	19	33	26
Three or more	14	25	19

x^2=46.581; df=3; p=.000

Table II.16.
Mean Number of Children per Visitor Group

	Natural History	Science	Total
Mean	1.56	2.64	2.07
Median	1.00	2.00	1.00
±	5.81	6.79	6.31

RATINGS OF INTERPRETIVE STRATEGIES

Adult Respondents

Respondents were asked to rate nine interpretive strategies on a seven-point scale ranging from "Don't like at all" (1) to "Like very much" (7). Means and t-tests were calculated to determine if mean scores from the natural history museum sample differed significantly from those from the science center sample. Table II.17, which ranks the interpretive strategies in descending order based on the total means, summarizes some of these findings.

The three highest-ranked strategies for natural history museums and science centers were "live demonstrations," "things to handle/touch/manipulate," and "objects or artifacts." For five of the nine strategies, natural history respondents' mean ratings were significantly different from science center respondents' mean ratings. As shown in Table II.17, "video programs," though ranked seventh by both respondent samples, was rated higher by science center respondents than by natural history museum respondents (5.01 and 4.58, respectively; p=.001). "Computer games," too, was rated significantly higher by science center respondents than by natural history museum respondents (5.07 and 4.24, respectively; p=.000). The same trend holds true for "activities for small groups"; science center respondents rated it significantly higher than natural history museum respondents (4.85 and 4.25, respectively; p=.000).[5]

[5]ANOVA were conducted to determine if differences between means for natural history museums and science centers were significant. Then, for significant Fs, post hoc pairwise comparisons were conducted using separate t-tests to determine if upward or downward trends were significant.

Table II.17.
Ratings and Rankings of Kinds of Interpretive Strategies

Exhibit Type	Natural History (±)	Science (±)	Total (±)
Live demonstrations	5.64 (1.6)	5.98 (1.4)	5.80 (1.5)
Things to handle/ touch/manipulate	5.54 (1.8)	5.95 (1.4)	5.73 (1.6)
Objects or artifacts	5.53 (1.5)	5.34 (1.4)	5.44 (1.5)
Dioramas	5.21 (1.6)	5.10 (1.5)	5.16 (1.6)
Things to listen to	5.07 (1.7)	5.23 (1.5)	5.15 (1.6)
Informational text/panels	5.17 (1.7)	4.92 (1.7)	5.05 (1.7)
Video programs[1]	4.58 (1.7)	5.01 (1.6)	4.78 (1.7)
Computer games[2]	4.24 (2.1)	5.07 (1.8)	4.63 (2.0)
Activities for small groups[3]	4.25 (2.0)	4.85 (1.8)	4.53 (1.9)

1. $t=-3.41$; $df=723.71$; $p=.001$ 2. $t=-5.87$; $df=712.60$; $p=.000$ 3. $t=-4.22$; $df=701.98$; $p=.000$

Respondents' ratings of "live demonstrations" and "things to handle/touch/manipulate" were very high on the seven-point scale. Nearly half or more than half of the respondents from each sample rated them a seven (natural history museums: 45 and 44 percent, respectively; science centers: 53 percent and 52 percent, respectively). This finding indicates that the data are not normally distributed (when plotted on a graph they would not form a bell-shaped curve). A mean does not accurately reflect respondents' rating if data are not normally distributed. To determine if there was a difference in the way the two respondent samples rated the two strategies, the data were made dichotomous and a chi-square was calculated.

Ratings for these two strategies were placed into two categories: those who rated the strategy a seven, and those who rated the strategy below seven. As shown in Table II.18, significantly more science center respondents rated this "live demonstrations" higher than did natural history museum respondents (53 percent and 45 percent, respectively; p=.040).

Table II.19 summarizes ratings from "things to handle/touch/manipulate." Significantly more science center respondents rated this strategy higher than did natural history museum respondents (52 percent and 44 percent, respectively; p=.032).

Table II.18.
Ratings of "Live Demonstrations" in Percent

Rating	Natural History	Science
1-6 rating (low)	55	47
7 rating (high)	45	53

x^2=-4.213; df=1; p=.040

Table II.19.
Ratings of "Things to Handle/Touch/Manipulate" in Percent

Rating	Natural History	Science
1-6 rating (low)	56	48
7 rating (high)	44	52

x^2=-4.591; df=1; p=.032

Ratings of interpretive strategies data were examined with gender, age, and visitor group type data to determine if there were any significant relationships. There were several significant relationships with all variables.

Regarding gender, women rated "objects or artifacts," "activities for small groups," and "things to listen to" significantly higher than did men, as shown in Table II.20 (p=.004, p=.013, and p=.001, respectively). Specifically, women rated "objects or artifacts" 5.58, and men rated it 5.27; women rated "activities for small groups" 4.70, and men rated it 4.34; and women rated "things to listen to" 5.34, and men rated it 4.92.

As noted earlier, the rating data for "live demonstrations" and "things to handle/touch/ manipulate" were not normally distributed, so the data were organized into two rating categories. More women rated both interpretive strategies higher than did men, as shown in Tables II.21 and II.22. "Live demonstrations" was rated high by 58 percent of the women and 39 percent of the men, and "things to handle/touch/demonstrate" was rated high by 52 percent of the women and 44 percent of the men.

Table II.20.
Gender by Ratings of "Objects or Artifacts," "Activities for Small Groups," and "Things to Listen To"

Exhibit Type	Males	Females
Objects or artifacts[1]	5.27	5.58
Activities for small groups[2]	4.34	4.70
Things to listen to[3]	4.92	5.34

1. t=-2.88; df=722; p=.004 2. t=-2.48; df=701; p=.013 3. t=-3.45; df=722; p=.001

Table II.21.
Gender by Ratings of "Live Demonstrations" in Percent

Rating	Male	Female
1-6 rating (low)	62	42
7 rating (high)	39	58

x^2=28.11; df=1; p=.000

Table II.22.
Gender by Ratings of "Things to Handle/Touch/Manipulate"
in Percent

Rating	Male	Female
1-6 rating (low)	57	48
7 rating (high)	44	52

x^2=4.876; df=1; p=.027

Six of the nine interpretive strategies were significant with age. As shown in Table II.23, older respondents rated "objects or artifacts" higher than did younger respondents (p=.002). The same holds true for "video programs," "dioramas," and "activities for small groups" (p=.005; p=.000; and p=.024, respectively). Although the mean ratings for "objects or artifacts," "video programs," and "activities for small groups" by respondents 45-54 years of age do not follow the upward trend, the t-tests indicate the upward trend is significant.

As one might expect, younger respondents rated "computer games" significantly higher than did older respondents (p=.007).

Table II.23.
Age by Ratings of Interpretive Strategies

Exhibit Types	14-24	25-34	35-44	45-54	55+
Objects or artifacts[1]	5.18	5.29	5.55	5.46	5.84
Video programs[2]	4.21	4.83	4.92	4.73	5.04
Dioramas[3]	4.83	5.05	5.11	5.22	5.91
Activities for small groups[4]	4.17	4.68	4.49	4.29	5.10
Computer games[5]	4.70	4.88	4.80	4.03	4.22

1. t=3.173; df=716; p=.002; 2. t=2.785; df=714; p=.005; 3. t=4.433; df=695; p=.000;
4. t=2.265; df=694; p=.024 5. t=-2.710; df=707; p=.007

A test for linear trend of proportions across categories of age was conducted for the ratings of "things to handle/touch/manipulate." Table II.24 shows the rating data divided into two categories (1-6 rating and 7 rating). By comparing the high-rating percentages to the low- rating percentages in each age group, one can see that for ages 14-34, more respondents rated the strategy high than rated it low. For the remaining three age categories (respondents 35+), more respondents rated the strategy low than rated it high (p=.008).

ANOVA showed that two of the interpretive strategies were significant with group type. Adults visiting alone and adults visiting with children rated "video programs" and "computer games" higher than adult pairs (p=.000 for both). This finding is summarized in Table II.25.

Table II.24.
Age by Ratings of "Things to Handle/Touch/Manipulate" in Percent

Rating	14-24	25-34	35-44	45-54	55+
1-6 rating (low)	12.9	21.4	36.2	18.5	11.0
7 rating (high)	14.3	30.9	32.9	13.7	8.2

Test for linear trend=4.876; df=1; p=.008

Table II.25.
Group Type by Ratings of "Video Programs" and "Computer Games"

Exhibit Type	Adults Alone	Adult Pairs	Adults and Children
Video programs[1]	5.07	4.39	4.94
Computer games[2]	5.21	4.21	4.78

1. F=8.6461; p=.000 2. F=8.1629; p=.000

Adults Responding for Children

Respondents who were visiting with children were asked to rate the same nine interpretive strategies for their children, as evaluators and planning team members assumed that parents know what their children like and do not like. Table II.26 ranks the interpretive strategies in descending order based on the total means.

The three highest-ranked strategies for natural history museums and science centers are "things to handle/touch/manipulate," "computer games," and "live demonstrations," although the ranking varies with institutional type. Science center respondents ranked "computer games" second and "live demonstrations" third, and natural history museum respondents ranked "live demonstrations" second and "computer games" third.

For six of the nine strategies, natural history museum respondents' mean ratings were significantly different from science center respondents' mean ratings (see Tables II.26-II.28). Three of those differences are reported in Table II.26. As one might expect, science center respondents rated "activities for small groups" higher than natural history museum respondents (5.16 and 4.68, respectively; p=.012). Natural history museum respondents rated "things to listen to" higher than science center respondents (5.11 and 4.54, respectively; p=.002). Finally, "informational text/panels," ranked ninth by both institutional types, was rated higher by natural history museum respondents than by science center respondents (4.07 and 3.42, respectively; p=.001).

Table II.26.
Ratings and Ranking of Interpretive Strategies for Children
(According to Adult Respondents)

Exhibit Type	Natural History (±)	Science (±)	Total (±)
Things to handle/ touch/manipulate	6.49 (1.2)	6.57 (1.0)	6.54 (1.1)
Computer games	5.68 (1.8)	6.31 (1.2)	6.03 (0.5)
Live demonstrations	5.95 (1.6)	6.02 (1.3)	5.99 (1.4)
Dioramas	5.28 (1.6)	4.97 (1.7)	5.11 (1.7)
Video programs	4.95 (1.8)	5.06 (1.8)	5.01 (1.8)
Activities for small groups[1]	4.68 (2.0)	5.16 (1.8)	4.95 (1.9)
Things to listen to[2]	5.11 (1.8)	4.54 (1.9)	4.79 (1.9)
Objects or artifacts	4.76 (1.9)	4.57 (1.9)	4.65 (1.9)
Informational text/panels[3]	4.07 (2.0)	3.42 (1.9)	3.70 (2.0)

1. t=-2.53; df=403; p=.012 2. t=3.12; df=421; p=.002 3. t=3.39; df=413; p=.001

"Computer games" was rated a seven by half or more than half of the respondents from both samples. Thus, ratings were placed into two categories so a chi-square could be conducted. Table II.27 summarizes these findings. More science center respondents rated it a seven for children than did natural history museum respondents (64 percent and 50 percent, respectively; p=.003).

Chi-squares were also conducted with interpretive strategy ratings and gender data. As shown in Table II.28, more women rated "live demonstrations" higher for children than did men (59 percent and 47 percent, respectively; p=.089). More women also rated "computer games" higher for children than did men (66 percent and 47 percent, respectively). See Table II.29.

Table II.27.
Ratings of "Computer Games" for Children in Percent

Rating	Natural History	Science
1-6 rating (low)	50	36
7 rating (high)	50	64

x^2=-8.681; df=1; p=.003

Table II.28.
Gender by Ratings of "Live Demonstrations" for Children in Percent

Rating	Male	Female
1-6 rating (low)	54	42
7 rating (high)	47	59

x^2=6.33; df=1; p=.089

Table II.29.
Gender by Ratings of "Computer Games" for Children in Percent

Rating	Male	Female
1-6 rating (low)	53	34
7 rating (high)	47	66

x^2=14.947; df=1; p=.000

Adult Ratings versus Child Ratings (According to Adult Respondents)

For each institution, adult mean ratings were compared to child mean ratings to determine statistically significant differences. In natural history museums, adult and child mean ratings differed for six of the nine interpretive strategies, as shown in Table II.30. Adults rated "things to handle/touch/manipulate" and "live demonstrations" higher for children than they did for themselves (p=.000 and p=.004, respectively). The child mean rating for "things to handle/touch/manipulate" was 6.48, and the adult mean rating was 5.57. For "live demonstrations," the child mean rating was 5.94, and the adult mean rating was 5.65. As one might expect, adults rated "computer games" higher for children than for themselves (p=.000). Adults rated it 4.23, and for children, 5.66. Adults also rated "activities for small groups" higher for children than for themselves (p=.002). The adult mean rating was 4.28, and the child mean rating was 4.66.

Adults rated "objects or artifacts" and "informational text/panels" higher for themselves than they did for children (p=.000 for each). The adult mean rating for "objects or artifacts" was 5.53, and the child mean rating was 4.75. For "informational text/panels," the adult mean rating was 5.12, and the child mean rating was 4.07.

Table II.30.[6]
Ratings and Rankings of Kinds of Interpretive Strategies by Adults and Children (According to Adult Respondents) in Natural History Museums

Exhibit Type	Adults (±)	Children (±)	Total (±)
Things to handle/ touch/manipulate[1]	5.57 (1.7)	6.48 (1.2)	6.03 (1.5)
Live demonstrations[2]	5.65 (1.7)	5.94 (1.6)	5.80 (1.6)
Dioramas	5.32 (1.5)	5.29 (1.6)	5.31 (1.6)
Objects or artifacts[3]	5.53 (1.5)	4.75 (1.9)	5.14 (1.7)
Things to listen to	5.02 (1.8)	5.12 (1.8)	5.07 (1.8)
Computer games[4]	4.23 (2.1)	5.66 (1.9)	4.95 (2.0)
Video programs	4.82 (1.5)	4.94 (1.9)	4.88 (1.7)
Informational text/panels[5]	5.12 (1.7)	4.07 (2.0)	4.60 (1.9)
Activities for small groups[6]	4.28 (2.1)	4.66 (2.1)	4.47 (2.1)

1. t=7.46; p=.000 2. t=-2.93; p=.004 3. t=6.25; p=.000 4. t=-8.60; p=.000 5. t=7.36; p=.000 6. t=-3.19; p=.002

In science centers, adult and child mean ratings also differed for six of the nine interpretive strategies, as shown in Table II.31. Adults rated "things to handle/touch/manipulate" higher for children than they did for themselves (p=.000). The child mean rating was 6.59, and the adult mean rating was 6.04. Like the natural history museum sample, adults rated "computer games" and "activities for small groups" higher for children than they did for themselves (p=.000 and p=.002, respectively). Adults rated "computer games" 6.33 for children and 5.04 for themselves. For "activities for small groups," the child mean rating was 5.17, and the adult mean rating was 4.88.

Adults rated "objects or artifacts," "things to listen to," and "informational text/panels" higher for themselves than they did for children (p=.000, p=.000, and p=.000, respectively). The adult mean rating of "objects or artifacts" was 5.39, and the child mean rating was 4.57. For "things to listen to," the adult mean rating was 5.13, and the child mean rating was 4.53. For "informational text/panels," the adult mean rating was 4.89, and the child mean rating was 3.43.

[6]Means were calculated for respondents who rated the interpretive strategies for themselves and their children. Respondents without children were omitted from these calculations.

Table II.31.[7]
Ratings and Rankings of Kinds of Interpretive Strategies by Adults and Children (According to Adult Respondents) in Science Centers

Exhibit Type	Adults (±)	Children (±)	Total (±)
Things to handle/ touch/manipulate[1]	6.04 (1.4)	6.59 (1.0)	6.32 (1.2)
Live demonstrations	6.01 (1.4)	6.00 (1.3)	6.01 (1.4)
Computer games[2]	5.04 (1.7)	6.33 (1.1)	5.69 (1.4)
Dioramas	5.14 (1.5)	4.98 (1.7)	5.06 (1.6)
Video programs	4.97 (1.6)	5.05 (1.8)	5.01 (1.7)
Activities for small groups[3]	4.88 (1.8)	5.17 (1.8)	5.03 (1.8)
Objects or artifacts[4]	5.39 (1.4)	4.57 (1.9)	4.98 (1.7)
Things to listen to[5]	5.13 (1.5)	4.53 (1.9)	4.83 (1.7)
Informational text/panels[6]	4.89 (1.7)	3.43 (1.9)	4.16 (1.8)

1. $t=5.91$; $p=.000$ 2. $t=-11.54$; $p=.000$ 3. $t=-3.08$; $p=.002$ 4. $t=7.13$; $p=.000$ 5. $t=5.95$; $p=.000$ 6. $t=11.68$; $p=.000$

DISCUSSION

The focus of much of the analysis was to determine differences between natural history museum visitors and science center visitors. Regarding gender and age, visitors to each institutional type were quite similar. Slightly more women than men were attracted to both natural history museums and science centers, and while science centers attracted a somewhat older audience, the difference is not statistically significant. The mean age of child visitors to science centers was slightly younger than the mean age of child visitors to natural history museums, but again, the difference is not statistically significant. Natural history museum visitors, however, are more educated than science center visitors.

Science centers attracted larger visitor groups than did natural history museums, and they also attracted groups with more children. The types of groups at science centers differed from those

[7]Means were calculated for respondents who rated the interpretive strategies for themselves and their children. Respondents without children were omitted from these calculations.

at natural history museums in that science centers attracted more adults and children than did natural history museums, but natural history museums attracted more adults, either alone or with other adults, than did science centers.

The ratings and rankings of the nine interpretive strategies provides interesting and useful information for exhibit developers, and here differences between visitors to each institution are accentuated. For adults, the three highest-ranking strategies for both institutional types were "live demonstrations," "things to touch/handle/manipulate," and "objects or artifacts." Adult respondents to science centers rated "video programs," "computer games," and "activities for small groups" higher than did adult respondents to natural history museums. In fact, overall, adult respondents to science centers rated six of the nine items higher than did adult respondents to natural history museums. The three strategies rated higher by natural history museum respondents were "objects or artifacts," "informational text/panels," and "dioramas." These ratings suggest that visitors' expectations, which are likely tied to previous experiences in natural history museums or science centers, may be a factor.

Visitors who frequent one type of institution may learn to expect a certain type of interpretive strategy, and visitors may also visit one institutional type because it tends to have interpretive strategies they have learned to expect. For example, science centers typically have more computerized exhibitions than do natural history museums, so science center visitors may respond more favorably to and come to expect "computer games." Natural history museums tend to have dioramas, artifacts, and text-heavy interpretive exhibitions, whereas these three interpretive strategies are often absent from science center exhibitions. Thus, it is not surprising that natural history museum adult respondents rated "dioramas" "informational text/panels," and "objects or artifacts" higher than science center adult respondents.

Gender and age are factors regarding the ratings of some interpretive strategies. Women rated five of the nine exhibition strategies higher than did men ("objects or artifacts," "activities for small groups," "things to listen to," "live demonstrations," and "things to handle/touch/manipulate"). Age was also a variable. Older respondents rated "objects or artifacts," "video programs," "dioramas," and "activities for small groups" significantly higher than younger respondents, and younger respondents rated "computer games" significantly higher than did older respondents. In addition, for the ages 14-34, more respondents rated "things to touch/handle/manipulate" high than rated it low, and for the ages 35+, more respondents rated it low than rated it high. Since visitors to each institutional type are similar regarding gender and age--the female:male ratio is 53:47, and mean age is 38.19--this finding is important when thinking about the overall exhibition plan, regardless of institutional type.

Visitors to any institution rarely visit all exhibit components in an exhibition. They pick and choose where they will spend their time, and their choices are often a reflection of their personal interests regarding content and interpretive strategy (which are, in part, dependent on gender and age) and the visual and physical quality and appeal of the exhibit component. The above gender and age variations can be utilized from that perspective. Exhibit planners should consider that women may stop at exhibits with audio components or things to touch more frequently than men, women and older visitors (generally) may stop at cases with artifacts more frequently than will men and younger visitors (generally), and, generally, younger visitors may use computerized components more frequently than will older visitors. These findings suggest that messages within the exhibition, and especially the big messages, must be evenly distributed throughout the exhibition components. Older visitors who may not use any of the computerized exhibits should have access to the same type of information as younger visitors, who may use the computerized exhibits. Messages must be presented in several different ways using a variety of modalities.

Type of visiting group was also a variable with two of the interpretive strategies. Adult pairs rated "video programs" and "computer games" significantly lower than adults visiting alone and adult-children groups. These findings become more significant when viewed with other factors: the natural history museum sample had twice as many adult pairs as the science center sample; and *Stormy Weather* will travel to natural history museums as well as science centers. The content in "video programs" and "computer games," for a natural history museum audience, therefore, must be strongly considered--especially if visitors will be choosing among interpretive strategies.

Adult respondents also rated the nine interpretive strategies for their children. The findings fit the scenario described earlier: expectations respondents have about an institutional type, which result from frequent visits to that institutional type, may determine the rating. "Activities for small groups" and "computer games" were rated higher for children by science center respondents than natural history museum respondents, and "informational text/panels" and "things to listen to" were rated higher for children by natural history museum respondents than by science center respondents.

Science centers generally have more activities for small groups and computerized exhibits than do natural history museums, while natural history museums use text to convey information. "Things to listen to" may reflect respondents' experiences with blockbuster exhibitions, which often provide an audio interpretive component.

Adult and child mean ratings were also compared for each institutional type. For both natural history museums and science centers, the mean adult and child rating differed for six of the nine interpretive strategies. Comparisons between the two institutional types show remarkably similar patterns.

In both natural history museums and science centers, adults rated "things to touch/handle/manipulate," "computer games," and "activities for small groups" higher for children than for themselves. For natural history museums, adults also rated "live demonstrations" significantly higher for children than for themselves.

In both institutional types, adults rated "objects or artifacts" and "informational text/panels" higher for themselves than for children. For science centers, adults also rated "things to listen to" significantly higher for themselves than for children. In both institutional types, mean adult and child ratings for "dioramas" and "video programs" did not differ.

These findings suggest that there are some similarities in the way adults think about themselves and children regarding interpretive strategies. Clearly, adults have preferences for ways in which they like to receive information, and they think their children have preferences, too.

These data become more meaningful if examined in the context of group type. Both institutional types attracted groups composed of adults and children, but more of these groups were attracted to science centers than to natural history museums. Nearly half (45 percent) of natural history museum respondents were adults either visiting alone, with another adult, or with several adults. For science centers, adult visitors (without children) constituted 24 percent of the sample. *Stormy Weather* presents a challenge to exhibit developers because the exhibition will travel to both natural history museums and science centers and natural history museums attract more adult visitors without children. Adult visitors have specific preferences regarding interpretive media, and this difference, though evident in data from both institutional types, seems more prominent for natural history museums simply because they attract more adults-without-children groups than do science centers.

Part III:

In-Depth Interviews

IN-DEPTH INTERVIEW FINDINGS

In Part III of the study, major findings from in-depth interviews with adults and children are presented. Data are reported question-by-question from the interview guide (see Appendix A). Interview data fell into two categories: knowledge of storms and experience with storms. A brief outline, using headings from the interview guide, follows:

Knowledge of Storms

What are different types of storms?
What do these storms [thunderstorm, hurricane, blizzard] have in common?
What is different about these storms [thunderstorm, hurricane, blizzard]?
What is a storm?
What is happening on this weather map from one day this summer?
What do meteorologists measure to predict the weather?
What are definitions for the five basic indicators used to predict the weather?
What is happening in this picture [GOES (Geostationary Operational Environmental Satellite) visible image]?
What is happening in this picture [GOES infrared image]?
What is happening in this picture [Doppler radar image]?

Experience with Storms

What is the last storm you remember?
What was most memorable about that storm?
What words or phrases are true when thinking about storms?
How did you find out about today's weather?
What does it have to look like outside to know a severe storm is approaching?
What actions do you take if a severe storm is approaching?

In general, regional differences among respondents did not emerge in the knowledge-based questions but were more of a factor in the experience-based questions. Where relevant, responses are followed by "DC" (NMNH), "SL" (SLSC), "MI" (MMS), or "SF" (CAS). Otherwise, data collection sites do not accompany visitor comments.

The *Stormy Weather* exhibition team thought there might be differences between adults and children in terms of their storm knowledge and experiences; thus, these two data sets were analyzed separately. When data were analyzed qualitatively, adult and child findings are presented separately; adult findings appear first, followed by child findings. Qualitative findings are presented in descending order starting with the most prevalent responses. Selected quotations are provided to illustrate findings. Where data were quantified, adult and child findings are presented together. Often tables are used to summarize findings. Data are presented in descending order based on the "total" column.

DEMOGRAPHICS

In-depth interviews were conducted with eighty adults and forty children. Twenty adults at each of the four data collection sites and twenty children each at NMNH and SLSC constituted the sample for the original interview. Forty adults and twenty children each were interviewed about Doppler radar at NMNH and SLSC. Children ranged in age from 8 to 13 years old. Adults were visitors 14 years and older. Although interviewees were selected randomly, interviewers attempted to divide the data population evenly between males and females. See Table III.1.

Table III.1.
Demographics in Percent

Age Ranges	Male A n=60	Female A n=60	Total A n=120	Male B n=59	Female B n=61	Total B n=120
8-10	05	05	10	08	10	18
11-13	11	13	23	08	08	16
14-18	03	00	03	03	06	08
19-24	05	03	07	05	04	09
25-34	05	09	14	08	10	18
35-44	09	13	22	07	08	15
45-54	08	03	11	08	03	12
55-64	03	02	04	00	01	01
65 and older	03	04	07	03	01	03
Total	50	50	100	49	51	100

"Male A" and "Female A" reflect the original population of respondents; "Male B" and "Female B" reflect the respondents for the Doppler radar question only.

KNOWLEDGE OF STORMS

The first group of questions focus on respondents' knowledge of storms. These questions address the *Stormy Weather* exhibition team's keen interest in discovering what knowledge, ideas, and misconceptions visitors will bring to the exhibition. Team members also wondered if storm knowledge would vary by region.

What Are Different Types of Storms?

Adults and children were asked to name as many types of storms as they could. Responses to this question give a sense of the storms to which interviewees have been exposed, either through personal experience or the news media. Readers should note that interviews were conducted in the summer; thus respondents mentioned blizzards less often than they might have if they were queried in the colder months. Moreover, some interviewees mentioned hurricanes, typhoons, and cyclones, not realizing they were the same storm type.

<u>General Findings</u>: As mentioned above, regional differences were not a factor in the amount or quality of knowledge respondents had about storms. Hurricanes were mentioned most often by adult interviewees, followed by rain/thunderstorms/monsoons. The most prevalent response among children was rain/thunderstorms/monsoons, followed by tornadoes (see Table III.2).

Table III.2.
Storm Types in Percent

Storm Types	Adults n=271	Children n=125	Total n=396
Rain/thunderstorms/monsoons	22	26	23
Hurricanes/typhoons/cyclones	29	17	20
Tornadoes	15	22	17
Blizzards/ice/snowstorms	11	08	10
Lightning/electrical storms	05	04	05
Hail storms	04	04	04
Dust/sand storms	03	03	03
Floods	02	05	03
Wind storms	03	04	03
Earthquakes	01	05	02
Tropical depressions/storms	02	01	02
Don't know	00	02	01
Nor'easters	01	00	01
Squalls	01	00	01
Tidal waves	01	01	01
Tsunamis	01	00	01

Columns do not add up to 100 due to rounding.

In this table, "n" stands for the total number of responses, not the number of individuals, because some respondents gave more than one name for the same storm type (e.g., hurricanes and typhoons). Similar storm types were grouped into one category to facilitate analysis.

What Do These Storms [Thunderstorm, Hurricane, Blizzard] Have in Common?

Interviewees were shown pictures of the three main storm types (see Appendix A) and were asked what these storms had in common, or, in the case of some children, what was the same about these storms. Interviewers were interested in hearing how respondents talked about storms and the scientific knowledge they drew from in thinking about the three types of storms. Only a few adults and children could not provide any response to this question.

<u>General Findings</u>: Adult and child responses were similar in that the same categories emerged from both data sets. Both interviewee groups talked about how storms affect people's lives and the elements and qualities that different storm types share.

<u>Adults</u>

Adult interviewees overwhelmingly described <u>how storms affect people's lives</u>. Considerably more than half of adults, when thinking of what thunderstorms, hurricanes, and blizzards have in common, talked about the terrible toll storms take on life and property as well as the ways storms affect day-to-day existence.

> They're all very damaging to people and their houses. For instance, that looks like it's hitting a tree. Then the tree could fall on the house and break the house. They're also very emotionally damaging for people. Maybe a family member died because of the storm. Other family members could remember that forever, and there would be trouble in the future.
>
> People are both frightened and awed by them. Human nature is to both fear and admire nature, what nature's capable of. They also cause damage, economic hardship, physical hardship, sometimes death. Very destructive.
>
> They can really slow down human activity, in a big way. They're all very impressive, too. Humans can't do much about it but clean up after the storm is gone.
> They play havoc on the land, people, cars, freeways, and highways.

Slightly more than one-third of adult interviewees talked about <u>the elements and qualities of weather that storms share</u>. These respondents did not talk in scientific terms but described what happens during storms. Many of the responses in this category were simplistic.

> Water. (In what way?) Ice, when it's going to melt, it's going to be water. This one, the wind and coming with water. Oftentimes in thunderstorms the water will be coming down.
>
> They're wet. They're violent. High winds usually.
>
> Wind, I would think. They're dark.
>
> Probably wind, lots of wind . . . and I guess parts of the elements--it's coming from the sky.

A few interviewees were slightly more sophisticated in their responses and described <u>atmospheric conditions</u> they thought were common to all storms.

> Clouds. (Anything else come to mind?) Moisture, atmospheric conditions. (What kind of atmospheric conditions produce a storm?) Hot and cold air, moisture, just the Earth's rotation and atmospheric pressure.
>
> Moisture. Usually a lot of wind. There tends to be a front or something that comes through in connection with them--in other words, a change in the temperature or pressure.

Finally, a few interviewees described the commonalities of storms in <u>miscellaneous ways--the release of energy that occurs during storms, their connection to nature, their predictability, and the length of time they last</u>.

> It's an awesome force of nature.
>
> There's a great deal of energy expended in those. Different types of energy released. They often involve wind. Lightning storms involve a great deal of instant energy discharge, I guess you would say it that way. Hurricanes are slower buildup.
>
> They're unpredictable in terms of the damage that can be caused by them.
>
> They can last a long time.

Children

Child interviewees, like adults, saw storms primarily in terms of <u>their impact on human life</u>. This response was mentioned by the majority of children interviewed.

> They're all dangerous. They could all take electricity out of places because they could pull down wires and stuff. They're violent. They could hurt people, in the snow people could get trapped, stay in a car and get hit.

> You might not want to be outside during them. And most people don't like them.

> They're all destruction. They destruct in different ways, like snowstorms. . . . And hurricanes have bad winds and stuff. They sometimes really destroy homes bad.

Less than one-quarter of children discussed <u>the elements of weather that storms had in common</u>. As with the adult interviewees, these responses were highly simplistic descriptions of what happens during storms.

> They all have a lot of wind. And something might come down from the sky, because in a blizzard they have snow, and in a hurricane there's wind and rain, and the lightning from the thunderstorm.

> They all have wind.

Finally, a few children described the common characteristics of storms in <u>miscellaneous ways--their connection to nature and the ways they form</u>.

> They all come from Mother Nature, and they're all natural.

> They all originate in clouds and winds and stuff.

What Is Different about These Storms [Thunderstorm, Hurricane, Blizzard]?

Responding to the same pictures used in the previous question, interviewees were asked about differences among the major storm types.

General Findings: In response to this question, both adults and children talked about the seasons, regions, and temperatures associated with different storms more than how storms affect people's lives. Adults, however, talked about region differently from the way children talked about region. Adults talked about region in terms of temperature, and children talked about region in terms of geography.

Adults

The majority of the adults differentiated among the storms by describing the different temperatures, seasons, or regions of the country or world in which the storms tend to be found. Some respondents who mentioned region talked in terms of climate; others simply indicated that they happen in different locations without further elaboration.

> This one is mainly warm weather, this is extremely cold, where the climate would be very cold. A hurricane would never hit anywhere like Norway, or the Arctic or anything, and of course a blizzard would never hit anywhere like the South Sea Islands. And this one, a lightning storm, it's generally in hot weather.
>
> The differences probably would be the temperature. You have snow, you have colder temperature. This is a hurricane, electrical storm, different temperature.
>
> This one's got winter, it's real cold in this one. That looks like it's during the summer, because everything's still green there.
>
> Geographical location in all probability, this being a hurricane and this being a snowstorm. The geographical locations would most likely be different. Hurricanes are possible in the northern part of the hemisphere but not very likely.
>
> They probably happen in different places. I don't think you could have a hurricane where you'll have a snowstorm.

Slightly more than one-third of adult respondents described differences in terms of <u>different elements of weather (e.g., wind, snow, rain) associated with each storm</u>.

> This is an electric storm, this is a snow storm, and this is a wind storm.
>
> The thunderstorm has more lightning than a blizzard, but a hurricane has more winds than either one of them, the most wind pressure.
>
> I think the presence of air can be important. For example, in a hurricane, air speed is very high, but in some others it's not.

When some interviewees looked at the images, they discussed <u>the levels of impact on people's lives</u>. Considering how many adult respondents discussed this topic in the previous question, relatively few talked about the varying degrees that storms can affect people.

> This one you can't travel in, and this one you can't travel in, truthfully, and you could travel in this type of storm.
>
> A snowstorm is really cold, and you don't want to get in your car. Thunderstorms, you don't want to be on the phone. Hurricanes, you don't want to be outside.
>
> They all can kill you different ways.

Finally, a few interviewees spoke about differences in <u>miscellaneous ways</u>--the length of time they last, how storms form, predictability of storms, and colors generated by storms. The few respondents who described storm formation gave more sophisticated responses than other respondents and were the only ones to discuss the interrelationship of various factors (e.g., wind and temperature) that come together to form storms.

> A thunderstorm is over in a matter of moments. A tornado is something that comes through and it's done. Five minutes in one location, while it would seem like an eternity, is still only five minutes. A hurricane can go on literally for days, build up and then if you're in the direct path, once the eye has gone over, you've got it the other way a second time around.
>
> Temperature, the presence of electricity, and the intensity of the wind, and the barometric pressure. Well, in a hurricane, the barometric pressure is very low, which creates the swirling effect. In a thunderstorm, I don't particularly know if it's a depression in the barometric pressure, it's more of a frontal clashing in between a cold and a warm front. I don't know specifically if the barometer falls, and then in a blizzard, the barometer falls.

> If you have lightning, it's more of a sudden, you can't do anything about it. If it's going to hit, it's going to hit. A snowstorm and hurricane you can kind of halfway prepare for, get out of its way if you have to. It's big enough.
>
> Each one has different colors. Lightning storms, you've got flashes of blue, purple, red, green, stuff like that. Snow kind of covers up all the dirt in the cities . . . makes everything look nice and white and light blue. Of course storms make everything hazy. (Hurricanes?) In general, but afterwards everything turns brown and green and clean.

Children

The majority of child interviewees talked about <u>the different elements of weather</u> (e.g., wind and rain) of each storm type. As with the adult interviewees, these responses tended to be simplistic, relying on the obvious characteristics of each storm. Some children also grouped characteristics that had no relationship to each other.

> A blizzard has snow, a hurricane has rain and wind, and a thunderstorm, well, it has lightning, rain.
>
> This one's in the winter season, this one's never happened to me, this one happened on my block.
>
> Because the blizzard doesn't have trees [responding to the specific image of a blizzard]. And plus it's heavy wind, and that's not heavy wind.
>
> This hurricane is all water . . . thunderstorms--it's mainly electricity and atoms and stuff.

More than one-quarter of children described <u>differences in region, tied to characteristics of the landscape</u>, that distinguish one storm from another. Children talked about region differently from the way adults talked about region; adults spoke about region in terms of temperature, while children spoke about region in terms of geographical characteristics (e.g., presence of water) that help generate storms. This difference could be tied to topics children are learning in school.

> They don't all happen in the same places. There's different areas where a thunderstorm will happen than a hurricane. (Can you tell me where each kind of thing happens?) A hurricane would happen near the ocean, near water and things. A lightning and thunderstorm, it will happen in open areas, like in the suburbs and farm country. (Why doesn't the hurricane happen over land?) Because there's not a lot of water near there to keep it moving and a lot of wind and stuff.
>
> They occur in different places. Snowstorms are more up north. Hurricanes are around the ocean. Thunderstorms are pretty much everywhere.

Hurricanes can only develop over water, and they can't last long over land.

Finally, a few children discussed <u>differences in temperature or season</u> in which certain storms are experienced.

> One involves snow, and it's usually in the wintertime. And rain and thunder's usually in the spring. And hurricanes, I don't know about them, but they're probably during the summer.

> The blizzard happens in the winter, and hurricanes usually happen in the spring and summer.

> They're all in different seasons, I guess. Different times of the year.

What Is a Storm?

After answering several "softer" questions about storms, interviewees were asked to define storms, to elaborate on what they are and how they form. The intention of this question was to find out how much respondents--adults and children--understand about the factors that contribute to storm formation. This question was also an opportunity to listen to respondents' language as they struggled to explain a complex, although common, occurrence in their lives.

General Findings: Many themes emerged from these data, several of which appeared in both adult and child data sets: storms are natural events, they include various weather elements (e.g., wind and rain), they are determined by temperature, and they affect people's lives. The number of responses that fell into each theme, however, differed between adults and children. In addition, adult responses were more sophisticated and detailed than children's responses, likely due to adults' ability to use more complex language.

Adults

Almost half of adults described storms as something natural that just happens. These people thought of storms as either more violent forms of nature or more severe forms of weather; a sense of inevitability ran through both types of responses.

Nature

> It's nature trying to keep continuity of similar factors throughout, and it's doing it at such a rate that it becomes uncomfortable for humans. Then uncomfortable, as far as temperature, as far as electrical discharge, as far as noise, as far as physical wind, movement of air.
>
> A storm is a violent form of nature which happens only periodically. Depends on what type of storm it is. Lightning storms are probably a more frequent type of--and less predictable.
>
> It's a force of nature.

Weather

> A storm is just a condition, well, what is a storm! It is a somewhat extreme condition of climate. Temporary in nature.
>
> It's just bad weather. Bad weather coming in and causing the environment, you know, the weather to change.
>
> It's a matter of severity. It rains on a regular basis, but it doesn't rain torrentially like it

would during a hurricane.

Less than one-quarter of interviewees defined storms as a <u>mixing of various elements</u> (e.g., temperature, clouds, and humidity). These respondents tended to be fairly hesitant in their responses.

> Difference in the atmosphere, the temperatures in the atmosphere. Humidity and the cold front coming together. (Why does that cause a storm?) I'm not sure how to phrase it now. Just the colliding of the different weather systems.
>
> When certain elements of nature come together. Kind of like, heat and water causes steam, I guess maybe wind and rain produces storms.
>
> A combination of environmental factors or conditions that are occurring. Things that result in the storm conditions. (What factors play a part in that process?) Temperature variations, cloud movement, and environmental conditions.
>
> I think there's a lot of factors involved in a storm. You have to have certain kind of low pressure; you have to have rain, circulation, wind, and I think that's about it-- and warm water.

Some interviewees described storms as being <u>determined by temperature</u>. These respondents talked about temperature as either a clashing of different temperatures or a change in temperatures.

Clashing Temperatures

> The air flow, the temperature, the cold air and warm air reacts. Causes a difference in the temperature and depending on the season it is, it reacts accordingly.
>
> It seems as though it usually is related to conflicting, either extremes in temperature which meet, it has to do with the larger patterns of weather, and where they, how they interact in an immediate area. Because you have a huge thunderstorm in one particular place, it's perfectly nice twenty miles north and twenty miles south, but right where we are the cold and the warm have come together to cause a huge thunderstorm.

Changing Temperatures

> The elements. (Such as?) Clouds, or the temperature of the Earth. It's just heating and cooling of water and air.
>
> Cooling, warming, I guess of the Earth.

Some respondents defined storms in terms of <u>air pressure</u>. These respondents talked about pressure as either a clashing of different pressures or a change in pressures.

Clashing Pressures

> A mixture of high and low pressure. . . . Something to do with when they meet, since there's a turning force, there's always turning, that's why hurricanes always turn clockwise in the northern hemisphere and counterclockwise in the southern hemisphere, because the turning of the air. When the winds meet they just happen to spin that way.
>
> Usually isn't it around development of a low-pressure area, and it's different air currents and temperature. It has to do with barometric pressure in the atmosphere. But storms, are often, isn't it a low-pressure area fighting against a high-pressure area?

Changing Pressures

> I guess air pressures cause things that wouldn't happen on a regular basis as far as lightning goes. Sudden changes in pressure and precipitation levels.
>
> A change in air pressure and all of that. (Do you know why changes in air pressure cause storms?) I'm trying to think what I've. My understanding of the change in pressure, air can rush in or pushed out. And, just that can, some changes.

A few respondents defined storms as they did in the above two questions--in terms of <u>weather elements</u> (e.g., thunder, wind, and rain). Responses in this category were highly simplistic.

> When I think of a storm I think of high winds, maybe temperature drop, rain, snow, whatever, it depends what time of the year. Lightning, thunder, high winds.
>
> It's rain, precipitation, sometimes thunder, sometimes lightning.

A few interviewees defined storms in terms of <u>how they affect people's lives</u>.

> A storm is something that happens that can cause damage, can be life threatening, scary. (What makes it different from just clouds in the sky?) Because they can be destructive. Clouds in the sky are not destructive. They're pretty.
>
> It's usually something that has the potential for harm or damage or destruction. And it's something that might cause you to change your activities, to alter your behavior in reaction to the weather that's happening.

Finally, a very small number of interviewees defined storms as <u>complex cycles of events</u>. These were the only interviewees who grasped the complexity of the subject and were able to discuss some nuances.

> A storm is a collection--let me think this out. It has to do with precipitation building up in the air and forming into the clouds, and the clouds just kind of unleash--I think there's something about the moisture coming down and then going up and rising into cloud formations. . . . The cycle.
>
> It's just the physical changes in the atmosphere which produce wind and precipitation, so it has to do basically with location of water vapor and high pressure and low pressure areas. (What do the pressure areas have to do with a storm?) Well, the pressure areas would be what would cause the wind which is associated with the storm. (Why?) Generally speaking, wind movement is based on a lot of things. Temperature, if you're talking about convection, the area the wind, the part of the atmosphere that would go up would cause a vacuum and cause other parts around it to be sucked in and this movement is called wind. Actually, temperature changes in various areas you probably have to say causes the wind. Because the air moves in an upward direction, because of temperature, then something has to go in to replace that. Basically the same thing would happen on your frontal air masses because it all involves rising air.

<u>Children</u>

Slightly more than one-third of children interviewed defined storms by <u>the elements of weather</u> (e.g., rain and snow) present. As in previous questions, respondents who offered this answer spoke simply and with some hesitation.

> It's when weather is not good. Most the time there's rain during a storm or thunder. Some type of water coming down. It's not sunny, something that you would want to go out in. It's something you wouldn't want to go out and have a picnic in.
>
> Rain and snow and lightning or something. (Anything else you can think about to describe a storm?) Real strong winds.

One-quarter of the children saw storms as <u>natural events</u>. Like adults, these young respondents saw storms as inevitable facts of life.

> They're formed by the weather, by Mother Nature creates them. Sometimes they have to happen, they just happen and you can't predict them or anything.

> It's something that happens and it's a thing that sometimes is helpful and sometimes is not and dangerous sometimes.

Some children saw storms as events that <u>affect people's lives</u>.

> Storms are more violent than just a little rain shower. And they can cause a lot more destruction than just getting rained on a little.

> They can really hurt you. Damage lots of stuff.

A few children attempted to explain why storms happen and described a <u>clashing of temperatures or other elements</u>. These respondents offered more thoughtful and sophisticated responses than some other young respondents.

> When there's hot and there's cool air and then they mix together and then they make different wind currents and then start a storm.

> It's where the climate, like hot and cold do air at each other, like fighting.

> Mostly basic elements go into it. Like when water and fire and these combine, and they make high speed winds, electric flashes, falling water.

Finally, one child discussed storms as <u>a cycle of events</u>. This interviewee clearly understood the complexity of storms and the multitude of factors that contribute to their formation.

> All storms start with clouds. And sometimes the storms go over lakes and ponds and it turns the water that's in them into a water vapor, the sun does, and then the water vapor comes up in the clouds and then it comes over a different spot and once it's so full, it just rains or if it's colder, it will come down as snow. Sometimes it will be sleet.

What Is Happening on This Weather Map from One Day This Summer?

The *Stormy Weather* exhibition team was intensely interested in how well people could interpret data from weather maps. To answer this question, interviewees were given a weather map from the *Washington Post* from one day in July 1994 and were asked to interpret what they saw. Four major weather indicators were illustrated on the map: temperature, precipitation, high- and low-pressure systems, and warm and cold fronts. After interviewees responded to the map, they were prompted by interviewers to talk about the indicators they did not discuss initially. If appropriate, respondents were also prompted to try to explain what they saw on the map in terms of interrelationships of the individual weather indicators.

This one question generated fairly complex and dense data. Embedded within responses are indications of how fully interviewees understand both the individual indicators and the way they work together to cause storms and lesser weather events. Readers should note that, except for a few obvious cases in the child data for this question, evaluators did not pass judgment on the accuracy of responses. Major trends and patterns are reported here; it is the responsibility of the exhibition team to determine the level of knowledge held by respondents.

Data were analyzed in two ways for both the adult and child interviews. First, evaluators counted how many indicators were discussed by each person, and they then placed respondents in two categories: those who discussed one or two indicators, and those who discussed three or four. Then, evaluators looked to see how many respondents attempted to explain what they saw on the map; explanations were placed in several categories for further analysis. Number of indicators is presented first, followed by explanations.

<u>General Findings</u>: Adults and children talked about the weather map similarly, although 15 percent of the children were unable to respond to the question. About half of the respondents in each group identified one or two weather indicators and the other half identified three or four. Both groups were also able to identify the symbols on the maps, although it is clear that they did not grasp the concepts behind the symbols. Adults found more ways to describe what was happening on the weather map than did children. This difference may reflect adults' accumulated exposure to listening to weather reports and looking at weather maps as well as their more sophisticated language ability.

Adults

Adult interviewees were <u>almost evenly divided between those who discussed one or two indicators and those who discussed three or four</u>, with a few more in the latter category. Many adults were not confident in their responses; there was a sense of hesitation and guessing in many of the responses. Although many interviewees could literally "read" the map--identify that H stands for high-pressure system, for example--most could not understand the concepts behind the symbols. The individuals quoted below <u>did not</u> offer any explanations for what they saw; they simply tried to decipher the symbols.

Discussed Three or Four Indicators

> A lot of rain. Along the coast, mostly, and in the Midwest. (What about these Hs and Ls and stuff?) The H is for high. There's a lot of pressure or something, and the L is for low pressure, and then the points on the line show fronts, and I think this line shows the jet stream, whatever that is. (How do fronts and pressure affect storms?) It's what causes the storm. When they clash, that's what causes a storm.

> Rain, high pressure and low pressure here. We have a cold front moving here, that would be wonderful. It's been very hot. (Can you talk a little bit about high pressure and low pressure and how they affect storms?) Not really. But I do know that it definitely has to do with the jet stream and all of that. (What about a front?) Like a cold front moving in or something like that? Well, just from what they tell me on TV, if a cold front's coming my way, you know it's going to cool off.

> On the West coast it looks like it's up in the 80s and 70s, and it looks pretty calm there, little rain, and it's pretty much raining in the central states. There's a low front right here. (What is a low front?) It means it's going to be cold. Usually colder weather. Actually if it's mixed like this, it's stationary, see how it says down here [in the legend], and then this would be a cold front with the spiky things, and a warm front would be the ones with just the round ones, and these are the fronts. (What about these Hs and Ls?) Those are high- and low-pressure systems. (How do those affect weather?) Well, in a high-pressure system it's usually humid, you know, high temperatures. Usually most high temperatures are out in the West and stuff.

> A cold front there, there is a warm front there, coming, maybe that way to the east? Precipitation area, that means on that side in Omaha it will be a certain weather. Isotherms mean areas of same temperature, same temperature on the West. It's going to rain there, and there in the middle, and there. (What about the Hs and the Ls?) H means high pressure, and L low pressure. High pressure means the wind is very high above you.

You can see high- and low-pressure systems. Fronts moving. Rain, appears to be and the temperatures. So this would be a summertime map judging by the temperatures throughout the United States. As I said, different fronts, high- pressure/low-pressure areas, isobars, contours. (What are those pressure areas going to do to the weather?) They're going to affect the weather, they're going to change the weather from one geographical location to another as they move from west to east. (Why does the weather move west to east?) Because of the Earth's rotation.

Discussed One or Two Indicators

It's raining, isotherms swinging across the country, from west to east. I see a couple of fronts, cold, warm. Don't see any stationary. Looks like pretty good weather in Miami on this particular day.

There's rain, isn't that rain, all those little dashes are rain down there isn't it? It looks like there's a front coming down. My husband is a real weather person. I let him do it. Well, all I know is that these are probably fronts coming in to either push weather forward or hold it still or make it stationary, or whatever.

Looks very rainy, around the Florida region. Got some clear spots. It looks like rain in kind of waves. (What about the other lines and Hs and Ls and all that stuff?) That's kind of like high-pressure fronts and other things.

This is showing the winds, how they're traveling across the United States. Perhaps cold fronts. (And what would a cold front do?) What would it do? I guess it would bring in cold weather to a certain part of the United States. (And how about the Hs and Ls?) Those are highs and lows. Don't ask me what it means.

Looks like there's a cold front, coming along the Mideast. Rain in the South and the East, rain in front of the cold front in the Midwest, I guess the West has some rain and I don't understand the highs and lows. (You noticed that the rain was in front of the cold front. Is that a consistent phenomenon?) I think it is. (What about these black lines without the triangles?) I guess it's showing the highs and lows, but I don't understand . . . the different temperatures.

It's going to tell you the highs, there's a high here and a high over here and there's a low here, but I'm afraid I can't interpret it for you. (What do highs and lows have to do with storms?) Depending on where they are, the high and the low control the storm, well, they control the climate.

<u>Approximately half of adults interviewed offered explanations</u> for how the symbols depicted on the weather map interacted to create storms or weather events. More interviewees who identified three or four indicators were able to offer explanations than those who identified one or two indicators, but some who mentioned one or two indicators also tried to explain what they saw. The explanations fell into five categories discussed below. The first two categories were most common, with only a few respondents offering explanations in the last three categories.

A Warm Front Meets a Cold Front

> They talk about lows and highs and, well . . . that means it's raining over here I think. It might be a cold front coming and between a cold front and a warm front, there's always rain, and humid weather. (Do you know why that is?) Well I suppose the circulation between the two extremes, and the turbulence comes in, but I can't explain it specifically.

> Cold front coming in from the Pacific Northwest, and the jet stream probably coming down like this. And of course uneven temperature distribution and precipitation, obviously, because here's the precipitation lines. (You noticed the cold front. How does that affect weather, storms?) That causes the moist air coming up from the Gulf and the Southwest to hit this cold air and you get disturbance in the air, of course. It sets up violent winds and violent precipitation.

> It seems to be a very hot summer day, because I'm looking at the Great Lakes area and it's 80 degrees up there, and it's generally cold up there. . . . And it's 80 degrees above where I used to live, so it must be mid-July . . . for it to be that hot. It's probably raining on this eastern coast and down south around New Orleans. There's a belt of rain coming up through here and down through there and there. (What about these lines with the triangles and circles?) They have some kind of a cold front coming in there from Canada. Northwestern Canada right here, bending down that way and that's a warm front right here coming in. (So what do you think is going to happen in that area where the warm and cold fronts are kind of close to each other?) It will rain. Hot and cold meet, it's just like on the side of your glass.

High Pressure Creates Good Weather, Low Pressure Creates Bad Weather

> Does not appear to be predicting rain or snow in New Jersey. I don't entirely understand the isotherms, though I understand there are highs and lows coming in. Stationary is where rains tend to occur, when the warms meet the colds. (What about the highs and lows? What do they have to do with all this?) Highs are good and lows are not good. Lows bring the rain, and when the highs and the lows stay together, the rain doesn't stop coming down--or snow--is what I think I understand.
> We're having rain up the East coast, you've got nice weather in the northeastern part of

the United States. (How do you know you've got nice weather?) Because of the high-pressure area. Looks like there's probably in the Midwest and the central part of the South all the way through Texas, it looks like it's clear, and we've got a low- pressure area that's coming into the Midwest and is probably going to create some weather when it moves through. Depending on what time of the year, there aren't any temperatures on here, so depending on what time of the year it'd be, there could be either snow or thunderstorms, or gentle rains or whatever. Looks like the North and the western part of the country, they're having pretty good weather because there's another high-pressure area up there, and the same for the southwestern part of the country.

We've got rain in the southeastern part of the country, and then in the Midwest we have rain. No snow. Rain also going up into Canada, low-pressure system that's coming out of Canada and dipping down into Denver, and high-pressure system that's out in Montana, up near the Seattle area. (When you're talking about high- and low- pressure systems, what are they and how do they affect weather?) Low-pressure systems will bring some kind of weather with it. High-pressure systems usually keep things dry. There's not weather usually associated with a high-pressure system. Low-pressure system also down in Florida, high-pressure system in the Gulf of Mexico.

Cold Fronts Bring Rain

This is a cold front coming through, which is bringing the rain to this area. This cold front has already gone through, which is producing the rain behind it. This is where we're living [Houston] . . . hot, so it must be a summer's day. (And what about the Hs and Ls?) They're high- and low-pressure regions. Generally cooler weather's the low pressure, and generally hotter weather is nearer the high pressure.

High Pressure Meets Low Pressure

There's a storm front coming across South Florida that we'd probably see within the next day or so. The southeastern United States through the eastern coast areas is getting a fair amount of rain. There's some pretty heavy-duty turbulence up there in the Great Lakes. (What's causing it?) Because there are two different . . . this is the low and the high are going to be interacting with each other. That always makes for a fair amount of extreme weather conditions. (Do you know why that is? Why does that happen?) It has to do with the air pressure, and when the air pressures interact, that's what creates turbulence.

Complex Cycle of Factors

> There's a high pressure over the New York area, New Jersey. High pressure means air coming down. Air coming down isn't cooling, it's warming, so you're not really going to have much precipitation in that area. Not many clouds, if any. Seems low pressure up in Minnesota, that's tied to a front, and more than likely you have an air mass coming out of Canada or out of the Pacific Northwest, and since you have a front there you probably have moist, warmer air. That area would not be warm, but warmer air coming out of the Gulf and the Atlantic, with the air circulation around the high being clockwise and counterclockwise around the low. That would indicate that the air flow would be from the Gulf up north probably having a meeting line at this point where the warmer air is overriding the colder air, and therefore you would have precipitation along the front, which they show as these dashed lines right here. You also have these other lines through here, which are, I guess they're not isobars, those are temperature lines. They've drawn in the differences in temperature. Take for instance Chicago is 90 degrees, and you have 100 degrees going up through Arkansas and Oklahoma, so actually that's going to be a hot spot (in Texas?) Right. Fort Worth area, between looks like Monterey, Mexico and the panhandle of Texas there up through Little Rock, all that area is probably going to be over 100 degrees, and everything in between this line and this line is going to be between 90 and 99.

<u>Children</u>

Child interviewees talked about the weather map in a fashion similar to the adults: <u>approximately half of these young respondents identified one or two weather indicators, with the other half discussing three or four indicators</u>. Children were similarly hesitant and unsure of their responses. Their language tended to be simple; most children needed continuous probing to encourage them to talk about all elements of the map. Like adults, many children could read the symbols on the map but clearly did not understand the concepts behind the symbols. Fifteen percent of children interviewed were not able to answer this question at all. The comments below reflect those children who only identified weather indicators and who <u>did not</u> attempt to explain what they saw in the weather map.

Discussed One or Two Indicators

> It was raining in a lot places. Wasn't sunny. Some places it was warm.
>
> It's going to be rainy here. Front here. (What's a front?) A lot of cold air or a whole lot of hot air comes and like really sudden. (Moving?) It's moving like the wind pushes it and stuff.

A lot of rain. (Where do you see rain?) Here, here, here, all in there. A lot of heat. (How do you know that's heat?) There is a cold sort of cold there. (Sort of cold. Do you know what a cold front is?) Not really. Cold storm. Rain storm.

Discussed Three or Four Indicators

> You can see where the rain is especially. Where it's going to be cold. Basically what temperature it will be and where. If we have snow. The pressure.
>
> It was really hot down in Mexico. 100 degrees. It was raining in some parts, and it doesn't look like it snowed any. Let me think. There was a cold front moving down to the Midwest. (What is a cold front?) Let me think a second. Been out of school too long! It's when a big mass of cold air comes. (What about these Hs and Ls?) High pressure and low pressure.
>
> It's raining on the East coast mostly and all over there. It's going to be hot in Texas. (How do you know that?) Because, does that mean the temperatures 100 degrees? (100 degrees, yeah. What about these Hs and Ls?) That means high pressure and low pressure or something.
>
> Rain. (Where do you see rain?) Right there and along the edge of--and there's rains all over. (Are you pointing at the lines?) Yeah. (What do those lines mean, do you know?) No. (What's going on on the West coast?) It's high temperatures, not really high, but kind of high temperatures. (And what does that mean?) It's caused by the currents, not the currents, because of the water. (Do you know what this L and this H stand for?) Low pressure and high pressure. (And what is high pressure and low pressure?) Like when it's going to rain probably. Or when it's raining. (And what about this line that has like a triangle and circles, what are those things?) Cold air and hot air. Warm.

Almost half the children interviewed, when talking about the weather map, demonstrated misunderstandings of some concepts. Many children had misconceptions about high and low pressure, while some children were confused about warm and cold fronts. Although some adults also were confused about these concepts, their mistakes were not as obvious as the children's. Therefore, adult misconceptions in the data were not highlighted.

Misconceptions About High and Low Pressure

> (What about these Ls or Hs?) The Ls mean low, Hs high. (Low or high what?) Weather. (Weather? Can you tell me more?) Like, 90 degrees would be high, and then 50 degrees would be maybe low.
>
> It's going to be high up here, high weather. (What do you mean by high weather?) It's going to be warm. Warm. And it's going to be cold there. (Where there's an L.)
>
> (And the Ls and the Hs, what do you think they stand for?) Low and high. (Low and high what?) Weather. (What part of the weather?) Like high in the 90s, low in the 50s.
>
> (What else do you see going on the map?) Uh, the highs. Hot. (You said a high? What does that mean when you say that's a high?) That's a high temperature.

Misconceptions about Warm and Cold Fronts

> (What does that mean when it shows that there's a cold front coming?) Probably has cold weather, maybe snow.
>
> (Here's some other lines that have triangles or circles on them, what are those lines for?) Triangles mean cold and the circles mean warm. (Cold or warm what?) Weather.
>
> (What about some of the other symbols on the map? Like this line with the triangles on it?) That would be the cold lines. Or it would be cold around that area.

<u>One-quarter of child interviewees offered explanations</u> for the symbols depicted on the weather map. They explained the weather phenomena in three ways, the most prevalent being that storms are formed when warm air meets cold air.

Warm Air Meets Cold Air

> Raining a lot. Looks like you got heat waves, a cold front. (What is a cold front anyway?) When like a wave or wind, cold wind comes through. Okay. Well, you know that there's a cold front and there, you probably know that that's a warm front. (What's going to happen when those two are so close together like that?) Tornado. (Tornado. Why does that happen?) Because when the warm air mixes with the cold air, it starts, it goes like that, and swirls up.

I can tell you in Kansas City it was raining. And, there's a lot of rain and some hot temperatures in Mexico and Phoenix around in that area, the West coast, and hot weather on the East coast. Pretty hot anyway. And some rain on the East coast, some in the Midwest, and hardly any rain on the West coast. (How about the lines with the triangles and circles on them?) That means that there's either a cold or a warm front coming. This would be hot, and this area would be colder. (What do fronts have to do with storms?) Well, if cold air hits hot air, it can cause a tornado. (That's good to know. So is there anyplace on this map that looks like there actually might be something like that going on?) Right here kind of. And maybe right in that area.

High Pressure Creates Good Weather, Low Pressure Creates Bad Weather

Well, it's pretty warm temperatures. (Any particular place for warm temperatures?) It's 100 in southern California and through Texas, it's 90 at the top of the East coast, and it's raining in New Orleans, Atlanta, Florida, the Carolinas, Virginia, Kansas City, it's raining up north in Canada. (Anything else you see happening?) There's a, looks like a high-pressure system coming in and low-pressure system going down. (How do you know that?) Because of the H and the L. (What is a high-pressure system?) I think it's when it gets hot and humid and it's pretty dry. (What's a low-pressure system?) It's a lot of, it's raining, it's like the cool air and sometimes, usually it's rain.

High Pressure Meets Low Pressure

It's raining here, and it's raining all through there, midwest kind of, little by Nevada and stuff. Warm in some areas, actually the whole country's pretty warm right now--80 or 90. There's some warm fronts and cold fronts, some are coming, and the warm fronts over here. Oh, this is like connecting the same, air pressure and stuff like that. I guess that's about it. There's no snow. (You noticed the fronts and pressure and stuff, how does that all work together to make storms or not make storms?) Sometimes when the clouds go under each other and over each other, then that pressure makes it into rain or snow or whatever.

What Do Meteorologists Measure to Predict the Weather?

Adult and child interviewees were asked what meteorologists or weatherpeople measure in order to describe and predict the weather. Data are reported quantitatively in Table III.3.

<u>General Finding</u>: The most prevalent response among adults and children was barometric pressure, followed by temperature. The third most frequently mentioned response by adults was humidity/moisture. Among children, it was rain/precipitation (see Table III.3).

Table III.3.
What Meteorologists Measure in Percent

Indicators	Adults n=80	Children n=40	Total n=120
Barometric pressure	78	33	63
Temperature	59	43	53
Humidity/moisture	43	25	37
Rain/precipitation	20	30	23
Wind	19	28	22
Wind speed	28	10	22
Clouds	11	05	09
Don't know	04	13	07
Wind direction	09	03	07
Jet stream	08	00	05
Previous weather patterns	04	08	05
Mold counts/pollen	03	01	03
Dewpoints	03	00	02
Flip a coin	01	00	01
Fronts	01	00	01
Radar	01	00	01
Time of day	01	00	01

Columns do not add up to 100 due to some respondents giving more than one answer.

What Are Definitions for the Five Basic Indicators Used to Predict the Weather?

After respondents were asked what tools they thought were used to predict weather in the above question, they were asked to define the five basic indicators regularly used by meteorologists: temperature, wind speed, wind direction, relative humidity, and barometric pressure. By asking people to define these terms, evaluators were able to assess their levels of understanding versus their abilities to do no more than name the indicators.

Adult and child responses were easily categorized and quantified. Tables III.4-III.8 present summary responses by adults and children for each indicator.

General Findings: Adult and child respondents easily defined temperature and wind speed but were much less certain about wind direction, relative humidity, and barometric pressure. The degrees of understanding varied between adults and children, as shown in the tables that follow.

Temperature

Ninety-six percent of adults and 98 percent of children understood temperature. For the purposes of this study, evaluators determined that interviewees who mentioned "warmth or coolness in the air," or even "hot or cold," "understood" temperature. There were few variations between adults and children in response to this question, as shown in Table III.4.

Table III.4.
Definitions for Temperature in Percent

Definitions	Adults n=80	Children n=40	Total n=120
Warmth/coolness	96	98	97
Measure of weather	01	00	01
Don't know	03	03	03

Columns do not add up to 100 due to rounding.

Wind Speed

Ninety-three percent of adults and 80 percent of children understood wind speed. For the purposes of this study, evaluators determined that mention of "velocity" or "how fast the air is moving" indicated that respondents "understood" this concept. Except for the "don't know" category, there were few variations between adults and children in response to this question, as shown in Table III.5.

Table III.5.
Definitions for Wind Speed in Percent

Definitions	Adults n=80	Children n=40	Total n=120
Velocity of wind/how fast wind is moving	93	80	88
Types of gusts	03	00	02
How high the wind is traveling	00	03	01
Don't know	05	18	09

Columns do not add up to 100 due to rounding.

Wind Direction

<u>Unlike wind speed and temperature, there is a discrepancy between adult and child knowledge regarding wind direction. Thirty-nine percent of adults and only 3 percent of children understood wind direction</u>. For the purposes of this study, evaluators determined that interviewees who mentioned "the direction from which wind is blowing" "understood" wind direction. Overwhelmingly, child respondents thought of wind direction as the direction wind is blowing to; adults were almost evenly divided between where wind is blowing to and where wind is coming from as a definition for wind direction, as shown in Table III.6.

Table III.6.
Definitions for Wind Direction in Percent

Definitions	Adults n=80	Children n=40	Total n=120
Direction wind is blowing to	44	80	56
Direction wind is coming from	39	03	27
East, west, north, south	06	00	05
Don't know	10	18	13

Columns do not add up to 100 due to rounding.

Relative Humidity

<u>Very few adult and no child respondents understood relative humidity to indicate the amount of water air can hold at a given temperature</u>. "Moisture/wetness in the air" was the most prevalent response among adults, and "don't know" was most prevalent among children, as shown in Table III.7.

Table III.7.
Definitions for Relative Humidity in Percent

Definitions	Adults n=80	Children n=40	Total n=120
Moisture/wetness in air	65	28	53
Don't know	06	38	17
Moisture relative to how much air can hold at given temperature	14	00	09
Heat/temperature of air	01	18	07
Moisture relative to how much air can hold	09	00	06
Sticky/humid air	01	15	06

Columns do not add up to 100 due to rounding.

Interestingly, a few adults and children, when asked specifically what the "relative" part of "relative humidity" meant, answered in extremely literal terms! The two quotations below illustrate this aspect of the data.

> (Where do they get the word relative in there? Why don't they just say humidity?) They named it after my uncle because he lost his house. (and he's a relative?) Yeah. Being respectful. (Adult)

> Like when a neighboring country, I mean a neighboring state, how much you had. (Child)

Barometric Pressure

<u>Even though two-thirds of the adults attempted to define barometric pressure, few were confident about their response. Eighty percent of the children said they did not know the meaning of barometric pressure</u>. Data are presented quantitatively (see Table III.8) and qualitatively, as interviewees' descriptions of barometric pressure were much more detailed than descriptions of the other four indicators. Quotations by adults appear first, followed by quotations by children.

Table III.8.
Definitions for Barometric Pressure in Percent

Definitions	Adults n=80	Children n=40	Total n=120
Don't know	29	88	48
What it measures	48	05	25
What it indicates	15	08	13
Related to humidity	09	00	06
How it is measured	08	00	05

Columns do not add up to 100 due to some respondents giving more than one answer.

<u>Adults</u>

<u>Nearly half of adults talked about barometric pressure in terms of what is measured</u>. As shown below, responses varied from confident to extremely hesitant.

> Barometric pressure is the closer to Earth you get, the more dense the air is--in other words, than it would be if you went up higher, the less dense. Different elevations have different barometric pressures. And when it gets colder the barometric pressure increases; when it gets warmer it decreases.
>
> The air pressure at any given point, measured generally with a reference to sea level normal barometric pressure, 31.
>
> A measurement of the pounds per square inch of atmosphere that's on any given point.
>
> I wonder if it's related to gravity or not. It's the amount of pressure being measured in a

> particular area at a particular time related to a relative pressure.
>
> How dense the air is--how much force the air is exerting on any one point at rest.
>
> I envision it as the stack of air that's above you and how heavy it weighs upon you.
>
> I know what it is, but how to explain it? Barometric pressure is something that is used to determine high- and low-pressure systems.
>
> The pressure of the atmosphere at that point.
>
> That's the pressure on the Earth I think.

The remaining three categories were each mentioned by a few interviewees.

A few adult respondents discussed <u>what barometric pressure indicates</u>. These respondents seemed more confident in their responses.

> If there's going to be a storm, the barometric pressure will drop.
>
> I know when the barometric pressure is low, it's usually bad weather. When it's high, it's usually good weather.
>
> Low pressure means unsettled stormy conditions; high pressure means it's going to be clear and fair.

A few adults were clearly confused and <u>connected barometric pressure to humidity</u>.

> The pressure between, how would you say that, the humidity somehow? The humidity in the air?

And a few adults talked about <u>how barometric pressure is measured</u>.

> Pressure of mercury--the amount of inches of mercury raised in a vial at any given moment.
>
> You could measure it with a bowl of mercury and a little--it's got a vacuum inside the closed end of the tube, so that it raises it up. You measure how far the mercury is raised up the tube.

Children

A very small number of child respondents discussed what barometric pressure indicates.

> It depends on what the barometer is, if it's going to rain or not.

An even smaller number talked about what barometric pressure measures.

> How much the pressure is like putting on Earth or something.

What Is Happening in This Picture [GOES Visible Image]?

In this question, respondents were shown a GOES (Geostationary Operational Environmental Satellite) visible image of a hurricane (see Appendix A). Images of Hurricanes Andrew and Iniki were used at different data collection sites. The *Stormy Weather* exhibition team was interested in knowing if visitors could understand what the image was depicting and how the image was created. There were several parts to this question. Each part is isolated, and data generated from both adult and child interviews are presented quantitatively and qualitatively.

General Findings: There is a substantial difference between adult and child knowledge regarding this image. More than half of adult respondents and 15 percent of child respondents knew that the photograph represented a satellite image of a hurricane. Tables III.9-III.11 provide a breakdown of the specific data generated by this question.

Types of Storms

Adults correctly identified the storm depicted in the image twice as often as children. More than 80 percent of adults and almost 40 percent of children recognized a hurricane in the photograph. Table III.9 summarizes what respondents thought was the subject of the photograph.

Table III.9.
Types of Storms Depicted in the GOES Visible Image in Percent

Storm Type	Adults n=79	Children n=39	Total n=118
Hurricane	84	38	68
Generic storm	04	13	07
Don't know	10	10	10
Tornado	01	18	07
Missing data	01	26	09

Columns do not add up to 100 due to rounding.

"N" values are less than the total sample because one respondent from both the adult and child data sets did not respond to this question.

The "missing data" row indicates that not all interviewees responded to all parts of the question.

How Hurricanes Were Identified

Of those respondents who mentioned hurricanes, some adult and child interviewees indicated how they knew the image represented a hurricane. **Of those who identified hurricanes in the image, <u>78 percent of adults and 55 percent of children recognized the distinctive circular shape of the hurricane</u>.**

Table III.10.
How Hurricanes Were Identified in the GOES Visible Image in Percent

How Hurricanes Were Identified	Adults n=53	Children n=11	Total n=64
Distinctive shape	62	55	61
Eye of the storm	16	09	14
Distinctive shape/eye of the storm	16	00	13
Televised images of hurricanes	08	36	13

Columns do not add up to 100 due to rounding.

"N" values reflect those who knew hurricanes were represented in the image.

Because respondents talked about the shape of hurricanes in different ways, from complex to simplistic, selected quotations about hurricane shapes from adults and children are presented.

> (How can you tell that they're both hurricanes?) Because of the circular motion. It looks like it's spinning, and you can see the eye of the storm. It's real calm in the middle, like a hurricane is. It's real intense around the eye. (Adult)
>
> The circling motion says it must be a severe hurricane or a tornado. (Adult)
>
> (How do you know it's a hurricane?) By the counterclockwise spiral that occurs in the northern hemisphere. (Adult)
>
> That looks like there's everything swirling around that part, and that's where there's probably a big . . . hurricane. (Adult)
>
> It's like in a circle. (Child)
>
> I know they have that little spiral-type thing. (Child)
>
> Because you can see all the swirling wind and stuff. (Child)

How the GOES Visible Image Was Created

Respondents were asked how they thought the image was created. **<u>Many more adults than children responded correctly. Sixty-eight percent of adults and 38 percent of children thought the image was produced by either a satellite or a camera in space</u>.** Table III.11 summarizes these data.

Table III.11.
Means of Creating the GOES Visible Image in Percent

Means of Creating Image	Adults n=79	Children n=39	Total n=118
Satellite/camera in space	68	38	58
Don't know	22	18	20
Airplane/aerial camera	08	15	10
Computer	00	21	07
Radar	03	08	04

Columns do not add up to 100 due to rounding.

"N" values are less than the total sample because one respondent from both the adult and child data sets did not respond to this question.

To give the *Stormy Weather* exhibition team a feeling for how respondents talked about the image, several quotations follow.

> It tells you the way they are going, the wind is moving, and the clouds, and this is something very heavy in the middle. (How do you think they made this picture?) I think it's a satellite picture. (Adult)
>
> Looks like you're looking at a hurricane over some islands in Hawaii. (How do you think this picture was made?) Looks like from a NOAA satellite. (Adult)
>
> That looks like a hurricane. (How can you tell?) Because hurricanes usually are like round and stuff. (What's going on right here?) That's the eye of the hurricane, that's the part where the storm's not as rough as it is on outer areas. (Adult)
>
> It's turning. That's the wind and everything all together there, the heat and humidity and everything. (And how would they make this picture?) I don't know how they make it. Just take a picture. (Adult)

I would assume a hurricane. That looks like the eye of the storm but maybe not. It's just like what you see on the news. Is this over water? (Yeah, that's Hawaii.) It's a hurricane? Or just a storm? (What clues would you see that would tell you it might be a hurricane?) Just the visual image you see like on the news we were watching, the hurricane, the circular motion being created there. (How would they make this picture?) I'm sure they have some kind of high-tech equipment for it. (Adult)

There's going to be a storm in Hawaii probably. Or something. (You mean what kind of storm?) Yeah. . . . Tornado or something like that. (And how would this picture have been made?) How? It looks like on a computer. (Child)

That's a hurricane, and they expect that to be the eye of the storm. (How did you know it was a hurricane?) I remember seeing it on TV. I seen things on TV. (And you recognized it? And what makes it recognizable?) That it's twirly. (How did they make this picture?) I don't know. (Any guess?) They could've took it from a plane or something. (Child)

Radar. Some kind of radar. (Where would this radar be?) Where the weather capsule is. (Child)

Via satellite. It just shows the storm moving. (Child)

What Is Happening in This Picture [GOES Infrared Image]?

In this question, respondents were shown an image, generated by GOES infrared technology, of a hurricane over Florida (see Appendix A). As with the satellite image discussed above, the *Stormy Weather* exhibition team was interested in knowing if visitors could understand what the image was depicting and how the image was created. They were interested to know if there were differences in the way interviewees responded to the two satellite photographs. There were several parts to this question. Each part is isolated and data generated from both adult and child interviews are presented quantitatively and qualitatively.

General Findings: Significantly less adults and children were able to identify a hurricane in the GOES infrared image than in the GOES visible image discussed above. Fewer adults and children were also able to identify satellite technology in the GOES infrared image than in the GOES visible image. Tables III.12-III.14 provide a breakdown of the specific data generated by this question.

Types of Storms

Twice as many adults as children correctly identified the storm in the GOES infrared photograph. Fifty-six percent of adults and almost one-quarter of children recognized a hurricane in the photograph. See Table III.12.

Table III.12.
Types of Storms Depicted in the GOES Infrared Image in Percent

Storm Type	Adults n=79	Children n=39	Total n=118
Hurricane	56	23	45
Don't know	28	15	24
Generic storm	15	15	15
Tornado	01	10	04
Thunderstorm	00	08	03
Missing data	00	28	09

Columns do not add up to 100 due to rounding.

"N" values are less than the total sample because one respondent from both the adult and child data sets did not respond to this question. Due to the complexity of this question, not all interviewees responded to all parts of the question, as indicated by the "missing data" row.

Meaning of Color Bands

Half of the adult and child respondents attempted to discern the meaning of the color bands in the hurricane portion of the image. Of those respondents who discussed the colors, several response categories emerged. **The most prevalent response among adults was that the colors represented different temperatures; among children the most prevalent response was that the colors represented different intensity levels within the storm. Details are summarized in Table III.13.**

Table III.13.
Meaning of Color Bands in the GOES Infrared Image in Percent

Meaning of Color Bands	Adults n=48	Children n=21	Total n=69
Temperature	42	33	40
Wind and/or rain	31	24	29
Intensity	19	38	25
Combination/guess	04	05	04
Pressure	04	00	03

Columns do not add up to 100 due to rounding.

Because respondents talked about the color bands in different ways, as shown above, selected quotations about the colors from adults and children follow.

Temperature

Several respondents assumed the image was created using infrared technology, and that this was tied to temperature differences within the storm.

> Now that's infrared photography. That deals with heat. This is probably--the first one's probably visual, although, usually visual is white from the clouds, infrared photography showing heat and red is usually hot, it's probably another hurricane, and the blue is the cooler, we're showing the cool center of the eye and the heat and so forth generated by the storm itself surrounding it. (Adult)

This is a thermal image, taken from satellite. The hot spots on the storm are normally the more vivid colors, the red colors. In the center is the eye of the storm. You can also see the direction which the storm is going as well, but there's basically temperature that it's measuring within the storm itself. (Adult)

I suppose it's the heat coming off the land, isn't it? (Adult)

This is the heat, measuring how hot it is. It's very hot out here. I think that's a land mass being surrounded by very hot temperatures or something. It can't be a volcano. I have no idea what's happening in this picture. (Adult)

I think that's heat. (Child)

Like how intense the sun is. . . . It's got like, kind of orange and blue, means it's kind of hot and in the center it's all red. (Child)

Wind and/or Rain

It's probably measuring the amount of wind and putting it into colors somehow. (Adult)

Color enhancement showing variances within the hurricane, whether they are . . . wind velocity or moisture/rainfall. There's no legend to indicate. (Adult)

Either the faster speeds are where the red is, or that might be where the heavier stuff is, as far as rain and winds go. (Adult)

The reds are where the rain is really hard. (Child)

Intensity

Probably the different colors indicated in the picture shows the severity of the storm and where the eye of the storm is located. (Adult)

They saw the movement and they took a picture and made colors on it to show which was more dangerous. (Which area is more dangerous in the storm, from looking at it?) The red. Well, if that's really dangerous, that's a big area there. (What about this area right in the middle of it that's all blue and gray?) That's going to be the most dangerous because it's the center of the storm. (Child)

Combination/Guess

I think the red part may be the heat from the sun, and the blue part may be the water. Maybe the yellow the wind, I don't know. (Adult)

That's the water. (The blue part?) Yeah. And then the yellow part might be crops. (Child)

Pressure

These are just pressure systems and the direction they're blowing in. (Adult)

How the GOES Infrared Image Was Created

Respondents were asked how they thought the image was created. **More than half the adults and more than half the children thought a satellite or a camera in space was used to produce the image. Several adults, in conjunction with various imaging techniques, also mentioned infrared technology.** See Table III.14.

Table III.14.
Means of Creating the GOES Infrared Image in Percent

Means of Creating Image	Adults n=79	Children n=39	Total n=118
Satellite/camera in space	53	36	47
Don't know	25	21	24
Computer	06	33	15
Radar	10	03	08
Airplane/aerial camera	05	08	06

Columns do not add up to 1 due to rounding.

"N" values are less than the total sample because one respondent from both the adult and child data sets did not respond to this question.

To give the *Stormy Weather* exhibition team a feeling for how respondents talked about the GOES infrared image, several quotations follow.

> Looks like this is probably a tropical depression, because it's not quite as well-defined of a spiral, but there's a definite center. Looks like it might be infrared. It's still a satellite picture. (Adult)
>
> Computerized image probably received from a satellite. It looks like a major hurricane off the East coast, off of Cape Hatteras. (Adult)
>
> This is a radar photo. This is another hurricane, I suppose. Yes, it looks like a hurricane definitely. Depending on the color, at least comparing with what I learned about Andrew, this is where the strongest winds are. This is the eye, and that's about it. You know, strong winds and a lot of rain. (Adult)
>
> It shows the condition of the storm, but I don't know. (Adult)
>
> That one, a computer. (And what's going in that picture weather-wise?) There's going to be a twister somewhere like. And it's going to be really windy over here. (Child)
>
> I guess it's really hot around here. (Because of the red?) Yeah, the red and rain I think, or it's ocean. Florida, oh, so something weird's happening. (Florida's something weird!) I'd guess it's hot and cold and humid. (How would they have made this picture?) By computer graphics. They take a picture and run it through the computer, and they'd find out where it was hot and they'd trace a line from where it was hot and where it was cold, or, I don't know, if it was windy, blowing. (Child)
>
> A tornado. (How do you know that?) I don't even know. (Okay. Well, how do you think they might take that picture?) Probably go where this is and just take a picture of it. Click. And then copy it on the copying machine. (Child)
>
> Satellite, I guess. Like how fast the wind is moving or something and makes the picture according to certain colors that correspond to the wind and stuff. (Do you have any idea what the colors mean?) I think if it's a hurricane, I think it's the wind speed. And I think it's faster where the red is. (Child)

What Is Happening in This Picture [Doppler Radar Image]?

In this question, respondents were shown a Doppler radar image of thunderstorms over Oklahoma (see Appendix A). As with the satellite images discussed above, the *Stormy Weather* exhibition team was interested in knowing if visitors could understand what the image was depicting and how the image was created. There were several parts to this question. Each part is isolated, and data generated from both adult and child interviews are presented quantitatively and qualitatively.

General Findings: Two adults and no children correctly identified a Doppler radar image of thunderstorms. Tables III.15-III.17 provide a breakdown of the specific responses generated by this question.

Meaning of Doppler Radar Image

Respondents were asked, "What do you think this picture shows?" **Sixteen percent of adults and children together identified thunderstorms in the photograph. The most prevalent response among adults was "precipitation"; the most prevalent among children was "temperature."** See Table III.15.

Table III.15.
Meaning of Doppler Radar Image in Percent

Meaning of Image	Adults n=80	Children n=40	Total n=120
Temperature	23	30	25
Precipitation	25	15	22
Thunderstorm	18	13	16
Weather	14	20	16
Don't know	14	10	13
Geography	10	08	09
Hurricane	00	13	04
Radar	04	00	03
Miscellaneous	04	05	04

Columns do not add up to 100 due to some respondents giving more than one answer.

Miscellaneous responses are those that appeared in the data 2 percent of the time or less; they include "humidity," "pressure," "snowstorm," and "wind."

Meaning of Color Bands

<u>Adults and children were similar in their responses to this question</u>. The most prevalent response among adults was that <u>the colors represented different intensity levels within the storm</u>. Among children the most prevalent response was that <u>the colors represented different temperatures</u>. Other responses were scattered among few interviewees. Details are summarized in Table III.16.

Table III.16.
Meaning of Color Bands in the Doppler Radar Image
in Percent

Meaning of Color Bands	Adults n=80	Children n=40	Total n=120
Intensity	29	23	27
Temperature	26	28	27
Precipitation	28	23	26
Geography	05	18	09
Type of weather/storm	03	05	03
Wind	05	00	03
Miscellaneous	06	13	08

Columns do not add up to 100 due to some respondents giving more than one answer.

Miscellaneous responses are those that appeared in the data 2 percent of the time or less; they include "pressure," "humidity," "don't know," "cloud density," "lava," and "where hurricane will hit."

Respondents talked about the color bands in different ways, as shown above. Some people were extremely literal in the way they interpreted the colors, relating blue to water, green to grass, red to fire, and white to snow. Most respondents were hesitant in their responses and often acknowledged to the interviewer that they were guessing. Some respondents mentioned that they had seen similar images on television. Selected quotations from the three most prevalent categories of responses follow.

Intensity

Responses in this category were very general and described overall severity of a storm, without going into detail about what specifically was severe. Most respondents related the color red with increased intensity.

> Intensity of the rain. The redder it is, the more intense. (Adult)
>
> Probably a tornado in this area [red], and the severity would probably indicate the more severe weather. The darker red, the more severe weather. (Blue and green?) Where the storm isn't as bad. (Where would the tornado be?) In the reddish, orange area. (Adult)
>
> In this area right here [red] it looks like it is more of a severe type of storm and the blue and green are pretty much everyday-type weather. (Anything else?) I see the white parts are unaccounted for, and I am not sure what that says. (Adult)
>
> Red is danger; green would be nice. (Adult)
>
> The different strengths of the storm. (Child)
>
> Red means tornadoes and all that. (And what do the colors indicate?) Where there's dangerous parts of the weather and where there's not. (Child)
>
> The colors indicate the severeness of the storm. If it's light blue, it's really severe. (Child)

Temperature

All respondents who mentioned temperature described varying degrees of hot and cold, and most associated red with warmer temperatures. Some respondents associated the numbers next to the color bars with degrees of temperature.

> Because the darker areas are where it's colder and the redder areas are where it's warm. (Adult)
>
> As you go across the spectrum from blue to red it gets warmer. (Adult)
>
> The red is hot, and the blue is cold. (Child)
>
> There's a lot of blue, and 10 degrees and 5 degrees is cold. (You think the colors indicate temperature?) Red's hot, and yellow's warm. Then it gets colder, up to blue and green. (Child)

Precipitation

Responses in this category described varying degrees of rainfall. Readers will note the variety of attributes assigned to different colors.

> How severe the rain is. (What colors show severity?) Not sure. Light ones are rain, darker colors are storms, perhaps. (Adult)
>
> Darker colors indicate heavier precipitation. (Which are the darker ones?) Green or blue. (Yellow or red?) No precipitation, I don't know. There is obviously a gradient chart. The green is something, but I don't know what. (Adult)
>
> Severe weather, I think. Red being the worst. The green being the lightest. (The worst meaning what?) The heaviest precipitation, rain, snow, probably. (Adult)
>
> The darker colors show where the heaviest rain is. (Which are darker?) Blue and green. (What about yellow, orange, and red?) Maybe that is where the sun shines. (Adult)
>
> A rain storm because the blue usually symbolizes rain. (How do you know?) Water is usually blue. (What do colors show?) The red and the orange might be high and green might be dry, like just regular. The blue might be a sunshower in certain areas and a rain storm in others. (Child)
>
> I think the bright ones kind of indicate sunny and the darker ones indicate cloudy, rainy. (Child)
>
> The orange shows sunny, the green shows rain or tornado or something, and the dark blue would show a hurricane. (Child)

How the Doppler Radar Image Was Created

Respondents were asked how they thought the image was created. **Ten percent of adults and 3 percent of children mentioned Doppler radar as the means of creating the image. More than half of children thought the image was created on a computer. Nearly half of adults associated the image with satellite technology.** See Table III.17.

Table III.17.
Means of Creating the Doppler Radar Image in Percent

Means of Creating Image	Adults n=80	Children n=40	Total n=120
Computer	39	55	44
Satellite	48	08	34
Radar	25	13	22
Conventional radar	15	10	13
Doppler radar	10	03	09
Aerial photograph	03	08	04
Don't know	03	08	04
Art materials (e.g., crayons)	00	08	03
Miscellaneous	04	03	03

Columns do not add up to 100 due to some respondents giving more than one answer.

Miscellaneous responses are those that appeared in the data 2 percent of the time or less; they include "heat-sensitive cameras," "MRI," and "reference books."

A lack of understanding emerged in response to this question. Several adults in Washington, D.C. and St. Louis mentioned radar and satellite technologies interchangeably. These respondents often recognized the image as Doppler radar but indicated that it was created by satellite. Many respondents were familiar with Doppler radar from watching television news and the Weather Channel. Clearly, these, and likely most, respondents, do not understand these technologies sufficiently to distinguish between them. They can identify radar, but do not fully understand the technology behind what they are seeing. Selected quotations that illustrate this idea follow.

(What do you think this picture shows?) Doppler radar system and the radar that it shows. (How did you know that?) The news channel. . . . (How was it made?) Satellite.

(What do you think this picture shows?) Looks like a Doppler radar or some kind of radar, weather radar. (What type of storm do you see?) Thunderstorm in here, I guess, in the red area. (How do you know that?) From watching TV. . . . (How do you think the picture was made?) Satellite, I imagine.

(What do you think the picture shows?) It shows cloud formations. (What type of storm do you see?) Thunderstorm. The intensity of the clouds. (What do you think the colors indicate?) The more red it gets, the more intense the storm; the lighter, the less intense. (By lighter you mean what?) The blues and greens. (How do you know?) Doppler 5. (Channel 5 weather, right?) Or it could be rainfall amount too. (How was the picture made?) Computer, satellite.

(What do you think this picture shows?) Where thunderstorms are in the area, maybe. (How do you know?) From watching the news, the Doppler radar they have on the screen. The darker areas, the higher rain. (Colors?) Well, I think from seeing the news, the darker colors show where the heaviest rain is. (So which are darker?) Blue and green. (What about yellow, orange, and red?) Good question, maybe that is where the sun shines. I don't know. (How was the picture made?) Taken from space, maybe.

(What do you think this picture shows?) It is a weather map. It is counties, but that is Cleveland, so it has to be Ohio. (What type of storm do you see?) Probably rain. The red would be, according to my TV, more intense. (How do you know?) It looks like Doppler radar on a TV set. In ours, red is bad, then down to blue or less bad. (How do you think the picture was made?) Satellite.

EXPERIENCE WITH STORMS

The remaining questions relate to respondents' experiences with various storms. In this section of the report, the region where data were collected is more relevant than in the previous section, "Knowledge about Storms." Although demographic data were not collected for each interview, and Part II of this report indicates that the four data collection sites attracted visitors from all over the country, some obvious regional differences did emerge in the data.

General Findings: Interviewees at the MMS talked about hurricanes more often than did interviewees from the other three sites. Children interviewed at the SLSC talked about tornadoes more did than other children and more than most of the adults, including those interviewed at SLSC. Other regional differences are discussed where relevant.

What Is the Last Storm You Remember?

The intention of this question was to uncover respondents' most recent or most vivid storm memories and to find out if respondents tended to talk more about storms they or their families experienced themselves or storms they heard about through the news media.

Adult and child responses were easily categorized and quantified; thus Tables III.15-III.16 present summary responses by adults and children.

General Findings: Almost half of adult interviewees mentioned hurricanes as the storm they remembered most. Although a greater proportion of adult respondents from Miami talked about hurricanes, these storms were discussed by adult respondents at all four sites. Blizzards and floods were mentioned by few respondents. More than half of child interviewees talked about thunderstorms as the storm they remembered most. Blizzards, floods, and tornadoes were mentioned by few children.

Table III.18.
Storm Types Mentioned by Interviewees in Percent

Storm Types	Adults n=80	Children n=40	Total n=120
Thunderstorms	36	58	43
Hurricanes	48	28	41
Hurricane Andrew	28	15	23
Other Hurricanes	20	13	18
Blizzards	09	03	07
Floods	08	03	06
Tornadoes	00	10	03

Columns do not add up to 100 due to rounding.

Approximately three-quarters of adults and three-quarters of children discussed storms either they or their families experienced directly. Of respondents who discussed Hurricane Andrew, twice as many experienced that storm directly as heard about it through newspapers or television. Both adult and child respondents had a wide variety of direct experiences with storms and were more likely to report on storms they had experienced than storms they had merely heard about.

Table III.19.
Means of Experiencing Storms in Percent

Means of Experiencing Storms	Adults n=80	Children n=40	Total n=120
Direct or family experience	74	80	76
News media	26	20	24

What Made that Storm so Memorable?

As a follow-up to the above question, respondents were asked why the storm they mentioned was so memorable to them. This question generated an array of responses, from mundane to extremely moving. Rather than group these responses into categories, selected quotations are presented to give team members a flavor of the rich ways in which adults and children talked about storms.

> Hurricane Andrew. (Can you tell me what you remember?) I used to live across from the [Homestead] Air Force Base, and we were told to evacuate because of flooding, although it never happened. We evacuated across the highway. The place that we evacuated to didn't hold up too well. It was a single family home, but I guess we were just unlucky as far as the angle of the house I guess. I remember early on it wasn't too bad until 11 o'clock at night. After that it started getting really windy. We finally closed up the doors and all that and started hearing these rocks from the houses out there that have pea-rock roofs. They were hitting the side of the house. It got worse and we started hearing things like rifle shots. We assume that was trees breaking. Pretty soon we had water coming in through the ceiling and all the fixtures. I guess we had about an inch and a half of water inside the house. All over the house. I guess we had maybe ten or fifteen people inside the house that had evacuated over there. The front door was where it was getting most of the storm, it was completely flat-on. You could see the front door vibrating back and forth. We wondered if the door was going to hold. Next a decorative window, big glass window it was opaque. It started to crack. We thought it was going to come in. It never did, it only lost maybe a little piece of glass. We kept waiting for the eye of the storm, we were listening to the radio and heard that the eye was coming ashore, but it never hit. The eye never came over us. (So you had the storm the whole time.) Yeah. We came through what we figured was the north eye wall. At one point the wind was coming from the front and all of a sudden it just switched directions. It never let up. We figured it was the back side of the storm. That's when we decided to look out through the holes in the glass because there's no wind out there now. There was an overhang in the front, supported by 4 x 4 posts. I looked out with my flashlight and said "You don't have an overhang anymore, it's gone!" and from then on it was all coming from the back side. We were all afraid that the wood that we put over the sliding glass door was going to come off. It was vibrating like crazy. If that had gone, the whole house would have been a total loss. I guess about 7 that morning it finally started letting up, but that's when the wood over the sliding glass door decided to fall off. The sliding glass door never broke. We were fortunate. We finally left and came out, and it was just unreal. It was like a war zone, is the only thing you could think of. My mother, she lives in Montana and my dad he lives in north Florida, so he could see all this on TV, but unless you're in the middle of it you don't get the full impact. You see banyan trees, huge banyan trees with roots as big as houses sticking straight up in the air, and cars that are just thrown around like toys. You see one house that is hardly touched. The next house has the roof missing. We came back to our house finally, we were driving through our development. Our roof was still intact. We had no damage inside the house. Our next-

door neighbor's sliding glass door blew in, and the whole inside of the house was blown out. Our house was just as we'd left it. We'd had some huge trees in the backyard, they were all blown down, a 40-foot avocado tree laying parallel with the house, and we had some other trees. I have to say that's probably the scariest six or seven hours I'd ever spent. I've never been more scared in all my life. Being in that house, we had three small children, no older than five, a six-week-old baby. The baby's mother and her mother were both hysterical the whole time, which made everything even worse. It was an experience I'd never live through again. Another hurricane like that, I even think it's coming this way and we're gone. (Adult-MI)

It was sometime this last spring, I think. (And what happened?) Thunder--it was at night--thunder, lightning, heavy rains. (Was there anything else that made this memorable for you? Did you have a power outage or anything?) No. Branches fell, damage to our trees, but that's about it. (Adult-SL)

Well, about two weeks ago there was a rain storm that was actually hail and it was in the 90s. All of a sudden this hail is coming down, the rain is practically going horizontal, the wind and the hail, so that if the windows were open it literally went, the rain went across the room. That was my most recent memory of a storm. And it quickly passed, it cooled the air for about five minutes and then it was back up in the 90s, high humidity again. (Adult-SF)

About two weeks ago in Atlanta. (What was it?) It was a tremendous thunderstorm. (What happened to you personally?) Started at about 3 o'clock in the morning and went to 6 o'clock in the morning, and for almost three hours straight the sky was completely lit up. (Did it wake you up?) It woke us up and kept us up. The water was, it was raining so hard, this was the beginning of the flood in Georgia, the big flood that they just had in South Georgia. In and around Atlanta we had tremendous rains, and I've never seen it rain so hard and the sky be lit up for three hours straight. (Did anything happen, like was power knocked out?) We were very fortunate, we didn't have power knocked out--well, momentarily, but that was it--but we lost some trees in the back yard, wind came up, we were concerned about tornadoes. (Did any touch down?) Not in our immediate area, but nearby on the way to work you saw some damage. (Adult-DC)

The flood that happened in my town this month. (Can you tell me something about it?) Like how long it rained. It rained for like two weeks and then it flooded all the low parts of our town, and the high parts . . . all over the town. All the water was shut off for two weeks. (What made the storm so memorable?) Probably because it flooded. And destroyed over half the town. (Did it damage your house? Did you live in the middle of it?) No. Just went in our basement, that's all that happened to our house. (Sounds like some kind of rain storm?) It was a thunderstorm that went on for like a week and a couple tornadoes happened during the thunderstorm. (Child-SL)

A bunch of branches fell on our house. Had some acorns on our trees, and they kept falling on our house and it was making funny noises. And a lot of rain. It rained for about four hours. (What made it so memorable?) Because, I guess because, we had to go downstairs into our basement, because there was suppose to be a tornado coming. (Child-SL)

Well, it was sometime this spring and it was a tornado. (Wow. Tell me about what happened.) Some parts of Lawrence, it tore down some of the houses and lots of fires because of telephone poles being down. It didn't quite get to where I live, but we had a lot of wind, and we took cover. But it didn't get to us. A lot of damage. (Did you know that the storms were coming? Did you do anything to protect yourself?) We took cover in our basement. We had a radio to find out where it was, and the power where I live in didn't go off, so we watched TV to see what was going on. (Child-DC)

We had a really big thunderstorm, and when we were driving, and we couldn't see the road. It was pouring so hard. (Did you have to pull over?) Well, we couldn't pull over, because if we did we wouldn't be able to get back on the road. It was last summer. We were coming home from day camp. (Okay. So, what about the storm made it so memorable for you?) We were with a lot of our friends, because it was like a carpool and my mom was driving. And it was like really scary, because the lightning hit in front of us and in back of us at the same time. An electric pole went down behind us, and it hit a tree in front of us. It was really scary! (Did you think something was going to happen?) Yeah. We did. Really. (You're lucky!) And then we had to stay at our friends house for the rest of the storm, because we couldn't go back to our house, it was too far away. (Child-DC)

What Words or Phrases Are True When Thinking about Storms?

To get a sense of respondents' general thoughts and feelings about storms, adults and children were given cards with various words and phrases on them. They were asked to sort the cards into two piles: those that are true when they think about storms and those that are not true. The phrases offered to children varied slightly from those offered to adults. Some options were simplified to make them more understandable to children.

General Findings: Adult and child responses to this question were similar. Both groups thought storms were a natural phenomenon and quite dangerous. More adults and children also thought storms were hard to understand than easy to understand. The fewest number of adults and children thought of storms as freak occurrences. See Tables III.17-III.18 for details.

Table III.20.
Words or Phrases That Are True of Storms
(Adults) in Percent

Words or Phrases about Storms	Adults n=80
Part of nature	90
Life threatening	76
Visually beautiful	75
Fascinating	74
Unpredictable	70
Scary	69
Harmful	68
Hard to understand	61
Beneficial	56
Predictable	36
Easy to understand	16
Freak of nature	10

Table III.21.
Words or Phrases That Are True of Storms (Children) in Percent

Words or Phrases about Storms	Children n=80
Dangerous	90
Harmful	73
A natural thing	70
Scary	68
Makes you take action	58
Hard to understand	53
Easy to see coming	48
Fascinating	43
Hard to see coming	33
Helpful	30
Easy to understand	25
A weird thing	13

How Did You Find Out about Today's Weather?

Respondents were asked the sources they used to find out about the weather on any given day.

General Findings: Television was the most common source for both adult and child respondents. Children were more likely than adults to go outside and check for themselves. Home instruments, weather radio, and computers were the least-used sources for obtaining information about the weather. Of those respondents who use weather radio, none mentioned NOAA specifically.

Table III.22.
Where Respondents Get Information About Weather in Percent

Sources for Information about Weather	Adults n=80	Children n=40	Total n=120
Television	44	78	55
Look outside	25	43	31
Commercial radio	24	30	26
Weather channel	25	23	24
Newspaper	20	23	21
Other people/parents	03	13	06
Telephone weather service	06	03	05
Home instruments	05	03	04
Weather radio	05	00	03
Computer	03	00	02

Columns do not add up to 100 due to respondents' speaking of more than one information source.

What Does It Have to Look Like Outside to Know a Severe Storm Is Approaching?

The *Stormy Weather* exhibition team was intensely interested to know if people recognized the signs of an approaching storm. This question was asked of respondents to see how an approaching storm was perceived and also to discover if there were differences between what adults and children noticed in their immediate environments regarding storms. In addition, team members wanted to better understand visitors' relationship to and ability to read the environment.

Respondents were intentionally not asked about specific storm types. By responding to the more open-ended word "storm," interviewees were able to discuss storms most prevalent in their region. Some regional differences were uncovered in these responses.

General Findings: Adults and children determine whether a storm is approaching by looking at the changes in the sky. More adults than children rely on television for learning about approaching storms.

Adults

More than half of adults talked about changes they saw in the sky--colors, rain, wind, or lightning. These respondents tended to group weather elements together when they talked about approaching storms. They usually did not talk about only rain, only wind, or only dark skies. When discussing these changing weather elements, it was usually in the context of tornadoes and thunderstorms. Such responses were most prevalent among interviewees in Washington, D.C., St. Louis, and San Francisco. Few respondents in Miami discussed changing weather elements as a sign of a storm.

> It gets very dark outside, and then it starts getting windy, then it starts raining. (DC)
>
> A good sign is flashes of lightning and it's very gray or dark. Usually a good sign. The wind, I usually pay attention to that because I ride a bike a lot myself, and if the wind gets strong enough to hold me still. (DC)
>
> If it starts getting very dark, dark clouds, I would be looking for something like that. Or the clouds changing from lighter to a darker cloud. Lightning in the area. (SL)
>
> The wind would be a good indication, when the wind starts picking up you know that it's close. I guess the color of the sky. The darker it gets. (SF)
>
> That red sky isn't very inviting. When a hurricane's coming and the sky turns red, we've seen that. Yellow streaks in the sky let you know, and high winds. (MI)

Some adult respondents answered that they rely on television or radio reports to warn

them of an approaching storm. More respondents from Miami said this than respondents from the other three cities. These respondents tended to talk more about hurricanes than other storms, although other storm types were also discussed.

> In the case of hurricanes, you have advance notice so you really can't wait until you see something bad outside; it's too late. (MI)
>
> You don't wait until something shows up outside before you do something if you pay attention to the weather forecast. You don't wait until the weather changes outside before you do something. (MI)
>
> I would listen to the news, I would prepare according to the emergency broadcasting system that they have down here because the sunshine can be bright as a dollar just before a hurricane, and it's just prior to that. (MI)
>
> I usually don't base my actions on what I see outside. I tend to base it more on what I've heard, or I can see on a weather channel [it] is coming. (SL)
>
> On the radio they'll report when they've actually spotted a funnel cloud. . . . Hurricane, I listen to when they expect it's going to make landfall, and make plans for it. (SF)

A few adult respondents at all sites but Miami talked about miscellaneous ways they detect an approaching storm--counting seconds between thunder and lightning, major occurrences, and animal responses.

> If there's a thunderstorm, you count and the lightning is very close. (SF)
>
> I probably wouldn't go downstairs [to take action] until some of the windows blew out or something. Or if the top of the roof blew off the top of the house. (SL)
>
> If you look at the birds, the way they fly. Ducks and frogs as well. They use them in China to know what the weather is going to be like. A duck would be nervous, moving up and down. Animals, you know, they're the ones who know the storm first. And hens, all these animals, domestic animals, dogs, they notice. But especially ducks. (DC)

Children

Almost all child respondents from both data collection sites talked about looking outside for darkening skies, wind, and rain as a way to know a storm is coming. These young respondents talked mostly about thunderstorms, although a few discussed tornadoes.

> If it was a thunderstorm, kind of black or gray, or a tornado probably light tan or green outside kind of sky, kind of greenish, orangeish stuff like that. It's real light and everything gets real calm, and then you hear like a freight train, and then the tornado comes. Thunderstorms you hear lightning and thunder and the sky gets real dark.
>
> I'd have to see it blowing trees down. Probably lift a big old tree and lift the roots out of the ground.
>
> First I'd wait and see and watch how hard it was coming down, and if the branches were hitting the windows and that kind of thing, because a big branch could fall and break the windows, and that would be an indication to go into a safe area.
>
> Maybe start getting dark. (Any other things it would look like?) Rain, lightning, and thunder.

A few children, mostly in St. Louis, indicated that they rely on television and radio reports to warn them of storms. These respondents mostly discussed tornadoes.

> If there's a tornado warning or a watch, and if they have reported one that's in your area, that's kind of important because that pretty much means it's probably likely coming to you.
>
> We always listen to the radio.
>
> Just what they say on TV.

And a few children at both sites talked about needing to see certain cloud forms to know a tornado was heading their way.

> On a tornado, you have a wall cloud and usually right in the wall cloud you'll see a tornado form. Of if you see a thing like a hole . . . and it's turning, then you'll probably see a tornado in that.

What Actions Do You Take If a Severe Storm Is Approaching?

One of the major goals of *Stormy Weather* is to educate visitors about what to do if they and their families are threatened by a severe storm. The exhibition team believes that people are generally ill informed about proper actions to take and hope to fill this knowledge gap through the exhibition and accompanying materials. This question was asked to determine how much safety knowledge visitors actually have. Like the preceding question, this question generated responses that showed regional differences among interviewees. Respondents were not asked to talk about specific storm types but were encouraged to discuss whatever storm was most relevant to them and their region of the country. Most respondents spoke about one type of storm, but a few talked about several.

Data are organized in two ways. Table III.20 presents a summary of the findings quantitatively, according to the three storm types and data collection site. Then, quotations by adults and children for each storm type are presented. These data are also organized according to the three major storm types: thunderstorms, hurricanes, and blizzards. Readers should note that a few respondents discussed actions they took during both thunderstorms and tornadoes--not realizing that tornadoes are part of thunderstorms. Each storm is presented with the actions that people would take, adult data first and then child data.

General Findings: Nearly all adult respondents at the four data collection sites and child respondents in Washington, D.C., discussed thunderstorms. Seventy-five percent of adults in San Francisco talked about this storm type as well. Hurricanes were of top concern to 75 percent of adults in Miami but of relatively little concern to adults and children at other sites. Snowstorms were discussed infrequently by adults and children at all sites, probably because data collection took place in the summer. See Table III.20 for details.

Table III.23.
Storms Discussed by Respondents in the Context of Taking Action

	Thunderstorms		Hurricanes		Blizzards	
Location	Adults n=80	Children n=40	Adults n=80	Children n=40	Adults n=80	Children n=40
Washington, D.C.	16	17	07	02	01	02
St. Louis	19	19	02	00	02	04
Miami	04	n/a	16	n/a	01	n/a
San Francisco	14	n/a	08	n/a	04	n/a
Total	53	36	33	02	08	06

General Findings: Regarding actions interviewees would take if a thunderstorm were approaching, adults and children responded similarly in that most said they would seek shelter.

Regarding hurricanes, many adults talked about needing to secure their homes. Only two children talked about hurricanes, likely because of where child data were collected--Washington, D.C. and St. Louis. Very few adult and child interviewees talked about blizzards, probably because data collection took place in the summer.

Thunderstorms: Adults

Over two-thirds of adult respondents discussed thunderstorms and the tornadoes that sometimes result from thunderstorms, indicating what they would do if one approached their town. Most of these comments were from all data collection sites but Miami.

Of adults discussing thunderstorms, most talked about finding shelter or, if they were outside, finding low ground. Responses ranged from simple to fairly detailed.

> I guess I would try to find somewhere to go, like in a shelter, like a building, or whatever.
>
> If I'm inside, I just stay inside. . . . If I'm outside, it depends on what it is . . . but I would probably head under cover.
>
> Go to the basement. (And if you were stuck outside?) Well, I guess they say to go to a ditch.
>
> We do not have a basement, so we go into a small room in the back of our house, which is protected by an earth wall. (And what if you were caught outside?) If there's a tornado approaching, then you hit the deck. Find a ditch, and get as low as possible.
>
> I'd find the lowest point that I could around, a basement for example, and get down there and find someplace safe in the basement to stay. If I were outside, I'd get out of the car, and if I could get under a bridge or in a culvert or someplace down low, again that's where I would go is down away from it.
>
> I head for a cellar, the southeast corner I believe--southwest corner, and some kind of a heavy structure above me. I guess if you're out somewhere, inside a building, away from glass, in a corner, southwest corner, under a table or a heavy structure, if you can find it? (Why the southwest corner?) That's where the storm comes from I think, generally it's traveling from. Then since the storm comes generally from the southwest--a summer storm--the safety chances that it would blow over you in that corner would be better. Whereas if you were in another corner it might suck you out of the basement and take you along.

One-quarter of adults discussing thunderstorms described things to avoid if they were caught outside.

> If there's a lot of lightning associated with it, I'd stay away from anything metal, away from trees.
>
> If it's lightning, I'd try to get away from trees and from water.
>
> Stay away from places that lightning might strike. . . . I wouldn't want to be out in a big wide open area watching the storm going on.
>
> Stay away from trees and power lines.

One-quarter of adults discussing thunderstorms talked about <u>safety measures they would take to protect themselves in their homes</u>.

> I would see that the doors are closed and locked, the windows are closed. See that the dog is in the house. And hope that the rest of my family is taking precautions too.
>
> I make sure that inside my residence, I make sure all the power is shut off.
>
> I would unplug my antenna and all my electrical appliances and turn off my air conditioner.
>
> Do not talk on the phone. And, recently, we've never done this before, but recently we heard a lot cases, even if it hits far away, it can affect your electrical. A woman I work with, in that storm I was telling you about first, it was actually not too far from her home, and she didn't have things unplugged and it ruined a couple of TVs.

And a few adults talked about <u>needing supplies or needing to evacuate</u>.

> I know first of all I'd get something to eat together. Flashlight, radio.
>
> I make sure that I put together a kit . . . and make sure there was a fresh water supply. Necessary things to survive during that time.
>
> Load up my son and my daughter and head for the mountains!

Thunderstorms: Children

Almost every child respondent discussed thunderstorms and what they would do if they encountered one.

Like adults, most children talked about needing to seek shelter. Many of these respondents had direct experience with thunderstorms and tornadoes and were reporting actions they had once taken.

> We had one while I was in gymnastics. So we had to stand in the doorway.
>
> Go down in the basement and get in the whatever position. Tornado position. (What's the tornado position?) On the ground, and they put their knees up to your chest, and you get down on the ground, and put your hands over your head like that. (Okay. What if you were caught outside?) Oh, go in a big hole or a ditch.
>
> We'd go down in our basement, and then we get under a table. A really strong table.
>
> One time we had a tornado warning at our house, and me, my sister, and my mom went into a closet under our steps.
>
> Get in the bathtub and put a cover over me. Or if I was out taking a walk or riding my bike, I would just find a real deep ditch and get in and lay down.
>
> I would get pillows or stuff and put it down in a hallway or something where there's no windows.

One-quarter of young respondents described needing to get supplies.

> I would get a flashlight or something like that. If the power went out, I still would be able to see.
>
> It would kind of be important to make sure that you have water, because it may be a long storm and you may need something to drink. And probably some food, and it would be nice to have somebody with you, so you don't feel lonely.
>
> We always have like canned stuff down there we could eat.

Some children talked about <u>what to do if they were caught outdoors in a thunderstorm</u>.

> If it was an electrical storm, I wouldn't go out in a big field and just stand there!
>
> I'd probably go--not under a tree. (Why not?) It's tall and lightning can strike that easily.
>
> Probably like go to an area, scrunched down really small, and just be there and, like away from metal and stuff like that. (Would you ever go under a tree?) No, because the lightning could tip the tree.

And a few child respondents described <u>safety measures to take indoors</u>.

> They say to turn off the lights so you're not telling the storm to go into your house.
>
> Close the windows and stay inside, and don't use the shower. (Why not?) Because then if lightning hits it can travel and you can be electrocuted through.
>
> Roll up the windows. Put all of your belongings in a safe place, so everything doesn't get ruined in a flood or something.

Hurricane: Adults

Slightly more than one-third of adult respondents discussed hurricanes when talking about what action they would take. These respondents were primarily from Miami, with a few scattered among the other three sites. Many of those responding had experienced hurricanes directly.

Of adults who discussed hurricanes, two-thirds described a need to secure their homes.

> Try to put up as much plywood as I can for the windows. Any loose materials outside need to be secured.
>
> Bring your plants in, either bring in your yard furniture or lash it to a tree so it won't blow away. Park your car near the house, near the side of the house so the wind won't be able to act all around it. Bring in your pets. Anything that's loose outside you'd best either lash it down or bring it in.
>
> Leaving your windows cracked and your shutters. . . . If they [victims of Hurricane Andrew] had not closed their doors up and their windows up and everything and left ventilation open, you see the air could have moved in and the roofs wouldn't have come off.
>
> I've also heard in a hurricane that you want to open the windows to let the air go through, instead of creating a vacuum inside your house or something.
>
> I've been near a hurricane and you batten things down ahead of time. You take whatever precautions to save property and to stay out of its way. You keep the radio on.

One-half of adult respondents who discussed hurricanes talked about needing to stock up on supplies.

> I would probably go to the store and buy the necessary items like flashlights, water, canned foods, candles, medical supplies, stuff like that.
>
> Get rain gear, sneakers or boots in case something gets broken, fill the tubs with water in case we need drinking water, get candles, try and keep a radio close by.
>
> I got bottled water, I made sure I had batteries laying around. Depends on the storm. I mean, tropical depression, I didn't see any reason to tape up my windows or anything, but I got bottled water, had some canned food, filled up my car with gas.

Stock up on fresh water and your batteries and your canned foods and breads and make sure if there's any prescription medication being taken in the house, have at least a week or two supply with you. . . . Plenty of gas in the car. Maybe a little extra on the side. Make sure everybody in your household is there, instead of out playing with neighbor kids and stuff like that. And, clothing, blankets, pillows, anything you'd need to spend away from your home. In fact, you might be away from your home. Make sure your bank card is in your wallet, and that's it.

Some respondents discussed <u>the need to evacuate if necessary</u>.

You'd evacuate if you had to, if you have kids especially.

I would just take a few valuables, things that are important, you know, pictures and things you can't replace, and leave. I wouldn't stay. Like with Andrew, too many people stayed in their homes and boarded up. I just wouldn't take that chance. I'd take my kids and leave.

It would depend on what type of storm it was, if it was like a hurricane or severe rain, with possible flooding, I would evacuate.

And a few adults talked about <u>the general need to find a safe place to be</u>.

If it was a really bad hurricane, go in the basement or something, or someplace safe where you're not going to get hurt.

If the sky looks bad, we always joke about getting in bed and covering up our heads, but we don't do that! No, we try to seek a safe place.

<u>Hurricanes: Children</u>

<u>Only two children discussed hurricanes in the context of this question</u>.

Board up the windows. And if you wanted to stay at your house, you'd get a bottle of water and batteries and things like that. And then, if you were going to leave, you'd board up the windows and you'd lock everything down and tie everything down that you could and then leave.

Get water, get candles.

Blizzards: Adults

Several adults discussed blizzards when describing what action they would take in a storm. These few remarks were scattered among all four sites.

Most adults talked about the need for adequate supplies.

> Obviously have a snow shovel on hand to dig my vehicle out. Salt to melt the snow or ice that would accumulate.

> Make preparations with food stocks and food provisions, depending on how long the storm was predicted to last, and how much snowfall was predicted.

Others discussed staying indoors and protecting electric sources.

> About all you can do to protect yourself is just stay indoors. If you're out in your car, don't go off alone, and have things in your car, too, maybe blankets, and food and water.

> You have to worry about whether or not you have an alternative heating source, because if your electricity goes out you probably won't have heat.

Blizzards: Children

Few child respondents mentioned blizzards.

Of those who discussed this storm type, half talked about needing supplies.

> Now we keep earmuffs, things in the trunk. We keep a safety kit, and there's sometimes band-aids and peroxide and stuff like that. We carry safety equipment.

> Once you have blizzard coming you should go out and buy water, lots of water and lots of food, because you may not be able to get out of your house because the snow may be so high.

The other half talked about staying indoors.

> You don't want to go out because you might get stuck in stuck in snow, so you might want to stay inside.

DISCUSSION

The *Stormy Weather* exhibition team articulated a number of questions they wanted to see answered through a front-end evaluation. Some of these questions were addressed in Part II; others are addressed here. Team members were concerned with some of the following issues:

- What does the public know about severe storms?
- What misconceptions about storms does the public hold?
- Are there differences in knowledge based on age?
- How well do people understand graphically displayed information about weather?
- How well do people understand weather forecasting?
- What are people's experiences with storms? What types of storms are most familiar to them?
- Are there differences in experience based on age?
- Do visitors use personal observations and "weather lore" to anticipate storms?
- How seriously does the public take storms, and do people know how to protect themselves if they encounter a severe storm?
- What differences in knowledge or experience exist among people living in various regions of the country?

The interviews with adults and children generated voluminous amounts of data that offer the *Stormy Weather* exhibition team much useful information as they strive to shape the exhibition in a way that considers visitor knowledge, experience, and perspective. This discussion analyzes and synthesizes major findings reported in the previous section in the context of the team's questions. Two major topics are addressed here: respondents' knowledge of storms, and respondents' experiences with storms. Embedded in the discussion of experiences are regional differences that emerged among respondents. Where appropriate, differences and similarities between adults and children are addressed.

Most adults and children are not knowledgeable about the scientific principles behind severe storms. There was almost no difference between what adults and children seemed to know about storms and about weather. Very few respondents were able to talk about the interrelationship of factors that produce storms. When asked what storms have in common, people talked about either the human experience--the damage storms inflict on people or property--or the characteristics of particular storms--wind, rain, lightning. It is significant that so many people talked about the human impact of storms rather than the science of storms. Visitors to museums, in fact most learners, try to find what is most relevant to them when they are confronted with new information or experiences. Respondents in this study looked for ways that storms affected their lives before they were able to begin thinking about science.

When respondents were asked to define storms, nearly half of adults indicated that storms were something that just happens. A much smaller percentage attempted to talk about atmospheric conditions that lead to storms. In fact, there was little consensus among adult respondents about the definition of a storm. Adults defined storms in many different ways, and few respondents had a comprehensive understanding of storm dynamics. Children, too, spoke in simple terms about storms, and only a very small number had the confidence to discuss atmospheric conditions that produce storms.

The forecast concerning visitor knowledge is not completely gloomy, though, in terms of the exhibition. Most respondents--adults and children--were familiar with a great deal of weather "jargon." They have heard phrases like "high-pressure system" and "winds from the northwest" before, but there is no indication in the data that they understand the concepts behind the words. Many respondents, in answering different questions, used many of the words and terms that will likely be included in the exhibition. They already possess a framework for learning about weather because their name recognition of weather words and concepts is extremely high. Since visitors already possess the framework for learning about weather, they will be able to "hang" new concepts and information on that framework when they encounter them in the exhibition. This framework is a significant advantage that other exhibitions on difficult or technical subjects often do not possess.

The team was interested in whether exhibition visitors would walk into the museum with misconceptions about storms. In terms of general knowledge about storms, respondents had more of an incomplete picture than a set of misconceptions. Some people talked about temperature, others talked about pressure, and others talked a variety of weather elements, but very few saw the big picture of how all the atmospheric conditions work together to produce storms. Specific, factual misconceptions that emerged from the data are considered later in this discussion.

Respondents were shown four pieces of graphically displayed weather information--a weather map from the newspaper, two satellite images of a hurricane, and a Doppler radar image of a hurricane--and were asked to describe what they saw in as much detail as possible. In general, adults had a much easier time analyzing this kind of information than did children.

The weather map was the most complex image shown to respondents; they were asked to discuss not only the indicators on the map but also their definition of the indicators and how the indicators work together to produce weather. Although adults and children were all able to offer responses to this question, most respondents were hesitant and lacked confidence. Data from the weather map question demonstrated most people's familiarity with weather terms on the one hand, but lack of familiarity with their meanings on the other. Both adults and children were able to literally "read" the map--identify some or all of the symbols from the legend and find their location on the map--but few were able to interpret those symbols.

Some differences between adults and children emerged in this question. Children were much less confident in their responses than adults. A great deal of probing and prompting was needed to get them to talk about all or most of the symbols on the map. Children's explanations for what they saw were also much more hesitant than the explanations offered by adults. Additionally, half the children interviewed held some obvious misconceptions about information contained in the map. Many children associated the H on the map with high, or hot, weather, and the L with low, or cold, weather. Other children associated cold fronts with cold weather and warm front with warm weather. Most adults did not make such obvious mistakes in their analyses.

The GOES visible image was fairly easy for adults to read and much more difficult for children. A majority of adults easily identified a satellite image of a hurricane, whereas only a small percentage of children could correctly identify the image. When only the means of producing the image was examined, two-thirds of adults identified satellite technology, while one-third of children could do so. When confronted with the GOES infrared image, also created by satellite, fewer adults and children could identify a hurricane or satellite technology. Despite the fact that children used a variety of sources to get information about weather (discussed below), their familiarity with and understanding of images commonly shown on television weather reports and in the newspaper were fairly low.

The Doppler radar image was difficult for both adults and children to identify. Only two adults correctly identified a Doppler radar image of thunderstorms. No child was able to do so. Computers and satellites were the most common responses to the question of how the radar image was produced. This finding indicates that adults, and some children, are familiar with the idea that satellites and computers are involved in weather tracking but cannot discern when they are confronted with products of that technology and when they are not. Knowledge of radar technology, and Doppler in particular, among adults and children is very low. Most of those respondents who identified the use of some kind of radar in the creation of the image were extremely hesitant in their responses. Several adult respondents discussed satellites and radar interchangeably, indicating significant confusion about the distinguishing features of each.

The *Stormy Weather* team was interested in knowing how well people understand weather forecasting. Here again, a large difference emerged between responses from adults and children. Respondents were asked to name the indicators commonly measured by meteorologists. A majority of adults named barometric pressure and temperature, and almost half identified humidity. Children were much less able to discuss indicators. None of the indicators were mentioned by a majority of the children, although nearly half mentioned temperature. Often, children had to be encouraged and the question rephrased in order to elicit a response.

Respondents were also asked to define five indicators of weather: barometric pressure, relative humidity, wind speed, wind direction, and temperature. Barometric pressure was overwhelmingly the most difficult for both adults and children to define. Interestingly, most adults knew barometric pressure was used by meteorologists to predict the weather, but few could define it with confidence. Most adults could not be more specific about how to define barometric pressure than saying "the pressure of the atmosphere." Almost no children could define the term. This lack of understanding of pressure was obvious in children's analysis of the weather map. In contrast, adults and children easily defined temperature and wind speed. From the data, it seems that most adult and child respondents were largely mystified by weather forecasts. They did not seem to understand that the indicators measured by meteorologists form a fairly complete picture of the nation's weather, even if they are not always accurate about a particular day's weather.

Respondents were asked a variety of questions to encourage them to talk about their own experiences with storms. Some similarities and differences between adults and children and among the four regions from which data were collected emerged in discussions on storm experience.

When adults and children were asked about the last storm they remembered, more adults talked about hurricanes and more children talked about thunderstorms and tornadoes. Some adults, even outside of hurricane regions, had experienced a hurricane in their lives, while fewer children had that experience. Adults, obviously, had more time to accumulate experience than children. Both adults and children were much more likely to report on storms they or their families had experienced than those they had heard about through the media. Hurricane Andrew was the only "national" storm discussed by respondents in any significant percentage.

Adults and children were remarkably similar in the words they chose to describe storms. Respondents were given cards with words and phrases about storms and were asked to choose which ones they thought were true of storms. The top choices of adults and children were that storms were a natural phenomenon and also quite dangerous. Both groups were very aware of the power and danger of storms and were respectful of the potential threat to human life. Both groups also acknowledged that they were scared of storms. The exhibition team had assumed children would be afraid of storms, but the data were very clear that adults are afraid as well. Both groups expressed significant interest in storms; in fact, adults and children were enthusiastic participants in the interviews. Most respondents enjoyed the opportunity to talk about storms and share their experiences. Adult and child respondents described storms as hard to understand, a finding that is interesting given the obvious enthusiasm respondents had for the subject. This finding indicates that people can be fascinated by and drawn to storms even if they do not understand all the scientific concepts.

Respondents were asked what sources they used to get information about weather. The most prevalent response among adults and children was television. Almost half of children, but only one-quarter of adults, relied on what they saw outside to learn about the weather. Children were more likely to rely on their own senses as well when trying to detect the approach of a severe storm. Almost all children reported that they watched for changes in the weather--rain, clouds, darkening skies--to know that a storm is approaching. Adults watched the skies, too, but also were likely to turn on the television or radio for reports. Some regional differences emerged in response to this question. Adult respondents with hurricane experience--mostly in Miami but also scattered throughout the other three sites--were more likely to rely on weather reports to learn of an approaching storm. Those adults with more thunderstorm experience--mostly Washington, D.C., and St. Louis--tended to look at the skies. Only two adults mentioned more unusual ways of anticipating storms, such as watching the way animals respond to incoming weather. No children discussed alternative ways to detect storms.

One of the *Stormy Weather* team's key concerns is public safety. Team members wondered how well people are able to protect themselves if they encounter a severe storm. All respondents were keenly aware of storm threats. Very few respondents treated storms nonchalantly. Most, as discussed above, considered storms to be dangerous and life-threatening and had a great deal of respect for their power. All respondents were able to articulate some reasonable action they should take in the face of an approaching storm. It is difficult to discern whether respondents would know the safety measures to take if they were in special circumstances, such as at a sporting event or a shopping mall, when a major storm hit their area. Most respondents talked about what they would do if they were outdoors or near their homes. They were confident in their descriptions of their actions, and many indicated a great deal of experiential knowledge in dealing with storms. Readers should keep in mind that museum audiences tend to be better educated than the general population, so storm safety knowledge may be higher among museum visitors than is commonly recognized among the public at large.

Finally, the exhibition team was concerned that visitors from "non weather" regions like California would not be able to relate to the content of the exhibition. The data indicate that this is not the case. People who were interviewed in San Francisco mentioned a wide variety of storm experiences. In fact, in the question asking respondents what actions they would take if they encountered a storm, San Francisco respondents talked about blizzards more than any other region, discussed hurricanes more than any other region other than Miami, and related almost as many thunderstorm experiences as respondents in Washington, D.C., and St. Louis. Team fears were not borne out in the data. It is unlikely that the exhibition will travel to a region where the visiting population at the host venue has no severe storm knowledge or experience.

Part IV:

Conclusions and Recommendations

CONCLUSIONS AND RECOMMENDATIONS

TEACHING ABOUT STORMS

A primary goal of this front-end study was to provide the *Stormy Weather* team with concrete information about potential visitors to the exhibition. Differences between natural history museum visitors and science center visitors, especially regarding interpretive preferences, and data from in-depth interviews offer the team information about visitor knowledge and perspectives that can be integrated into the exhibition development process.

Personalize Storms

A powerful idea emerged from the in-depth interviews. Many respondents, when thinking about what storms meant, talked about the ways they affect human life. People were drawn to the idea that storms affect the flow of human life in significant ways. The idea of destruction, disruption, and even death resulting from storms emerged again and again in conversations with adults and children. Because most people had experienced one or more severe storms in their lifetime, they related immediately to images of storms, and their first thoughts usually involved the human perspective.

The team was concerned that regional differences among visitors would be a factor in the way the exhibition was developed. The data indicate clearly that most adults have lived in a number of places and have experienced different storm types. Even children who have not experienced storm types directly have had exposure to storms through the media and think about human impact. Cumulative personal experience is more relevant than where people currently live. People look first to the human impact of storms, regardless of where they live, before they begin thinking about the science of storms.

Recommendations:

- Use this powerful connection people feel to the human side of storms to entice visitors to learn storm science. Show a dramatic storm like Hurricane Andrew, or even a major winter storm or tornado, with all its damage portraying the human impact of the storm. Then talk about the atmospheric conditions that produced the storm. Hook people with the human drama that is easy for them to relate to and then move on to science. This process can be repeated throughout the exhibition.

- Use the human appeal of storms to hook people into learning about safety. The data from both adult and child interviews indicate strongly that people already know about the dangers to human life posed by storms. The overwhelming majority of adults and children saw storms as dangerous and life threatening. The exhibition team does not need to spend much exhibit time and space teaching how dangerous storms are. Rather, spend more time teaching safety measures that can be implemented in a variety of circumstances, using the power of storms as a hook. All respondents knew at least one safety measure to take but may lack a more comprehensive sense of how to protect themselves.

- People have many storm stories of their own and like to share them. Both adults and children were eager to tell interviewers what had happened to them during this hurricane or that thunderstorm. This eagerness is evident in lengthy descriptions of memorable storm experiences that respondents gave. Give visitors an opportunity to share their stories with other museum visitors. Often, exhibition developers are at a loss as to how to help visitors actively participate in an exhibition. A useful tool could be a "talk back board." Offer visitors a bulletin board, organized by region of the country or storm type, with pieces of paper on which they can share experiences with other visitors. Host museums can collect these stories and turn them into newsletters that can be available in the galleries.

Explain Difficult Concepts

The content of *Stormy Weather* has a strong science ingredient that will focus on showing different meteorological conditions associated with each type of severe storm so visitors can begin to understand the conditions that cause severe storms. A number of poorly understood concepts emerged in the data. The team wondered about misconceptions about weather and storms commonly held by visitors. Data indicate that lack of understanding is more prevalent than misconceptions among both adults and children. The good news for exhibition developers is that there is no need to show people that their closely held ideas are wrong; rather, the task will be to explain partially understood ideas. Even the misconceptions reported by many children--that Hs on weather maps stand for hot weather and cold fronts always indicate cold weather--can probably be attributed to bad guessing.

Recommendations:

- A number of basic weather concepts need to be defined in the exhibition. Some that emerged in the data include relative humidity, wind direction, warm and cold fronts, high- and low-pressure systems, and radar, including Doppler radar. These are words and phrases that are familiar to visitors, but most people lack a clear understanding of what they mean. Children, especially, lack the appropriate language for talking about storms. By explaining poorly understood concepts, the exhibition can offer young people the language they need to express their ideas.

Imaging technologies offer an interesting challenge. Although many adults and children were able to identify a satellite-generated image, they thought the Doppler radar-generated image was from a satellite as well. Clearly, many people need to learn about the various imaging techniques and be shown graphically the differences between images created using satellites and those by other imaging technologies so they no longer think all storm-tracking images are satellite-generated.

- Another important idea that is not widely understood by visitors is that tornadoes are products of thunderstorm systems, not different types of storms entirely. Most people who talked about tornadoes and thunderstorms indicated that they were not related at all. The exhibition will have to show the relationship between the two very clearly.

- Barometric pressure is <u>the</u> basic weather building block that neither adults nor children understood. It is the only weather indicator that people cannot feel-- they know what temperature, humidity, and wind <u>feel</u> like. Despite the fact that most adults easily named barometric pressure as a weather indicator, few could confidently define it. Almost no children were able to define the term either. This concept, as well as the other difficult concepts noted above, need to be taught in a variety of ways. The current exhibition outline calls for an introductory area that explains and defines basic weather concepts. The team may want to consider repeating information from the introductory area in other relevant sections of the exhibition. For example, when storm dynamics are explained in the hurricane section, reiterate explanatory material about pressure. People will be more likely to learn a difficult concept they have never understood if there's an enticing reason to learn it and if it is repeated several times and in several ways.

- There is much opportunity for using computer interactives and videos to convey some of this information. However, team members should use electronic devices with caution. Of the nine interpretive strategies, adults rated computer games and video programs fairly low. These findings are important for natural history museums, as these museums attracted many more adults visiting alone or in groups than did science centers. Generally, adult pairs liked video programs and computer games less than adults visiting with children. Data indicate that children like to use computer games in both natural history museums and science centers. Science centers attracted more groups of adults and children than did natural history museums, so the team needs to find the right balance of electronic and other interpretive strategies (such as object displays, which ranked third overall) to appeal to both children who visit science centers and adults who visit natural history museums.

- Utilize as many exhibition modalities as possible. Women rated five of the nine interpretive strategies differently from men. Women reported liking looking at objects, engaging in small-group activities, and listening to audio interpretation more than men. In addition, women preferred seeing demonstrations and manipulating or touching exhibition components more than men. These differences are further complicated by age differences among adult visitors. Older respondents liked looking at objects and dioramas, watching video programs, and engaging in small-group activities more than younger respondents. However, younger adult respondents liked computer games more than older respondents. For example, if a computer program is the sole medium for teaching a particular concept, older audience members may likely miss this concept. Similarly, if an object and accompanying text are the only place where another idea is expressed, this idea could easily be missed by younger audience members. These findings again point to the need for redundancy. Do not be afraid to repeat ideas and concepts--especially critical ones--in different ways.

Stress Connections

It is obvious from the data that adults and children do not understand how the basic building blocks of weather work together to produce storms. People know small bits and pieces of information--some can talk about temperature, some can talk about warm and cold air, some can talk about precipitation--but very few can put the pieces together to form a complete picture of severe storms. In fact, many adults and children, in defining storms, spoke simply about the elements of storms they could see or feel--rain, wind, or lightning. These respondents were not even connecting what they could see out their windows with the movement of clouds or other atmospheric conditions above their heads. Visitors to the exhibition need to be able to connect the information they already have, no matter how simple, to the complex interrelationships that produce storms.

Recommendations:

- Stress connections wherever possible. The exhibition is a valuable tool to show visitors how different regions of the country, in fact the world, are connected by the atmospheric conditions that swirl around the globe. Almost no respondents indicated an understanding, or even an inkling, that weather that is happening in New England could have been produced thousands of miles away. Creating a sense of connection will be a difficult, although worthwhile, goal to pursue. Opportunities to make connections should be available to visitors throughout the exhibition.

- Utilize live demonstrations and hands-on exhibits as much as possible. Two interpretive strategies were consistently ranked within the top three strategies by adults and children overall. They were "live demonstrations" and "things to handle/touch/manipulate." The first strategy may require the presence of a museum staff member to demonstrate technology, facilitate group interactions, or explain a phenomenon or concept. Consider having a built-in public program/demonstration component (such as a retired meteorologist several afternoons a week) to respond to visitors' need to interact with and ask questions of a knowledgeable person. In addition, placing an expert in the weather station would help introduce visitors to the technology and would be an asset for those who enjoy learning by watching and talking with others. Many people find that being able to touch objects or have a hands-on experience with an exhibition component complements other ways of learning. Reproduction artifacts and low-tech interactives are extremely effective and low-cost ways of introducing and explaining scientific phenomena.

- Help visitors deepen their current weather knowledge by presenting a familiar concept--such as a newspaper or television weather map--in a way that thoroughly explains what is happening and how the various weather indicators point to the formation of a certain type of storm system. Have a "talking" or movable weather map, where visitors can make changes in temperature, fronts, and pressure systems and then see the impact of those changes on the weather in a particular region of the country. As noted above, a live demonstrator could be useful in this activity as well.

These findings create interesting exhibit and interpretive problems and possibilities. They are also very concrete. They identify the reality of visitors to museums and science centers--their varied ideas, attitudes, and preferences--and show that there is no general visitor. Exhibition components and interpretive strategies must reflect what visitors like, that men are different from women, that younger visitors are different from older visitors, and that children are different from adults. In addition, adults in pairs or groups have needs different from those of adults with children. When the *Stormy Weather* team begins to make decisions about integrating a particular interpretive strategy with content, team members must evenly distribute content around the exhibition as well as continually mix and match strategies with content. The exhibition will need to balance its exhibition techniques so that the stories of people do not get overpowered by the stories of technology. No one strategy should stand alone in terms of conveying an important idea or message. That message must be pervasive and contained in multiple strategies. The team must be attentive to content distribution among strategies and consider men and women of all ages and in all group types.

APPENDICES

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