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ABSTRACT

Over the past five decades, there have been a countless number of science-oriented programs that were viewed on television. In the last two decades, research has blossomed on informal science teaching, effective informal science teaching techniques, and the ideal environments for increasing science literacy in informal educational settings. This study explores who watches television, why they watch television, and the educational effects of television. One section of this paper explores the history of science on television and viewers' perceptions of that programming. Findings suggest that science and educational programming are not reaching vast numbers of the population, that people can and do learn from television even though learning is not their primary motivation, and that viewers do not relate well to scientists as they are portrayed in the media. Recommendations for increasing the effectiveness of television as a learning tool in science include incorporating realistic science content into popular television programming and involving the public in discussions about why science is important. A single Appendix is attached; discussing research methods in television program evaluation. (Contains 95 references.) (DDR)

Teaching Science by Television: The Audience, Educaiton, History, and the Future

by

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TEACHING SCIENCE BY TELEVISION: THE AUDIENCE,EDUCATION, HISTORY, AND THE FUTURE

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"Several hours of educational TV are broadcast daily during the morning and early afternoon hours. Most children do not watch many of these programs, however." (Cohen and Salomon, 1979)

INTRODUCTION

Countless discussions have occurred on the effectiveness of formal science teaching methods and on the content of the courses taught. In the last two decades research has blossomed on informal science teaching, effective informal science teaching techniques, and the ideal environments for increasing science literacy in informal educational settings. The 1980's heralded a new focus for research into informal science education; promoting science education through television. *Mr. Wizard* (1951- 1965, 1971- 1972) was the first comprehensive attempt to teach science through a weekly series. In the 1960's *The Undersea World of Jacques Cousteau* and the *National Geographic Specials* were relatively popular science television. The *National Geographic Specials* are still in production. The following decade experienced a greater diversity of science-oriented television programs than was previously known. The popular, *NOVA*, and the *Wild, Wild World of Animals* date from this time and are still being produced and aired. The quantity and quality of science programming continued to increase during the early 1980's and began to decline towards the end of the decade. The most noteworthy new science programs of the 1990's are *Bill Nye, The Science Guy* and *Beakman's World.* The proliferation of cable television stations has greatly increased the volume of programming and in limited instances, the volume of science programming available.

This paper will explore who watches television and why they watch in the first section. The second section will review research on the educational effects of television.

The third section will explore the history of science on television and viewers perceptions of that programming. The concluding section will combine our knowledge of viewers, the best techniques for imparting educational content, and make some suggestions about how we can increase viewers' exposure to and interest in science through television programming. Finally, an appendix is included which briefly reviews research evaluation methods for television programming.

Ratings for science programming in 1991-1992 show an audience average of 2.7 percent of all television households watching a particular program at any one time (Chen, 1994). Shows rated ranged from a high of 5.6 percent (*National Geographic Specials*) of all television viewing households to 0.2 percent (*3-2-1 Contact*). The figures are surprising in that extensive formative evaluation was conducted for *3-2-1 Contact* (Mielke and Chen, 1983) and it was designed and targeted to its audience's needs and desires. In fact, preschoolers are the majority of viewers for 3-2-1 Contact, a show specifically designed for eight to 12 year olds. Chen (1994) attributes the higher percentage of preschoolers watching 3-2-1 Contact to "flow," watching one show (3-2-1 Contact) after viewing Sesame Street.

When asked to agree or disagree with the statement, "It is not important for me to know about science in my daily life[.]", 14 percent of all Americans agreed (National Science Foundation, 1994, p. 132). Eighty-six percent of Americans' surveyed felt that science knowledge was important to them. However, only 18 percent of the public is attentive to and knowledgeable about science and science policy (Miller, 1987) and even fewer watch science-oriented television programs. Only five percent of American adults were found to be "scientifically literate" in 1985 (Miller, 1987).

Where do American's learn their science? According to a survey by SRI International (1988, p.78) about 20 percent of their national sample "identify leisure-time pursuits with a significant scientific component as their most important informal learning activity." Roughly 14 percent of an urban area's population visit museums three or more

times per year, 40 percent visit once or twice a year, and 46 percent do not visit museums (Hood, 1983). If we assume a generous three hours per museum visit Americans spend precious little time in museums. Americans who graduate from high school spend roughly 12,960 hours in formal academic pursuits. About 1350 hours of that is spent in science class (10 years of science classes for 45 minutes per day). This amounts to 56.25 24 hour days of formal science study. "...[I]t is from ...out-of-school sources that most people must learn for most of their lives" (Lucas, 1983).

The average American watches about 4.3 hours of television a day starting at age 2 (children ages 2-11 watch 3.2 hours per day) dropping to 3.12 hours per day during ages 12-17 and peaking at almost 5.9 hours of daily television viewing at ages 55+ (Nielsen Media Research, 1993). The television is turned on an average of seven hours and thirteen minutes a day (Nielsen Media Research, 1993) with 99 percent of Americans owning at least one television set (Nielsen Media Research, 1986). Americans spend over one-quarter of their waking hours in front of a television! (References in Anderson and Collins, 1988, pp. 12-13 suggest the commercial ratings services like Nielsen overestimate television usage.) The potential for information transfer by television is staggering. The underlying thesis of this paper is that if we capitalize on our knowledge of program preferences and research on learning from television, perhaps effective educational messages can be included in popular educational fare.

WHO WATCHES TELEVISION, WHAT THEY WATCH, AND WHY THEY WATCH

Television Viewers: Who Are They?

In a attempt to determine demographic characteristics of television nonviewers Jackson-Beeck (1977) found some significant differences between those who watch television and those who do not* (*nonviewer is described as one who watches less than

30 minutes per day). Nonviewers are statistically significantly different (p</= .10) than viewers on the following characteristics: they are female; married; childless; grew up in conventional families; identify less with religious doctrine; are gainfully employed; are professional, technical, clerical, or kindred employees; make less than $10,000 per year; are better educated; found in urban areas, and increase westwardly across the United States. Concluding, the author states that the 3.9 percent of the public who are nonviewers are "socially insignificant" in a "macro perspective."

Over 96 percent of all Americans regularly watch television. American television viewers average 1.2 hours of primetime viewing daily. Adult males watch 1.8 hours of primetime daily and adult women see two hours of primetime programming per day. Adult women watch television more hours per day in all time slots (weekday morning, weekday daytime, primetime, Saturday and Sunday less weekend primetime) except for three time periods. Children watch more morning and Saturday morning programming and adult males watch more Sunday daytime television. Cable television viewing accounts for 12.2 percent of all viewing in United States households (Nielsen Media Research, 1993).

Studying visual attention to television Anderson and Levin (1976) found that children at age one watched Sesame Street at a rate of 12 percent of the time in front of the television; at age two visual attention to television more than doubled to 25 percent; attention increased to 45 % for three-year-olds; attention at age four levels off somewhat to 45 % of the time. Condry (1989, p. 49) reported an unpublished study by Singer and Singer in which children who had no television at home declared that they watched two hours of television per day. Television is clearly a strong component in American culture and we become acculturated to it at an early age.

Virtually all citizens of the United States watch television. Americans spend more time watching television than they spend doing all other leisure time activities. In fact, the only activities we invest with more of our time are sleeping and working.

People have particular preferences for television program content, as we shall see in the next section.

Preferred Television Genres

Americans have specific preferences in their television viewing. Over 29 percent of television usage is to view feature films and dramas. Newscasts and news magazines account for over 17 percent of television viewing (capitalizing on this fact, the National Science Foundation produced a *How About* series starring Mr. Wizard for insertion in daily newscasts- the broadcasts continued for ten years (Tressel, 1990)) Talk and variety shows are the third ranked preference with a total of 13.3 percent of viewers tuning in weekly. Other preferred genre include: sitcoms (9.3 percent); children's shows, including cartoons (6.1 percent); sports (5.4 percent); serials (4.5 percent), quiz and game programs (3.2 percent); "reality" shows (*Cops, Rescue 911, Unsolved Mysteries*) (2.6 percent); and all other shows (9.2 percent) (Papazian, 1994). Science programming falls in two categories: other (*NOVA, National Geographic*, and other science documentaries) and children's programming (*3-2-1 Contact, Bill Nye, The Science Guy*, etc.). In 1992-1993 the *Star Treks: Next Generation* and *Deep Space Nine* (23.1 percent of viewers combined) were outranked only by *Wheel of Fortune* and *Jeopardy* (26.4 percent combined) in Nielsen Media Research (1993) ratings but amongst men they were the top rated shows. (Ormerod et al. (1989) feel that space and fantasy programs may be the best way to interest youth in science.) Adult males also included *National Geographic on Assignment* (4.6 percent) in ther top 10.

Lyle (1972) found developmental patterns of television program content in children and adolescents. Lyle reported that from grades one to six cartoons are the preferred television genre. Sixth graders tastes are oriented to adventures and sitcoms. Tenth graders lose interest in sitcoms while retaining the interest in adventure dramas. Previous work by Schramm, Lyle, and Parker (1961, p. 49) indicated that late

adolescence is when we become interested in "public affairs" television. Suprisingly, Lyle (1972, p.17) discovered that educational programs are watched by fewer children than those who watch news programming. Papazian's (1994, p.173) summary of the appeal of primetime programs confirmed the work above; children prefer slapstick comedy, "young adults" prefer spy stories and science fiction, and added that "older viewers" enjoy "easily digested" variety formats. According to Papazian's data (p.202-204) interest in sitcoms decreases with age; preferences for news magazines is high in young adults, dips during ages 35-49, and then increases to young adult interest levels or greater; the situation for so-called "reality" shows is similar to that for news magazines, and the audience for police dramas increases with age. Interest in drama serials (*Beverly Hills 90210, LA Law*) and movies varies with the specific program plot and target audience. Children were found to have age related preferences in a 1977 study by Rubin. Third grade children preferred adventure dramas, comedy and "children's entertainment programs, in that order. Seventh graders enjoy comedy, adventure dramas with sports and music/varieties tying for third. High school juniors first enjoy comedies followed by adventure dramas, and finally music/variety shows. **Children's educational programming rated last as a preferred usage in all age categories in this study**. We will next look at why people watch television to determine if an educational component for popular programming would conflict with people's uses of television.

The Utility of Television: The Public's View

Research on the utility of television has bifurcated into three camps, uses, gratifications, and the expectancy model. Uses are defined as "anticipated postexposure application of the mediated experience to attaining pragmatic goals" and "[g]ratifications are transitory mental or emotional responses providing momentary satisfaction at an intrinsic level" (Atkin, 1985). Additional research has identified an underlying "expectancy model" that posits the use of a medium if it is felt that the medium will

provide gratifications sought (Galloway and Meek, 1981; Van Leuvan, 1981). Kippax and Murray (1980) explored the needs satisfied by media usage and found that television is perceived to be effective in fulfilling needs for "self-identity and social contact", self-gratification, obtaining information, and entertainment or diversion. The authors ascribe the use of media to its perceived helpfulness in achieving the four needs. While television was perceived to serve the entertainment purpose its usage is not strongly related to the level of the entertainment need, film, however was significantly related to providing entertainment at the required levels. This research implies that television may be selected as a next best alternative to what people would really prefer to do because it does not fufill the need at the required level. A comprehensive treatment on the enigmatic use/gratification/expectancy theories of media usage are well beyond the scope of this paper. We do know that regardless of the underlying psychological aspects of television uses Americans spend most of their conscious, non-working hours in front of it.

Another branch of television research concerns whether viewers actively seek program content or if they passively accept what is available (Rubin, 1984; Windahl, 1981). These studies identified two types of television viewers, habitual or ritualized and intentional or instrumental viewers. Habitual viewers watch television to pass time, "for companionship, relaxation, arousal, and escape." Intentional viewers specifically seek information with particular goals in mind. Habitual users have a high regard for television and use it frequently. Intentional users neither highly value television or use it frequently. In conclusion Rubin stated that there is not a clear dichotomy, there is an overlap of user types in each individual. The availability of television remote control channel changers and the proliferation and diversity of cable television stations suggests that viewers may be more active and complex consumers of content than has been previously identified. This section will conclude with a brief summary of children's self-reports about their uses of television.

Television has been found to be a social role model for first graders (Lyle and Hoffman, 1972). Rubin (1977) discovered age-related trends in children's usage of television. Third graders firstly use television to pass time, for "arousal", and finally for relaxation. Seventh and eleventh graders' self reports were strikingly similar to those of the third graders except that both of these groups rated relaxation second and arousal, third. Using television to learn was always cited in the bottom third of uses by all three age groups in this study. Regardless of one's desired effects in their use of television it appears that programs identified as educational, either directly or indirectly via their venue (e.g. Public Broadcasting System (PBS)), may inhibit viewers from watching just because the programming is identified as overtly educational when the user is seeking something other than direct educational content.

LEARNING FROM TELEVISION

An abundance of research is available about how viewers can develop violent tendencies and learn patterns of violence from television (See references in Condry, 1989, pp. 61-68, 88-119). This section will explore the potential for teaching academic content by television. Initial research on learning from film was conducted during the Second World War on the "persuasive" effects of film-based messages. In the last two decades research has focused specifically on the differences of learning from different mass media and what particular effects television has on the learning process.

In comparing cognitive processing of text (with pictures), radio, and television messages Pezdek, Lehrer, and Simon (1984) tested third and sixth graders comprehension and memory. The authors found television to be a more effective teacher than radio but no difference in learning by reading and learning by television. One important note to this finding is that while reading requires 100 percent of the learner's attention the authors agreed that television viewers "can and do attend to television far less." This means that in spite of equal story treatment in books and on television one can learn

more with less effort from the television! Meringoff (1980) presented two groups of children (M age=7.6 and M age=9.6) a story either from an illustrated book or via television. The television group recalled more story actions and drew inferences based on visual content. Children who were read the story remembered more vocabulary and based their inferences on general knowledge and past experiences. Additionally, the children who had the story read to them asked more questions and made more comments about he story. One can interpret this research to show the television story contained more information resulting in fewer questions about the story. But the differences in vocabulary and less elapsed time and shorter distance traveled estimates in the television group indicates that there are major differences in how children process text and television presentations. A balance of media treatment is indicated in order the comprehensively develop children's perceptual skills.

Is it easier to learn by audio messages, or video messages, or combined audio-visual messages? Perlmutter and Myers (1975) explored this question using a group of preschool children. Children were either presented with a verbal list of objects, shown the object, or or the object was verbally labeled and simultaneously displayed. There were significant differences found between recall of verbally presented material (71 percent correct recall) and visually presented material (93 percent correct recall). No significant differences were found between visual presentation and combined verbal and visual presentation. The recall tests were performed verbally, visually, and both combined. The authors concluded that preschool children have a combined verbal and visual storage and retrieval system of memory.

Gibbons et al. (1986) also found that audiovisual presentation was more effective in promoting recall and reconstruction of stories in a study utilizing 4 and 7 year olds. A third study reinforced the findings of the first two (Greenfield and Beagle-Roos, 1988) but the authors also cautioned that audiovisual presentations may create a generation of children that are "less imaginative, less verbally precise, and less mentally active."

Studies that have directly measured learning from television have concentrated on programs that were originally conceived and design as educational shows. *Sesame Street* viewing produced gains in the skills and concepts taught in frequent and infrequent viewers with higher gains in younger children and with more frequent viewing (Ball and Bogatz, 1970). Significant gains in mathematical knowledge resulted from watching a magazine format program entitled, Infinity Factory (Bryant, Alexander, and Brown, 1983). In this study eight programs were viewed, each teaching two or three skills or concepts. One thousand students were posttested and significant gains in knowledge were reported over all ethnic groups.

Two hundred and ten participants from ten different cities watched a Mr. Wizard "science news insert" and scored an average of 61 percent better on a posttest compared to their pretest scores. The viewers were surprised at how much they had learned. The participants in this study reported that they watched science programming two to three times a month and visited science museums once a year (Research Communications, 1987). Intuitively, one imagines that those that visit museums (14 percent as noted above) are probably also those that watch science programming. Further research will speak to this hypothesis. Educational programming may be preaching to the choir.

Social skills are learned from television viewing. Noble (1983) found that children who viewed a nature program, *Australia Naturally*, "acquired the moral messages...with more force than they acquired factual information." Fourteen year old girls use serial dramas (soap operas) to learn about social interactions and their consequences (Palmer, 1982).

Learning from television is enhanced by interaction with others while viewing. When parents clarify issues or focus attention on specific aspects of a program significant gains in learning occur over situations in which there is no such interaction (Ball and Bogatz, 1970; Walling, 1976; Salomon, 1977, Watkins, et al., 1980). Gagne and Burkman (1982) studied adult learning from *NOVA*. Using a shortened and edited

version of a program on natural selection, viewers who had watched the program with a narrated voice-over which was designed to organize program material with the viewers past experience. The viewers who watched the voice-over version learned substantially more than those who did not.

Exploring how memory processes affect learning Kellerman (1985) notes the differences between semantic long-term memory (SLTM)- the location of "procedural, thematic, structural, and conceptual information" and episodic long-term memory (ELTM)-storage for "contextually dependent information, ...information about specific events or episodes.". Her work indicates that storage of information in ELTM may be inhibited for messages in the mass media, while storage in SLTM is enhanced. Most television learning research has concerned ELTM, recall of facts, events, or items. SLTM information focuses on how information is structured, organized, and used. Kellerman calls for more research into SLTM, and with the recent interest in promoting critical thinking skills in our children SLTM seems to be the more appropriate focus for educational program designers; teaching a general schema by television and allowing other informational sources to fill in the details. Support for Kellerman is found in Orozco-Gomez (1986) in his treatise on the cognitive effects of non-educational television. Orozco-Gomez demonstrates that separating television as a social and cultural institution from its technical aspects and separating its effects on skills and knowledge from its effects on beliefs, paints a distorted image of television's true effects. We may forget many of the facts or figures but we do retain a general impression of the experience.

Comprehension of television programming is related to an individual's experiences. This is born out by the fact that older children are able to comprehend programming that is not related to ther own personal experience but consists of information they have developed vicariously. Younger children without a wealth of vicarious experiences only comprehend things that they have directly experienced

(Newcomb and Collins, 1979). Additionally, the ability to make inferences and therefore achieve greater comprehension, also increases with age due to greater familiarity with television programming conventions, techniques, symbols, and codes as well (Smith et al., 1985; Collins and Wellman, 1982; Collins, 1982).

Two unrelated but seemingly important aspects of audio-visual productions are viewer identification with a character and humor. Identifying with a protagonist in a film causes viewers to better remember the words and actions of that character (MacCoby and Wilson, 1957)- this information is important to the discussion of how science and scientists are portrayed by television, which will be covered in a latter section. The use of humor in educational undertakings has been studied, one project by Kaplan and Pascoe (1977) demonstrated the effectiveness of humor in promoting learning when the humor is related to the educational message. Two other studies showed conclusively that humor increased both attention and comprehension in children (Bryant et al, 1981; Zillman, 1980). Bryant et al (1979) conducted content analyses on four educational children's programs: *Captain Kangaroo, Electric Company, Mister Rogers Neighborhood, and Sesame Street*. Only seven percent of tendentious humor and five percent of nonsense humor was directly related to the educational message being conveyed. Eighty-six percent of the tendentious and 85 percent of the nonsense humor, was "somewhat related to the educational message. Clearly, television producers are including humor to add to the entertainment aspects of programming but contrary to published research most of the humor is not directly tied to the educational message. One interesting but alarming note from this study is that 25 percent of he humor in the shows studied was tendentious. The authors identified tendentious humor as that which "was intended to be funny and if a person or thing was victimized, disparaged, insulted, embarrassed, or otherwise degraded." Is this what we want our children to learn when they watch educational television?

The Amount of Invested Mental Effort (AIME) is clearly related to how much one learns (Salomon, 1981). Salomon defined AIME as the number of mental elaborations times the reciprocal of the automaticity of the elaborations and is dependent on the perceived demand characteristics of the context or task. If we know that a task is difficult then we will expend more mental effort in completing the task. AIME is also a function of self-efficacy. If we think we can not do something we are less likely to expend effort on it. AIME is influenced by interactions with other viewers and through thought directed narration but it is also directed through the formal features of television programming. Television programming is a language in that it has grammar, syntax, and codes which we must decipher in order to understand the messages presented. The following section discusses research on the aspects of television which are medium-related and how we behave with our television sets.

TELEVISION VIEWER ETHOLOGY

Television viewing is not a monolithic activity. School aged children watch an average of 7.6 minutes of television before exiting the room (Anderson, 1987). Children regularly do homework, groom, play individually or with others, talk, read, eat, color, and play games averaging one-third of the time they are in front of a television(Anderson et al., 1986). Children look at and away from the television over one hundred times an hour (this holds true for adults, also) (Anderson et al., 1986).

There is a curvilinear relationship between age and hours spent visually attending to television. Hours spent attending to the television increase rapidly in preschool children peaking at age ten and declining, thereafter. Visual attention to television, actively viewing a program is highest with older school aged children (70 percent of the time in front of the television) which declines to 57 percent in adults (Anderson, 1983). This finding is interpreted to indicate older children find television a comprehensible information source. Men look at the television more than women (even though as noted

above, women spend more time with the television. Almost fifteen percent of the time the television is on, no one is in the room! (Anderson et al, 1986).

Attention to television is in large part an interaction between the understandability of the content and the formal features of the program. Formal features include voices, animation, sound effects, music, cuts, pans, and zooms. Program comprehensibility is a key factor in determining how long one attends to the television and subsequently whether the viewer actively processes what they see (Anderson and Lorch, 1983, Campbell, 1982). Varying abstractness, sentence complexity, and message redundancy had only a slight effect on viewers attention (Campbell et al., 1987). However, when dialogue was replaced with Greek dialogue or played backwards visual attention was reduced (Anderson et al., 1981; Pingree, 1986). Children are attracted to children's voices and unusual voices, movement, sound changes, and sound effects. Children's attention is negatively impacted by inactivity, long zooms, long speeches, adult song and dance, and male voices (Rice et al., 1983; Calvert et al., 1982; Huston et al., 1981; Alwitt et al., 1980). Sound effects that precede program transitions increase visual attention and inferential recognition for children in elementary school but were particularly important to younger children who typically have the greatest difficulty in comprehending television due to their unfamiliarity with the medium (Calvert and Gersh, 1987). Perceptual salience and the formal features of a program get and hold attention (Wright and Huston, 1983 and citations above) while comprehensibility guides information processing and also maintains attention..

Anderson et al. (1987) describe attentional inertia as "[t]he longer a look at TV is maintained, the conditional probability that it will be further maintained rapidly increases for about 15 sec, after which it increases slowly." This finding is particularly important for producers of educational messages- an individual message or string of messages must hold the viewers attention for a minimum of 15 seconds to increase the chance that the whole message or message string is attended to. Children rarely attend to the television

for ten minutes at a time- attention duration is typically less than a minute (Anderson and Field, 1983). One can conclude that educational messages should be on the order of roughly a minute with an attention grabbing component to hold attention during the first fifteen seconds.

Krull et al. (1977) measured various program's entropy (randomness of locations and randomness of verbal utterances) and compared them to formal program features (pace, unity, unit-to unit transition, tension building, and climax) and found a correlation between program complexity and viewer interest. The more developed the entropy and more complex the formal features were the higher the viewer interest. Change in programming appears to keep viewers attention. The authors also found a correlation between educational level and preference for increased entropy with more complex structure. This finding is important for educators both in television and in the classroom. Varying methods, scenes, and action has generaly has positive effects on individuals' attention in an audience.

HISTORICAL AND CURRENT IMAGES OF SCIENCE AND SCIENTISTS ON TELEVISION

Science on television can be found in newscasts, educational documentaries, children's educational programming, and entertainment fare. When Apollo 11 landed on the moon all the major networks were saturated with the news and related stories for almost two weeks (Perlman, 1976). Since the lunar landing no scientific endeavor has received such comprehensive coverage. The 1997 landing of the Martian Pathfinder Lander and Sojourner Rover was a media sensation for only two to three days.

The way scientists are portrayed on television and what the public's perception of who scientists are and what they do is an important topic. Since so few people have direct experience with formal scientific pursuits it is "...the creators of popular culture- from whom the wide American public receives its portrayals of science and scientists

(Basalla, 1976). Historically, (in the 1930s and 1940s) scientists on popular television were "elderly white males who were insane or evil" and over the last couple of decades that image has been transformed into a scientist who is white, "well-meaning but obsessed" who will let nothing stand in his way (Garfield, 1978). Reviews of research on the public's perception of scientists show that the masses idea of a scientist closely resembles the stereotype presented on the television and in films (Schibeci, 1986).

Gerbner et al. (1981) compiled some interesting statistics about science on television. The themes of science and technology dominant roughly half of all dramatic network programming (Although La Follette (1982) pointed out that much of popular science is pseudoscience like time travel and space travel). Sixty percent of prime-time programming and 70 percent daytime programming on weekends concerns science and technology themes, topics, or concepts. Even though science is a common theme scientists per se, are seen only once a week, and are the protagonists every other week. Scientists are seen in their occupational role on television at a frequency less than half of their frequency in the labor force (female scientists are overrepresented on television compared to their proportion in reality- except in children's programming where females are usually in secondary roles (Steinke and Long, 1995)). Scientists are portrayed as older, without family or significant other, dangerous, and usually headed for failure. Five percent of television scientists kill another person and 10 percent of television's scientists get killed (Gerbner, 1987). Would you aspire to be a lonely old crackpot who is likely to die soon or kill someone?

Reviewing the images of scientists on children's television Long and Steinke (1994) found images that supported and conflicted with previous research. Science is presented as truth and sometimes dangerous, the authors report. Television presents science as fun and as important to everyone in their everyday lives. Scientists appear elite and omniscient but they are not evil; they are typically benign. Greenberg's (1984) content analysis of children's television pointed out that technology (the results of

science) are imbued with the power to make everything better and is frequently used for destruction of evil. Scientists in cartoons are hapless buffoons or evil men bent on world domination. Greenberg finds science on Saturday morning television ambiguous and threatening. Physicist Phillip Morrison and Phylis Morrison (1984) note, as the authors above, that television programming (they use the example of the white-coated Doctor Bunsen Honeydew on the Muppets) represents science as something beyond the average American conducted by specialists who are almost superhuman. The Morrisons close with the comment that science needs to be connected with everyday life and the viewers personal experience which will result in a demystification of science and the realization that science is for everyone.

Gerbner et al.(1981) and La Follette (1982) note that science is presented on television as fact, without context, years of efforts and failures compressed into minutes, and presented by all-knowing experts. In Gerbner's (1987) analysis of the publics' attitude toward science he found that in spite of the typically positive images of scientists and science on television, viewing television dramas "exacerbate[s] public ambivalence and anxiety about science." While I agree that experiencing science from television as a primary source of information can cause ambivalence (because of conflicting medical reports, use of science and technology to create weapons, etc.) but dramas are not solely at fault. Hornig (1990) blames NOVA for perpetuating the tension between science and the general public as well as maintaining the dichotomy between "privileged" scientists and everyone else. Hornig believes that television should be an equalizer; it should make people feel comfortable with science instead of putting science on a pedestal to be worshipped by a minority elite as Hornig believes NOVA does.

The *Star Treks* portray science as benevolent. In these shows little has changed in four millennia. The social order is relatively unchanged with technology being portrayed as only good, providing leisure and health to all or it is used to combat evil. Banks and Tankel (1990) use the *Star Treks* as examples of television promoting the status quo;

promising the future will be good for all. The authors note that science fiction that shows society in decline, *e.g. Max Headroom* and *V*, failed because they are depressing and because commercial television is driven by advertising, advertisers do not want to portray the future as hopeless. Shows like *Star Trek* are targeted to the young. The dramatic shows, documentaries, and news reports are watched by older viewers. If the work discussed above is accurate, television seems to be pitching the benefits of science to the young while frightening or disillusioning older viewers.

Dornan (1990) believes that coverage of science in the media is dominated by a small group of scientists and science journalists who prefer to illuminate science in the "traditional, heroic, positivist" light showing science as an "assured avenue of access to the real." Dornan believes that preventing critical discussion of science benefits and pitfalls allows science to continue as it always has, elite, powerful, and omniscent. Preventing the public from entering the discourse about the future direction of scientific endeavor perpetuates the public's distrust of science and scientists.

Efforts have been made to make science educational and entertaining (e.g. *3-2-1 Contact, Bill Nye The Science Guy*) but the audience for these shows is small. There is a schism on popular television as to what science is and who scientists are. Science either makes ours lives better or threatens us with technology and conflicting studies about what works or what does not. The process of science is not infallible and it is time-consuming. The public must be informed that scientists fail and misstep, frequently. The public must also be invited to join in the discussions about the directions of science and shown how they, themselves are competent scientists, in their own right.

CONCLUSIONS: HOW CAN WE USE TELEVISION TO TEACH SCIENCE

Science and educational programming are not reaching vast numbers of our population. In fact, many viewers have negative attitudes about overtly educational programs. The vast majority of Americans spend significant amounts of time watching

television to pass time. The public prefer feature films, news and science fiction programs in their quest for relaxation, entertainment, and arousal. Children know what they want in science programs (cartoons, celebrity protagonists and guests, kids as primary performers, provide opportunities for the audience to participate, debate both sides of an issue, and a healthy dose of mystery (Jerome, 1984)) and through formative research television producers should find out what the public knows and wants.

Research shows that people can and do learn from television in spite of the fact that learning is not their primary motivation. Little research has been conducted on how much we learn from non-educational, commercial television. Learning from television can be enhanced through narration, parental involvement, judicious application of formal features, and by carefully selecting what is to be taught. Learning is facilitated by tying programming to the viewers frame of reference, airing salient programs, including humor tied to the educational purpose, and providing characters that viewers can relate to. "...[I]nstructional television is often at its best when it does not instruct" (Lundgren, 1972).

Viewers do not relate well to scientists as they are currently portrayed in the media. The white coats and racks of test tubes have to go. When visiting scientific laboratories on any university campus typically only the chemists are clad in white and surrounded by glassware. The public should see scientists as they are not as some scientists and journalists feel they should be seen.

The sometimes long, tedious process of science should be presented to the public and people should have opportunities to appreciate that they do science everyday when they test hypotheses about things as simple as selecting a food for their cat or finding the best tomato for their gardens. The public must be included in discusions about what science is important as they ultimately fund most science and stand to benefit from the results of science. The best way to educate the public is by including realistic science content in popular television programming and showing scientists as "regular" people

who are not infallible and do not know everything. Dramatic presentations on television should elucidate the scientific method, show the public how they use science daily, and present critical arguements about the pros and cons of particular scientific undertakings. News telecasts have a responsibility to demystify science by doing away with the demagoguery and pedantry by giving a balanced treatment of scientific issues. Popularization of science must "become attuned to the daily preoccupations of the layperson with a view to injecting them with a homeopathic dose of scientific literacy" (Fayard, 1991). Television cannot simply tell people that science is fun and important it has to show them how science can be fun and include the public in he discussion as to what science should be important.

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APPENDIX A: RESEARCH METHODS IN TELEVISION PROGRAM EVALUATION

Various quantitative and qualitative methods have been used to assess audience reaction to television programs. Educational content is typically assessed through pre- and post tests of recall and/or recognition. Testing and evaluation rarely present the total picture to the evaluator. Surveys and questionnaires may illicit less than truthful or inadvertently incorrect responses. Ethnography may affect the setting with the

potentially behavior-changing presence of the ethnographer. Quantitative methods that rely on hardware are unnatural and the presence of the hardware may affect the data. No method of testing or evaluation is perfect. In ideal circumstances a cadre of methods should be combined that overlap and reinforce each other (Ball, 1976). Not only should summative research be conducted but from the earliest stages of planning, formative evaluation should be an integral part of each step of the process. The following discussion of evaluation techniques primarily draws on the work of Mielke and Chen (1980; 1981; 1983); and Chen (1980-1981; 1983, 1984) because the authors provide a comprehensive review of their evaluation process and its outcomes on a science-based educational program. Additional techniques from other researchers will be introduced where appropriate.

Mielke and Chen (1983) describe the qualitative and quantitative formative research conducted for the production of *3-2-1 Contact.* The first step was to conduct a needs assessment centered on two key questions: "What does the public know about science?" and "What does the public want to know about science?" The second phase was to determine the correct format for the program. The questions posed in this phase included: "What are the television viewing preferences of the target audience?;" and "What formal features, characters, and presentation formats affect comprehension and appeal of science content on television?" Phase three evaluated the show prototype programs using a "mosaic" approach "where multiple research designs were applied simultaneously." The evaluators were interested in segment and cast appeal, program comprehensibility, what classroom potential there was for the series, and how does the program compare with other programs the target audience could watch? Even during the final phase, series production, evaluation and audience feedback was incorporated into the programming.

Evaluation Techniques

Science knowledge, interest, and perceptions

- Photograph study- Subjects are presented 30 photographs with one sentence captions sorted into six groups. Subjects are asked if they would like to learn more about each picture (by reading) using a four item Likert scale. After each group is completed subjects are requested to select he one they would most like to learn about and the one they would least like to learn about. Data analyzed was average appeal of each photo and percent most and least desire for more information.
- Open-ended questions- What do you like about science? What topics in science are you interested in? The results of this technique were found to be not as important as the actual production techniques used for the topic selected. Open-ended questions were modified to a questionnaire of four groups of 20 questions. Subjects were asked which question in each group were they most interested in the answer to. After completing the exercise the subjects were asked to write their own questions on the back. This technique provided model questions that were hoped to help the subjects frame their own questions.
- Hands-on exercises- Subjects were given "experiments" to conduct and questions to answer regarding the results. Answers were analyzed for semantic and conceptual difficulties. Results were considered in subsequent program design.
- Content analyses of science essays- Subjects' essay responses to two questions; "Why I would (or would not) like to be a scientist" and "A typical day in the life of a scientist" were analyzed. Data was coded by branch of science, attitude toward science, and frequency of particular responses.

Television viewing preferences and habits

- Television interest survey- To determine character, format, and program genre types that were preferred by the target audience an eight-page survey was distributed nationwide. Results were reported in Mielke, Chen, Clarke, and Katz (1978).
- Ratings analyses- Nielsen data was analyzed to determine interest in program format and age.

- Television guide excerpts- Comparing plotted drama against magazine/variety show formats excerpts from television guides were used as a questionnaire to determine which shows the target audience preferred during particular time slots. Many respondents indicated that they use television guides to chose programs.
- Program comparisons- A pair of programs or quartet was viewed and subjects were forced to choose their favorite. When viewing the quartet a least favorite choice was also required.
- Triplet voting- This technique was designed to determine appeal of program segments and topics. Nine excerpts were viewed in three groups of three. Respondents picked their favorite and least favorite in each group and their favorite and least favorite overall. This technique also modeled program selection behavior from glimpses.
- Meta-research on documentary films- Films were classified as most effective to least effective. Further analyses attempted to isolate the characteristics that increased appeal and comprehension.
- Program analyser- This technique was modified from the button-pushing design by Stanton and Lazarsfeld. Audiences push certain buttons to indicate interest or appeal and other buttons to indicate boredom or disinterest. The new system was computer-based (data collection, analyses, and display) but still relied on button (wireless keypad pushing). After the program the hand held wireless unit was used to record subjects answers to multiple choice questions about the program viewed. The researchers found that programmability of sampling interval and decision rules holds much promise for future research.
- Segment voting- Best and least liked segments are chosen after the program via questionnaire. This information is used to cross check program analyser data.
- Small-group interviews- This technique is focus group interviewing. Groups of three or four viewers are asked predetermined questions by an interviewer. Qualitative

responses about why or how are collected in the interviews. Responses were recorded verbatim and later content analyzed for minority and majority viewpoints.

- Interactive cable television study- Using an interactive cable television system allows researchers to query viewers in their own homes. Five response buttons are placed in each home and viewers respond to questions and answers posed via television. Freeze-frames of show segments were presented and viewer reaction data was collected. Data on viewer demographics, recall of content, and viewer perceptions about the program was collected.
- Cast appeal studies- This research was conducted via program analyser, small group interviews, and in-depth interviews and focused on favorite performers and perceptions of the cast.
- Viewer visual attention to the television is an important variable that is often overlooked or assumed to be 100 percent (Ball, 1976).
- Telephone response systems can be used for audience surveys. Either individual questions can be posed and viewers dial a certain number to respond or viewers can be interviewed at home by phone (Goldman and LaRose, 1981).
- Reeves and Thorson (1986) use a hand-held potentiometer (dial) to record viewer reaction to programming. The amount of turn is indicative of a particular quality the researcher is testing.

Measures of Comprehension

In addition to techniques already described above: small-group interviews, program analyser, and questionnaires (pen and pencil tests) two other techniques were utilized.

- Freeze-frame comprehension testing- The program is stopped at a certain spot and the viewers are asked about their understanding up to that point, being cued by the freeze-frame on the screen. This technique ascertains the viewers grasp or

uncertainty of program material and gives insight to whether content presentation was effective.

- Fill-in-the-track comprehension testing- Viewers are told they will narrate a program segment on the second viewing. They are then presented a complete program segment. It is shown a second time without the audio track. Subjects are asked to fill in the narration of the segment. Responses are recorded in their entirety. Analysis indicates comprehension, areas of confusion, and development of program-related vocabulary.

Measures of program processing

- Secondary task reaction time- Viewers push a button when a message or signal broadcast along with the target program is received. The delay time between message broadcast and button push is a measure of he viewers depth of involvement with the program. Responses may interfere with program processing (Reeves and Thorson, 1986).
- Electroencephalogram (EEG)- Electrical activity in the brain is monitored to determine alpha frequency (relaxation indicator) and beta frequency (indicating greater information processing activity) (Walker, 1980). This is a very intrusive method where data collection requirements may interfere with the data collected, although Reeves and Thorson (1986) claim the interference is negligible.
- Eye movement- Eye movement gives clues as to what parts of an image are interesting to a viewer. Electrodes are placed to the right of the right eye and to the left of the left eye and above one eye and below the other. This setup enables researchers to detect eye polarity and determine right/left and up/down motion (Dominick and Fletcher, 1985, pp.91-92).
- Pupil response- Monitoring change of pupil size by camera is used to indicate levels of attention (Dominick and Fletcher, 1985, pp. 92-93).

- Heart rate- Changes in heart rate are an index of anxiety level or attention. Heart rate is measured by electrocardiogram (EKG) (Dominick and Fletcher, 1985, pp. 93-94).
- Respiration rate- A thermistor placed in the nostril will give an accurate measurement of respiration rate. Respiration increases and decreases with viewer attention levels (Dominick and Fletcher, 1985, p. 4).
- Photoplethysmography- Measurement of blood pulse volume can be made with a light and a photoreceptor that monitor blood as it is pumped into capillaries. Blood pulse volume is an index of attention level (Brown and Weinman cited in Dominick and Fletcher, 1985, pp. 94-95).

Measures of arousal

- Urine analysis- Adrenaline excretion, noradrenaline excretion, and urine volume increase in response to sexual arousal. Urinary specific gravity decreases in males and females while creatinine excretion decreases significantly only in females (Levi, 1969). Levi (1964) also showed that Adrenaline and noradrenalin are indicators of "pleasant and unpleasant states." "Bland natural scenery lowered output while humor and aggression in films increased output.
- Plasma analysis- Wadeson et al. (1963) reported that levels of plasma 17-hydroxycorticosteroid (17-OHCS) increased in response to viewer exposure to war films and decreased in response to "Disney" nature films.
- Galvanic skin response (GSR)- Raskin (1973) reported GSR as a measure of attention. Schwartz and Shapiro (1973) noted Ruckmick used GSR to find differences in viewers of comedy, romantic, and conflict film segments. Clariana (1990) found gender differences in attention to science programming by GSR. Resistance to learning, arousal, and attention are also measured by GSR (Fletcher cited in Dominick and Fletcher, 1985, pp. 95-96).

- Electromyography- Recording electrical potential of the frontalis muscle predicts postural tension or anxiety (Lippold cited in Dominick and Fletcher, 1985, p. 92).
- Photoplethysmography- Measurement of blood pulse rate can be made with a light and a photoreceptor that monitor blood as it is pumped into capillaries. Blood pulse rate is an index of "readiness to respond" or arousal (Brown and Weinman cited in Dominick and Fletcher, 1985, pp. 94-95).

Other techniques of analysis

- Content analysis- Content analysis is used to break programs into individual units for quantification. We can analyze "...behaviors, themes, character portrayals, production variables," etc. (Dominick and Fletcher, 1985. pp. 8-9).

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