about 1000 years, contributes a rise of a only fraction of a meter, much less than the site-to-site scatter among the various modeled sea level patterns.

The fingerprint technique of Clark *et al*. (*1*) is a major step forward in our understanding of the interactions among the various realms depicted in the figure and their impact on the climate, because the decrease in ice thickness and the large increase in freshwater flux into the oceans in areas of deep water formation may have affected the atmospheric and ocean circulation during the last deglaciation.

References

1. P. U. Clark, J. X. Mitrovica, G. A. Milne, M. E. Tamisiea, *Science* **295**, 2438 (2002).
2. ESA SP-1233 (1), *Reports for Mission Selection, The Four Candidate Earth Explorer Core Missions* (European Space Agency, ESTEC, Noordwijk, Netherlands, 1999).
3. J. Wahr, M. Molenaar, *J. Geophys. Res.* **103**, 30205 (1998).
4. M. K. Cheng, C. K. Shum, B. D Tapley, *J. Geophys. Res.* **102**, 22377 (1997).
5. R. Devoti *et al.*, *Geophys. Res. Lett.* **28**, 855 (2001).
6. J. X. Mitrovica, M. E. Tamisiea, J. L. Davis, G. A. Milne, *Nature* **409**, 1026 (2001).
7. ESA SP-1227, *The Earth Explorers* (European Space Agency, Paris, 1998).

PERSPECTIVES: PSYCHOLOGY

The Effects of Media Violence on Society

Craig A. Anderson and Brad J. Bushman

Concerns about the negative effects of prolonged exposure to violent television programming emerged shortly after broadcasting began in 1946. By 1972 sufficient empirical evidence had accumulated for the U.S. Surgeon General to comment that "…televised violence, indeed, does have an adverse effect on certain members of our society" (*1*). Other scientific bodies have come to similar conclusions. Six major professional societies in the United States—the American Psychological Association, the American Academy of Pediatrics, the American Academy of Child and Adolescent Psychiatry, the American Medical Association, the American Academy of Family Physicians, and the American Psychiatric Association—recently concluded that "the data point overwhelmingly to a causal connection between media violence and aggressive behavior in some children" (*2*). In a report on page 2468 of this issue, Johnson and colleagues (*3*) present important evidence showing that extensive TV viewing among adolescents and young adults is associated with subsequent aggressive acts.

Despite the consensus among experts, lay people do not seem to be getting the message from the popular press that media violence contributes to a more violent society. We recently demonstrated that even as the scientific evidence linking media violence to aggression has accumulated, news reports about the effects of media violence have shifted to weaker statements, implying that there is little evidence for such effects (*4*). This inaccurate reporting in the popular press may account for continuing controversy long after the debate should have been over, much as the cigarette smoking/cancer controversy persisted long after the scientific community knew that smoking causes cancer.

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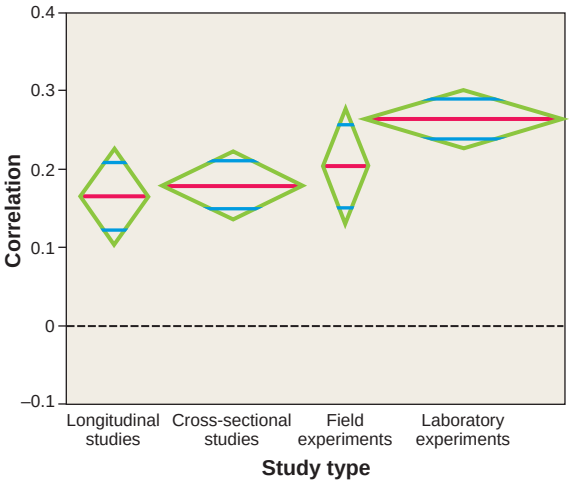
Aggression researchers have adopted a triangulation strategy to examine the effects of violence in the media. Specifically, divergent research methods have been applied in the belief that using several unique methodological approaches yields a clearer picture than would be possible with any single method. Results of a meta-analysis of all available studies investigating the hypothesis that exposure to media violence increases aggression are displayed in the figure (*4*). A positive link between media violence and aggression regardless of research method is clearly shown (see the figure). Experimental studies demonstrate a causal link. Laboratory experiments yield slightly larger effects than other studies, presumably because of greater control over irrelevant factors (see the figure). Field experiments demonstrate causal effects in naturalistic settings. Cross-sectional studies demonstrate a positive association between media violence and types of real-world aggression (for example, assault) that cannot be studied ethically in experimental settings. Longitudinal studies reveal long-term effects of early media violence exposure on later aggressive acts. These effects are not trivial in magnitude. For example, they are larger than the effects of calcium intake on bone mass or of lead exposure on IQ in children (*4*). Interestingly, recent work demonstrates similar-sized effects of violent video games on aggression (*5*).



Media violence and aggression. Effects of media violence on aggression for different types of studies. Diamond widths are proportional to the number of independent samples. There were 46 longitudinal samples involving 4975 participants, 86 cross-sectional samples involving 37,341 participants, 28 field experiment samples involving 1976 participants, and 124 laboratory experiment samples involving 7305 participants. Red lines indicate the mean effect sizes. Blue lines indicate a 95% confidence interval. Note that zero (dashed line, indicating no effect) is excluded from all confidence intervals.

The longitudinal study by Johnson and colleagues (*3*) is important for at least three reasons. It is the first published longitudinal study to link television exposure during adolescence and young adulthood to subsequent aggression, contradicting the common assumption that media violence affects only children. It therefore adds to extant research linking childhood TV habits to adult aggression and violence (*6*, *7*). Second, its relatively large sample size (707 families) and time span (17 years) allowed a meaningful test of television exposure on severe aggressive behaviors (such as assault and robbery). Third, by statistically controlling for key childhood factors known to affect aggression (including childhood neglect, family income, neighborhood violence, parental education, and psychiatric disorders) the investigators were able to rule out numerous alternative explanations.

One potential problem with the Johnson *et al*. study is the use of hours of TV viewing, rather than hours of viewing violent TV. This is somewhat problematic because the primary source of TV viewing effects on aggression is believed to be violent content. However, about

60% of TV programs contain violence, so the number of TV hours correlates closely with the number of violent TV hours (*8*). Thus, the use of TV viewing hours in this study probably underestimates the effects of TV violence.

Recent theory about human aggression suggests at least two approaches to reducing media-related aggression (*9*). One involves reducing exposure to violent media. Robinson and colleagues reported one such intervention that significantly reduced aggression among third and fourth graders over a 6-month period (*10*). The other approach involves changing children's attitudes toward media violence. Huesmann successfully used this approach to reduce aggression in first and third graders over a 2-year period (*11*). The study by Johnson and colleagues suggests that media violence affects a larger group of people than previously believed, and that interventions for adolescents might also be beneficial. Such approaches are needed because a heavy diet of media violence contributes to a societal violence rate that is unnecessarily obese.

References

1. Surgeon General's Scientific Advisory Committee on Television and Social Behavior, *Television and Growing Up: The Impact of Televised Violence* (U.S. Government Printing Office, Washington, DC, 1972).
2. *Joint Statement on the Impact of Entertainment Violence on Children: Congressional Public Health Summit* (26 July 2000); www.aap.org/advocacy/releases/jstmteuc.htm
3. J. G. Johnson *et al.*, *Science* **295**, 2468 (2002).
4. B. J. Bushman, C. A. Anderson, *Am. Psychol.* **56**, 477 (2001); www.psychology.iastate.edu/faculty/caa/abstracts/2000-2004/01BA.ap.html.
5. C. A. Anderson, B. J. Bushman, *Psychol. Sci.* **12**, 353 (2001); www.psychology.iastate.edu/faculty/caa/abstracts/2000-2004/01AB.html.
6. L. R. Huesmann, *J. Soc. Issues* **42**, 125 (1986).
7. _____, J. Moise-Titus, C. Podolski, L. D. Eron, *Dev. Psychol.*, in press.
8. National Television Violence Study (Center for Communication and Social Policy, University of California, Santa Barbara, CA, 1998), vol. 3.
9. C. A. Anderson, B. J. Bushman, *Annu. Rev. Psychol.* **53**, 27 (2002); http://psych.annualreviews.org/cgi/content/full/53/1/27?ijkey=wZXD4ZASNg4bU&keytype=ref&siteid=arjournals.
10. T. N. Robinson, M. L. Wilde, L. C. Navracruz, K. F. Haydel, A. Varady, *Arch. Pediatr. Adolesc. Med.* **155**, 17 (2001).
11. L. R. Huesmann, *J. Pers. Soc. Psychol.* **44**, 899 (1983).

Links to other video game violence articles:

1. C. A. Anderson, K. Dill, *J. Pers. Soc. Psychol.* **78**, 772 (2000); www.apa.org/journals/psp/psp784772.html.
2. Written version of testimony given by C. A. Anderson on 21 March 2000 at a hearing of the U.S. Senate Commerce Committee; www.psychology.iastate.edu/faculty/caa/abstracts/2000-2004/00Senate.html.

Additional Web sites related to violence:

1. www.mediafamily.org/index.shtml2
2. www.colorado.edu/cspv/
3. www.lionlamb.org/
4. http://curry.edschool.Virginia.EDU/curry/centers/youthvio/
5. www.youngmedia.org.au/
6. www.childrennow.org/
7. www.actagainstviolence.com/medviolence.html
8. www.killology.com/
9. www.cme.org/

PERSPECTIVES: EARTH SCIENCES

The Study of Superfloods

Victor R. Baker

Large, high-energy floods are both rare and dangerous. Evidence of their impacts in the geologic record is often subtle, but the greatest obstacles to advancing the knowledge of superfloods have come from misapplied scientific logic. Particularly troublesome are flawed notions of hypothesis testing, verification, and the principle of simplicity. Contrary to conventional views of scientific methodology, there has never been a general theory of superfloods that could be tested, confirmed, or falsified by observation and experiment. Instead, as in much of geology, observation has preceded theory, and understanding has emerged as previously unrecognized phenomena were discovered.

Methodological problems with the study of superfloods began early, at the inception of geology as a science. The influential 19th-century geologist Sir Charles Lyell passionately advocated a regulative principle for validating the inferences that geologists make about the past. Presuming that geologists reason by induction, Lyell thought that such a principle was necessary if geological inferences about past causative processes were to achieve the same kind of certainty as those made in experimental sciences like chemistry and physics. It was Lyell's most capable critic, the Cambridge polymath William Whewell, who in 1832 named this principle "uniformitarianism." Epistemological uniformitarianism holds that scientifically reliable inferences about the past must be confined to invoking only the slow-acting, low-magnitude processes currently in evidence to human observers.

Deposits of the cataclysmic Missoula floods. The largest boulder has a long axis of 18 m. It was eroded from scabland basalt outcrops and was transported about 10 km to the proximal portion of the immense Ephrata Fan, which covers about 1000 km^2 of the Quincy Basin in east-central Washington state.

This principle was applied blindly by Lyell's intellectual descendents well into the 20th century. In the 1920s, Bretz's documentation (*1*) of the spectacular effects of late-glacial flooding in the Channeled Scabland region in Washington state met with immense criticism from the scientific community. Not until the 1960s was it generally accepted that this flooding was caused by catastrophic failure of the immense ice-dammed Glacial Lake Missoula along the southern margin of the Cordilleran Ice Sheet, which covered the northwestern mountains of North America about 20,000 years ago.

Over the past 40 years, evidence has accumulated for catastrophic failures of ice-dammed lakes, overflows of lakes that had formed along ice margins, and subglacial outburst flooding in the many river systems associated with the immense continental ice sheets of the last ice age. The southern margin of the Laurentide Ice Sheet that covered northeastern and north-central North America was episodically drained by outburst floods (*2*). These freshwater discharges greatly influenced ocean circulation and climate at the end of the last ice age (*3*).

Even more extensive evidence of superflooding has been documented in Asia, recorded best in the Altai Mountains of the upper Ob river basin (*5*). Spectacular superflood features are also found in the upper Yenesei river basin in Tuva. A system of huge spillways connected the late glacial lakes that inundated large parts of the Ob and Yenesei basins. The huge meltwater influxes greatly extended the areas and volumes of paleolakes in basins now occupied by the much smaller Caspian and Aral Seas and drained into the Black and Mediterranean Seas (*4*). The mountains forming the border regions of modern Russia, China, Mongolia, and the central Asian republics also contain extensive evidence of ice-

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