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Neural Network Simulations Support Heuristic Processing Model of Cultivation Effects

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Many studies have shown that heavy TV viewers make social reality judgments more in line with televised reality. Shrum's (2001) heuristic model of cultivation effects predicted and found that biases in first-order cultivation judgments resemble heuristic processing. Systematic processing eliminated the effect. This study presents a series of computational simulations to examine whether a simple feed-forward neural network model exhibits learning behavior in accordance with Shrum's model. The data from the model are tested in contrast to data from human participants. Results closely fit human data. Simulations show that increased television exposure increases construct accessibility; television exemplars are not discounted when exhibiting the cultivation effect; and systematic processing reduces or eliminates the cultivation effect.

The television is a prominent fixture of the American living room, and social scientists have pondered the extent of the medium's effects for decades. One field of empirical work has centered on the ways in which heavy television viewing affects social reality perception. Known as cultivation analysis, this work is built around the premise that television viewing alters perceptions of social reality (e.g., Gerbner, Gross, Morgan, & Signorielli, 1994). The basic assertion is that heavy television viewers' reality will be shaped by television, and heavy viewers will make social judgments that are more in line with the televised reality than actual reality. In a typical cultivation study, heavy TV viewers will give answers to real-world questions that are distorted toward the "television answer." For example, a typical question asks participants to estimate what percentage of the American workforce is involved in law enforcement. Heavy viewership often predicts an increased response that is far above the actual percentage. In a meta-analysis of cultivation studies, Shanahan and Morgan (1999) found that, most commonly, such studies

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found a *cultivation effect* of 12%. That is, heavy television viewers tended to answer questions about social reality (e.g., rate of violence, occupations, prevalence of marital dissatisfaction) as 12 percentage points more prevalent than light television viewers. These higher estimates more closely reflect the frequencies portrayed on television than natural frequencies. The authors note that although this is a small effect, it can have a powerful impact on society over time.

Almost as soon as television viewing was shown to be related to social reality perception, researchers began to investigate how the cultivation effect occurred in the human mind (e.g., Hawkins, Pingree, & Adler, 1987). Such an approach is beneficial because understanding the mental processes underlying the effect will result in theories that are better able to predict conditions under which any given individual might avoid such biased judgments. Furthermore, understanding how cultivation occurs in the mind can help us understand why the cultivation effect is not invariant across individuals and situations. Indeed, television distorts social reality for some individuals far less than for others. How those individuals encode, store, and retrieve information viewed on television will likely help us understand why only some are affected.

Research into the cognitive processing of television has indeed suggested possible mechanisms that are likely responsible for the cultivation effect. One scholar predicted and found that the kinds of things that happen on television simply come to mind more easily for heavy television viewers (Shrum, 2001). This finding suggests that television-related ideas, or constructs, are more accessible for heavy television viewers when they think of social situations that happen both in the real world and on television. Given the frequency of television viewing, it is of interest to understand how television memories color judgments about the actual non-mediated world. Shrum (2001) found that viewers appear to fail to properly ignore—or discount—memories from television when asked to estimate the frequency of social events frequently portrayed on television. The current article outlines relevant research to the cultivation effect, introduces computational modeling techniques that might help us understand the relationship between television viewing and social reality distortion, and reports results of an original neural network simulation of social reality perception.

Computational modeling is growing in popularity in communication research (e.g., Bradley, 2007; Palazzolo, Serb, She, Su, & Contractor, 2006; Yang, Roskos-Ewoldsen, & Roskos-Ewoldsen, 2003), although this process has been widely used in the sciences for hundreds of years (e.g., Weisberg, 2007). Computational modeling allows researchers to explicitly test theorized relationships by simulating the phenomena of interest. These simulations often involve formal modeling using a series of mathematical equations. In the case of behavioral data, causal links often must be inferred. However, computational models can be constructed exactly as the underlying theory predicts, and the causal direction can be controlled. If the simulated results closely correspond with actual human data, additional evidence is gained that attests to the validity of the theory. Furthermore, the model's behavior can be dissected and taken apart to examine which parts of the model allow it to perform as humans do.

THEORETICAL BACKGROUND

The Cognitive Approach

At its roots, cultivation theory is a macro-level society-based theory. Gerbner and colleagues worried that television was cultivating a distorted world view within society. Others have approached cultivation theory from the level of the individual viewer. A recent line of work by Shrum and colleagues has attempted to provide a more cognitive account of the cultivation effect and conditions that modify the effect (Shrum, 1995, 1996, 2001; Shrum & Bischak, 2001). This suggests that television-based memories may exhibit a stronger effect when participants have less personal experience with the topic. In the course of investigating the cultivation effect, a pair of refinements to the theory have been discovered: resonance and mainstreaming. Resonance involves situations where people's personal lives closely parallel the television world (for a discussion, see Shanahan & Morgan, 1999). In these cases, resonance predicts that television will have an especially pronounced effect since it resonates with real-world experiences. Mainstreaming predicts somewhat the opposite case. In those cases, people whose life experiences are altogether unlike television are thought to be more strongly pulled into television's mainstream (see, Shanahan & Morgan, 1999).

Shrum and Bischak (2001) found evidence that did indeed support a possible moderating role for personal experience. They found that television viewing level predicted estimates of societal crime risk and crime risk within participants' own city (i.e., New York City) but not within their individual neighborhood. Furthermore, those authors found empirical support for the notion of resonance. The combination of television and personal experience more strongly affected heavy viewers, as the notion of resonance predicts.

In addition to studying these refinements of cultivation theory, a line of research has investigated how much cognitive effort goes into to estimating social reality situations. When making these social reality estimates, the possibility exists that people simply make snap judgments or use some sort of a mental shortcut. Within the social psychology literature, this kind of quick thinking has been dubbed heuristic processing. Shrum (1997; 1999; 2001; Shrum, Wyer, & O'Guinn, 1998) has examined cultivation theory from this heuristic processing perspective. Shrum's *heuristic processing model of cultivation effects* provides compelling evidence that the cultivation effect seen in surveys arises from heuristic processing. In an experimental design, participants who were instructed to provide the first answer that came to mind (i.e., heuristic processing) showed the same pattern of results as controls given instructions typical of the cultivation paradigm, whereas participants encouraged to make a careful, reasoned, good decision (i.e., process systematically) showed an opposite pattern. Heavy viewers in both the control and heuristic groups gave significantly higher estimates of crime than low viewers in their respective conditions. Among the systematic group, however, heavy viewers actually gave lower estimates of crime rates than light viewers. Although the data described here represent estimates of crime, a similar pattern emerged for estimates of occupations, affluence, and to a lesser extent marital satisfaction. To support the model, Shrum (2001) examines work by Kahneman and Tversky that has become known in social psychology as *heuristics and biases* (e.g., Tversky & Kahneman, 1990). Shrum (2001) examines the possible influence of several heuristics, but primary attention is paid to the *availability heuristic*, which posits that information is judged to be more prevalent if it is more available to recall (Tversky & Kahneman, 1973).

Especially informative from the Shrum (2001) findings is the fact that controls performed in exactly the same manner as the heuristic group and markedly different from the systematic group. This suggests that heuristic processing is the default method of making such judgments. Accordingly, unless people are specifically instructed to engage in a mode of processing that differs from their default strategy or they have an independent motivation to engage in such processing, people in their daily lives appear to make these judgments in a way that produces a replicable cultivation effect.

The idea of expedient processing being biased is at odds with the usual nonscientific implications of fast processing. For example, if you place your hand on a hot stovetop, a protective reflexive action will begin to withdraw the hand before the conscious perception of heat occurs. Heuristic processing presumably developed because expediency benefits us most of the time. However, in the social realm, one can easily imagine scenarios wherein this benefit of expediency is instead detrimental. In social situations in which carefully reasoned, systematic processing is to be desired, heuristic processing may prevent optimal evaluation of the situation. The overall cultivation paradigm appears to have exposed once such case, wherein there are parallel environments in the real and mediated worlds. Although many facets of the worlds coincide, the frequency of certain events (e.g., violent crime) differs markedly. When making the decision whether to walk through a certain park at night, for example, it appears less than ideal to allow media events to unduly influence the decision.

Shrum and colleagues have added a valuable contribution to the social construction of reality literature, and the research program offers a better understanding of how the cultivation effect occurs. The studies also offer suggestions for media literacy campaigns. Yet after reading the cultivation literature, the social scientist is left with the impression that unless a heavy television viewer explicitly avoids heuristic processing for every social judgment, that person is relatively more likely to view society through television's lens. Taken without qualification, this is a rather strong claim, and it is important to note that many of the studies cited above focus on a particular class of judgments, which have been dubbed first-order cultivation judgments (Potter, 1991; Shrum, 2004a). These first-order cultivation judgments typically involve questions about set-size or probability, such as "What do you think the chances are that an unaccompanied woman would be the victim of a violent crime late at night in a New York City subway?" Conversely, second-order cultivation judgments typically involve judgments about attitudes and beliefs, such as agreement with the statement, "The world is a more dangerous place today." The nature and extent to which heavy viewing affects second-order judgments remains an empirical question. Early evidence suggests that these types of judgments are not so prone to heuristic bias (L. J. Shrum, personal communication, February 23, 2004). Nonetheless, theorists are left without a specific model of how cultivation occurs in the brain, or more specifically the processes through which the television world is made more available and salient. That process is the primary focus of this study.

When Cultivation Occurs

Whether experienced in person or through the media, information cannot be instantaneously stored. As anyone who has ever taken an exam can attest, acquisition of knowledge is not immediate. Instead of facts and events being quickly stored into long-term memory, it appears that this process is an incomplete one, wherein some parts of the world receive more attention and are more likely to be stored. At any given moment, an incomprehensibly large amount of information is available to perceptual intake (e.g., the way your pant leg feels against your left knee), but only a small amount of this information is attended to, and even less is stored into long-term memory. For example, we can often remember the gist of a television advertisement we have seen once, but we might not even recall the brand being advertised or anything specific, such as the wardrobe of each actor and actress. Thus, only a subset of information is stored, and usually only an even smaller subset can be retrieved for future decision making.

This raises the question: Does cultivation occur at the time information is stored in memory, or does it occur when the response to a cultivation question is asked? In many respects, this is a chicken-and-egg question. The answer likely depends on one's perspective. In order to exhibit any relationship between television viewing and social reality, something about the televised reality must be stored. Since viewers can readily supply television memories (e.g., Shapiro, 1991), we know this information is stored. Thus it is possible that cultivation occurs at the time of memory storage. However, if that were the case, experimental manipulations at the time judgments were made would have little effect on first-order cultivation estimates. This is not the case. Numerous studies have investigated the effect of manipulations at the time of judgment, and a consistent picture has emerged.

The findings that processing strategy moderates the cultivation effect offer empirical support for the notion that cultivation occurs at retrieval (Shrum, 2001). Indeed, Shrum et al. (1998) found that merely calling a person's attention to their TV viewing habits eliminated the cultivation effect. In a related study, Busselle (2001) found that participants who were asked to think of an exemplar from a category (e.g., "someone shot with a gun") before making social judgments failed to exhibit a cultivation effect; however, participants who made the judgments before being asked for an exemplar demonstrated a typical cultivation effect. Further support for this notion comes from the finding that heavy viewers showed faster response latencies when providing judgments to these types of questions, indicating better availability of the answers (Shrum & O'Guinn, 1993).

Memory Source

There is evidence that the source of a memory can play a role in cultivation tasks. During a task where participants were asked to recall events typical of cultivation questions, Shapiro (1991) found that once participants started drawing memories from a particular source, that source was a significant predictor of the next-to-be-recalled memory's source. That is, once a participant started thinking of TV memories, more such memories came to mind. Because the real world and the mediated world share many common facets, it may be possible for the two realities to somewhat blend together in memory (Shapiro & Lang, 1991). Accordingly, Shrum (2001) posits that source discounting may be responsible for the cultivation effect and its disappearance during effortful processing.

As the average viewer watches TV over the years, much of this information is being stored as if it were real because the brain did not evolve to distinguish reality from artificial, mediated environments (for a complete discussion, see Reeves & Nass, 1996). With some probabilistic distribution, the source of the message/event is being stored in memory as well. Most of the time we can easily recall where we learned something. Other times, however, we cannot recall the source no matter how hard we try. It follows that when watching television, some of the time the memories being stored are insufficiently associated with a fictitious source (Shrum, 2001). A memory that is only weakly—if at all—associated with a fictitious source is therefore more likely to be blended into perceptions of actual reality. As with most cognitive variables, the likelihood with which this is stored is likely to be an individual difference variable. Although agreeing with Shapiro and Lang (1991) that source confusion is more likely to happen with heavy viewers—all other things being equal—recent research suggests that some individuals are less likely to make this error (Bradley & Payne, 2004). Those individuals good at storing fine detail of televised information should most readily have source information available when they go to make first-order cultivation judgments. Not surprisingly, then, those people who made more source confusions demonstrated a stronger cultivation effect (Mares, 1996). Furthermore, viewers with the best memory for information from past television programs made significantly less biased first-order judgments (Bradley & Payne, 2004). Thus, a model of human memory that hopes to account for the cultivation effect must also account for source memory findings, too, because memory sources can be used to discount media memories.

Modeling Memory

Recent formal models of memory take into account the general notion of a spreading activation network, a concept with which early work was conceptualized (Shapiro, 1991; Shapiro & Lang, 1991). Within these models—often patterned as neural networks—memories are stored as varying connection strengths between processing units in the model (e.g., Rumelhart, 2000). Within this approach, perceptual input is encoded as unique patterns input to the network (e.g., a visual memory could be encoded as a pattern of activation across an array of photoreceptors). These patterns are *learned* by varying connection strengths between neural units, and these strengths increase with repeated exposure. This approach allows knowledge to be stored as patterns of connectivity between neural units, much as neuroscientists now believe the human brain functions. Thus, each memory is distributed across an array of neurons, and no single neuron contains any single memory. That is, the system's memory is the collection of neurons and the connections between them. A distributed form of memory allows a broad collection of units to store information and avoids the problems of a so-called grandmother cell, or one particular cell (or even a few cells) in your brain that represents your grandmother. If a grandmother cell were to die because of a small trauma to the head, then the person would instantly forget their grandmother and nothing else. This seems quite unlike human experience.

The neural network—also sometimes called connectionism (Rumelhart, 2000) or Parallel Distributed Processing (Rumelhart & McClelland, 1986)—approach is especially attractive as a model of cognition because the very nature of neural networks leads to properties observed in human cognition and behavior. First, neural networks can generalize. That is, given an input pattern that the model has never before seen, it can detect the statistical similarity between that pattern and every pattern it has even seen before, and it can use that knowledge to generalize to the novel situation.

A model without this ability would be utterly lost every time it encountered a new situation. Take for example the television viewer watching an all-new crime drama. Despite the fact that the viewer has never seen *that* drama before, he or she can nonetheless make fairly accurate predictions about what will come next based upon experience with many previous similar shows. Indeed, viewers are quite capable of judging what would or would not typically come next (Shapiro & Chock, 2003; Shapiro & Fox, 2002). Secondly, the models show graceful degradation. That is, when some of the nodes become inactive (simulating neuron loss that happens in real brains), the model drops from perfect performance, but its performance is still fairly accurate given that the knowledge was distributed across many connections. With a localist model of memories stored in separate traces (i.e., one trace per one memory), you have the aforementioned problem of forgetting your grandmother should the grandmother cell perish. A distributed model allows you to forget some things about your grandmother following a head trauma (e.g., her birthday or address) but still remember her in general. Finally, the networks can complete previously learned patterns given just a part of that pattern some time after learning. Thus, neural networks can *recognize* familiar things amid noise.

Consider a simple neural network with the following neurons (a) living thing, (b) animal, (c) bird, (d) robin, (e) canary, (f) can fly, (g) red, (h) yellow, (i) blue, (j) wings, (k) feathers, (l) scales, (m) gills (adapted from McClelland & Rogers, 2003). This network might "live" in an area with two types of birds, robins (a-b-c-d-f-g-j-k) and canaries (a-b-c-e-f-h-j-k). Based upon the similarities and differences within this environment, the network can learn what similarities birds share and the differences among them. Thus, when this network encounters a blue jay for the first time (a-b-i-j-k), it can infer that it is a bird (c) from the statistical similarity to other birds it has seen. However, when the network encounters a sunfish for the first time (a-b-h-l-m), it is unlikely to mistake the similar yellow colored object as a bird since birds vary in color. Without having been explicitly taught to do so, the network learns to generalize based upon statistical similarities in the world.

The generalizability of such networks suggests that such a model might perform much as humans perform when exhibiting the cultivation effect. At the time of retrieval, for example, the study participant attempts to think of how often a certain crime occurs. In this case, we will use the example of what percentage of crimes are committed by strangers. At this point, the cognitive agent attempts to *retrieve* memories of crime and perpetrators. For most people, this is a novel thought. Most people have not tried to answer that specific question before. In a neural network, *answering* this question is implemented by passing that pattern of information through the network and computing the resultant output. There is virtually no context to this task, so the retrieval pattern is unlikely to closely match any previously encoded and stored pattern. That is, like the human, the model has never had this exact thought before. However, the retrieval pattern is likely to *vaguely* match most stored patterns that deal with crime. Since real crimes tend to bear some similarities to one another, there should be some statistical similarity in the patterns dealing with the concept of crime, or the model (or person) would never be able to generalize prior learning to any novel situation. Thus, unfamiliar patterns presented to the network would result in some weak memory of that type of crime overall. For heavy TV viewers, there should be more patterns associated with TV memories, thus the general activation of "crime" should result in an output that is more likely to be biased in the TV direction. However, when processing effort increases, when specific exemplars are input as patterns, or when source memory is especially available, the output patterns should converge over time toward a more specific representation of a particular crime. Such a model would then be less likely to provide a vague response and more likely to provide a concrete response. In the terminology of Shrum's model, the neural network should not be using heuristic processing and instead should be carefully pondering the question.

Neural Network Simulation

Hawkins and colleagues (Hawkins et al., 1987) failed to find support for a learning model of cultivation. Yet it remains possible that cultivation is a product of learning (at some level it must be), and Shapiro (1991) and Shrum (2001) have offered both theoretical models and empirical data that accord with a connectionist explanation of the cultivation effect. Thus, to test whether a connectionist model can account for the cultivation effect, a rudimentary feed-forward neural network was constructed (see Figure 1). In a feed-forward network such as this, the world provides information patterns as input, and the model produces its expected output. During early learning, the model makes erroneous predictions, and this error is used to update its connections to reduce error in the future. Thus, as the model "watches" a television scenario, it generates a hypothesis about what will happen. When the outcome does not match its expectations, the model updates its memory. That is how learning occurs. For a formal description of the back propagation learning algorithm used in learning, see Rumelhart, Hinton, and Williams (1986).

For an analogy, consider a naïve television viewer. The first time she watched *Grey's Anatomy*, for example, if you stopped the episode and asked her what happened next, she would likely make an incorrect prediction. The television world does *not* mimic the real world, or television would be very mundane (Shapiro & Chock, 2003; Zillmann, 1991). In this example, given some event, real doctors likely write out a lengthy report. That rarely happens on television. Instead, the TV doctors likely have a romantic encounter in an empty examining room or something similarly exciting to see. Over time, our naïve viewers (and our neural network simulations) would come to learn

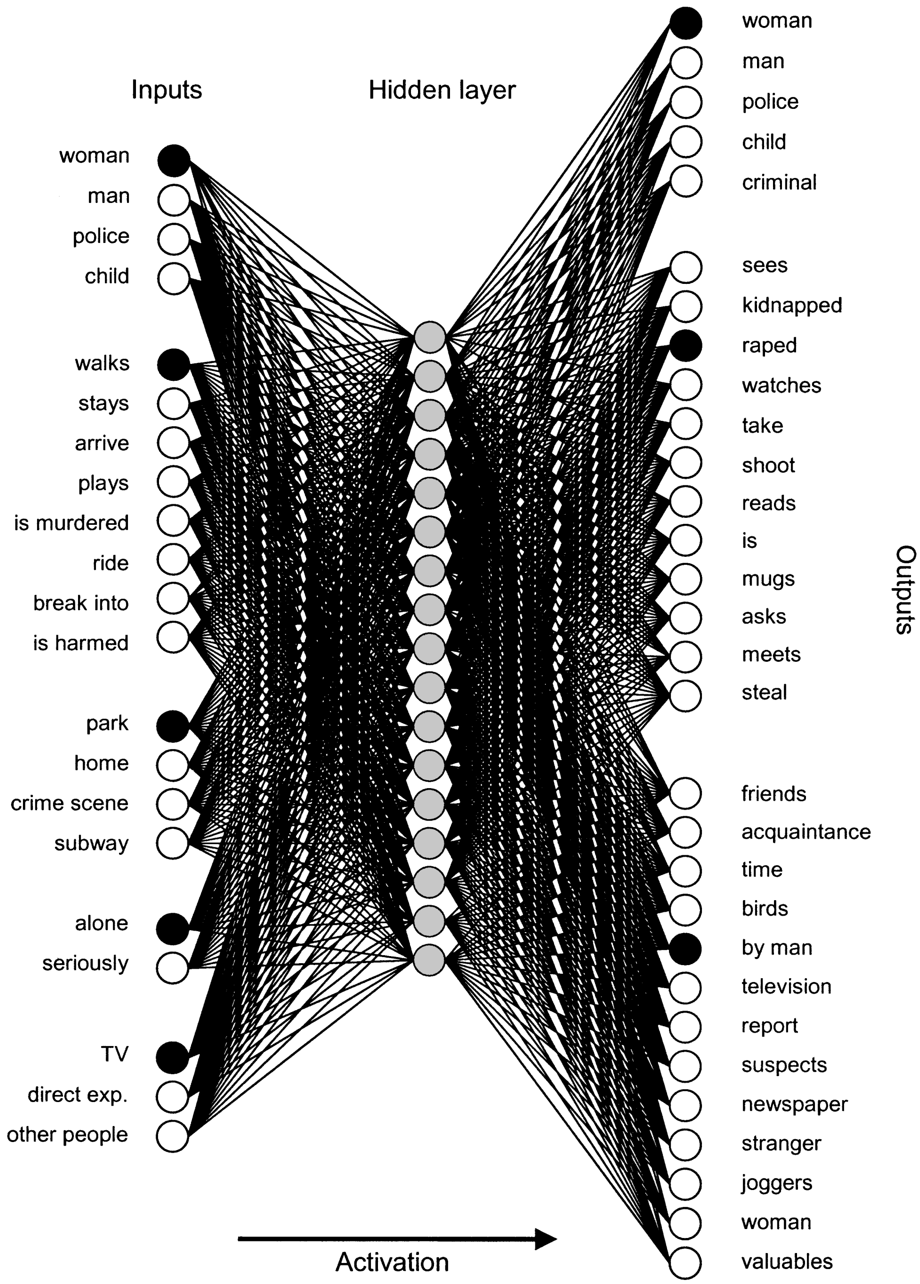

FIGURE 1 A three-layer feed-forward connectionist model representing memories from three possible sources: direct experience, other people, and television. Inputs are divided roughly into: subject, verb, object, modifier, and source. Outputs approximately equate to subject, verb, and object. Here an over-represented TV scenario of a woman walking alone in the park and being raped is depicted.

and expect the TV answer. Thus, in both viewer and model, the mental representation of television would be modified to better represent the TV world. No matter how contrived, this example should have some degree of reality to the reader. It is exactly those mental processes that you are using to say "yes, real doctors are less romantic" that the model in Figure 1 attempts to capture.

Shrum's (2001, 2004b) heuristic processing model includes five specific propositions. This study attempts to test three of the five propositions.

Proposition 1: Television viewing increases construct accessibility. In terms of testing the model, this serves as somewhat of an existence proof that a connectionist model can produce the cultivation effect. If frequently presented television constructs are more accessible in models trained with more television scenarios, it will provide evidence in support of Proposition 1.

Proposition 2: Accessibility mediates the cultivation effect. This proposition cannot be tested in a simple feed-forward neural network. In a simple model, such as Figure 1, all activation occurs in one time step, which does not vary between networks. Thus, response latency cannot be controlled in a model simulation as it was with actual participants (e.g., Shrum, 1996).

Proposition 3: Television exemplars are not discounted. Shrum (2001) argued that television exemplars retrieved during the judgment process were used in making the judgments. Experimental evidence indeed suggested that when not instructed to do so, participants fail to discount television exemplars by source (Shrum et al., 1998). The connectionist model here is predicted to do the same. When no source cues are provided at time of judgment, the model should be biased by television memories.

Proposition 4: Systematic processing reduces or eliminates the cultivation effect. Experimental data has shown that when people try to make good decisions, they are able to do so (Shrum, 2001). Given that television memories are less influential when attempting to make good decisions, this suggests that participants are able to discount source memories when they attempt to do so.

Proposition 5: Ability to process information moderates the cultivation effect (Shrum, 2004b). The current study does not address this proposition because in order to implement ability to process in a neural network, several additional assumptions would be required that are beyond the scope of this study. Specifically, in order to test this proposition, one would need to incorporate a theory of what it means to be able to process and how that would be implemented in a neural network. Many methods exist for degrading processing in a neural network (e.g., add Gaussian noise to the input; cause some of the connections to be improperly computed), and it is not immediately clear which of these would correspond to ability to process as theorized by Shrum (2004b).

METHOD

The model was trained on several scenarios and the resulting outcome. That is, the model was trained on some scenarios and the disposition of those scenarios. The source of these memories came from direct experience, other people, and television (see Shapiro, 1991). For experiences that came from real life, resulting outcomes never featured crime. The TV version always featured crime. Admittedly, this is an exaggeration of TV's distorted picture of the world, but the principles would hold for a slightly less exaggerated ratio. So, for example, the model was taught that it had a personal direct memory that "a woman walks in the park" and "the woman watches birds." Conversely, its TV-based remembered outcome for this scenario was "the woman is mugged by a man." All 33 of the training exemplars can be seen in the Appendix. There is no claim made here that the scenarios in the appendix are an accurate sampling of any person's life experience. Instead, these scenarios draw on the types of questions that have been asked of actual human participants (e.g., Hawkins et al., 1987; Shapiro, 1991; Shrum, 2001), and they are paired with typical TV outcomes and typical real-world outcomes.

The empirical test of the model was how it performed (i.e., generalized) when given the scenario "a woman walks in the park" without any source information—a pattern it had never encountered before. This is an important distinction to make. The model was trained by observing events that happen in the world (real and mediated) and learning the outcome of those events. Then, the model was tested using input patterns that it had never seen during training. Specifically, as with human participants, the model was given a scenario without any cues to source memory. This is crucial to the cultivation literature, as it has been shown that any priming of TV viewing erases the effect (Shrum et al., 1998). Here, the network must use its overall knowledge of the world to generalize to a novel scenario. If the model were simply tested on the same patterns it had learned, it would be trivial; and more importantly, the model would show *no* cultivation effect, for it learns real-world events just as well as it learns TV events.

Model Implementation

The model shown in Figure 1 was constructed as a simple feed-forward neural network with a back-propagation learning algorithm. In back-propagation, the model learns by being presented with an input and an output (e.g., it is presented with a television scenario and the outcome of that scenario). The model then compares the real-world output with its expected output. The difference—or error—in the model's expectation is gradually used to update the connection weights. This updating—or learning—is gradual to prevent the model from becoming completely dependent upon the immediate past. That is, if learning is complete and immediate, the model will be unable to generalize over a series of events but will instead think that whatever just happened will always happen again.

Separate models were simulated as both "heavy viewers" and "light viewers." For the light viewer, the model was shown each memory (direct experience, other people, TV) twice during each pass through the data (i.e., 2:2:2). The order of presentation was randomized. For the heavy viewer, one of the exemplars from direct experience and other people was replaced with the TV version (i.e., 1:1:4). Simple neural networks are trained by presenting the entire set of stimuli many times. Each presentation of the set of stimuli is called an epoch.

Overall, each model was given 66 inputs during each epoch of training whether it was a heavy viewer or a light viewer. It was important not to increase the number of total inputs per epoch (e.g., go from 66 to 88), as the model would better learn each of the patterns and show less generalization (see for example, the list length effect in psychology, e.g., Murnane & Shiffrin, 1991). That is, the heavy viewer model would simply be a better-trained model if it were simply presented with more stimuli. The model was trained on the data for 1,500 epochs. A sigmoid activation function (i.e., a non-linear activation function) was used, resulting in outputs from 0 to 1.

The model was simulated using MATLAB Version 7.1 software (MathWorks, Natick, MA), and inputs ranged from 0.1 to 0.9. When a concept was present, it was entered as 0.9, else it was 0.1. This local method of input prevents artificial correlations between scenarios created in the input and allows each concept to be input as orthogonal to all others. In the hidden layer (i.e., a layer that neither receives direct input from nor provides direct output to the world), the model determines similarities needed to represent the trained outcomes. That is, representations are distributed in the hidden layer.

During model testing, the model's performance was assessed by measuring output on the crime-related nodes given the novel input pattern. Thus, during testing, learning was disabled, and the model was fed patterns such as "a child plays in the park alone" without any source cuing. The model's response was the average activation over the crime-related output units (i.e., kidnapped, mugged, and raped). This procedure was constructed to underestimate any possible cultivation effect, as the TV training input for each of the outcomes featured just one of the three crimes. This averaging procedure was used for scenarios one through four in the Appendix. For "police arrive at a crime scene," model response was the activation of the verb node "shoot" (as opposed to "take" for take report). Finally, for the two questions regarding serious harm and murder, response was activation of the node "stranger" as opposed to "criminal." Because the model was trained as 0.9 when an outcome happened and 0.1 when it did not happen, greater activation translates to a more likely guess toward that outcome.

To test Proposition 1, the model was given the same input pattern (i.e., the word nodes were the same as in the Appendix) with the three source inputs all set to 0.1. Thus, the model encountered a pattern it had never seen, was provided no source cues, and had to generalize from experience.

To test Proposition 3, the models' performance was compared when there were no source cues, when there were TV source cues, and when there were random source cues. Unlike a human participant, it is difficult to instruct a neural network *not* to think of something. The test of Proposition 1 covered the case where the simulated subjects were given no source information at testing. This illustrates the models' performance when source is ignored. And unlike human participants, the model allows us to say for certainty that memory source is being ignored (i.e., because we can directly control the inputs). Yet this does not speak directly to performance when discounting TV versus not discounting TV. Shrum et al. (1998) were able to prime human participants with their TV viewing, and in turn it appeared that humans discounted TV memories, and the cultivation effect was moderated. Such a prime should increase the cultivation effect here, as the prime will cause the models to think about TV. Thus, this proposition is tested in two steps. First, control performance should mirror that of a small TV prime (i.e., both should demonstrate the cultivation effect). Secondly, small random source primes should lessen the cultivation effect. That is, this proposition argues that the cultivation effect depends on ignoring TV primes. Thus, when a random source is primed on each unique trial, the cultivation effect should be lessened *if* cultivation effects depend upon a failure to discount sources.

To test Proposition 4, the model also was given the same input pattern, but because Shrum (2001) had participants attempt a good decision, the model had both direct experience and memories told to it by other people set to "on" and TV set to "off." This accords with self-reports that people discount TV when trying to make a good decision and the fact that even priming TV eliminates the cultivation effect (Shrum et al., 1998). Furthermore, Shapiro (1991) found that memories that came from other people were good predictors of social reality estimates. Because both source inputs were simultaneously turned on during testing, this too, will cause the network to try to generalize, as it had never seen that input before.

RESULTS

The first proposition states that television viewing will increase construct accessibility. The study tests whether a neural network would demonstrate this effect. The model in Figure 1 did demonstrate a cultivation effect, showing greater activation on the output nodes corresponding to the "TV answer" than to the real world answer, $F(1, 78) = 4.78$, $p = .03$, $\text{eta}^2 = .06$. Neural networks that received more of their lifetime learning from television sources, showed greater activation of units representing TV constructs ($M = .31$, $SD = .08$) than networks with fewer television examples ($M = .27$, $SD = .09$).

TABLE 1 Model Simulation Results as a Function of TV Viewing Level and Instruction Type

	Instructions			
	None		Systematic	
Scenario	Light TV	Heavy TV	Light TV	Heavy TV
Woman walks park alone	0.286	0.363	0.095	0.031
Child plays park alone	0.150	0.276	0.079	0.081
Woman rides subway	0.162	0.635	0.109	0.025
Woman at home alone	0.320	0.442	0.107	0.008
Police arrive crime scene	0.602	0.706	0.003	0.001
Man is murdered	0.274	0.343	0.078	0.023
Woman is seriously harmed	0.326	0.372	0.058	0.013

Note: Values represent output node activation. The network was trained such that feature absent responses were 0.1 and feature present responses were 0.9. The activation function is nonlinear, so a direct translation to percentages of activation may be misleading.

Although this finding is an existence proof and will not come as a surprise to connectionists, it does demonstrate that learning from TV and an over-representation of TV exemplars in memory can bias social reality estimates (see Table 1). Figure 2 shows the results of the model plotted against human data from a recent study (Shrum, 2001, Figure 1 control data). When the two Y-axes are coordinated, the model performance mimics human data.

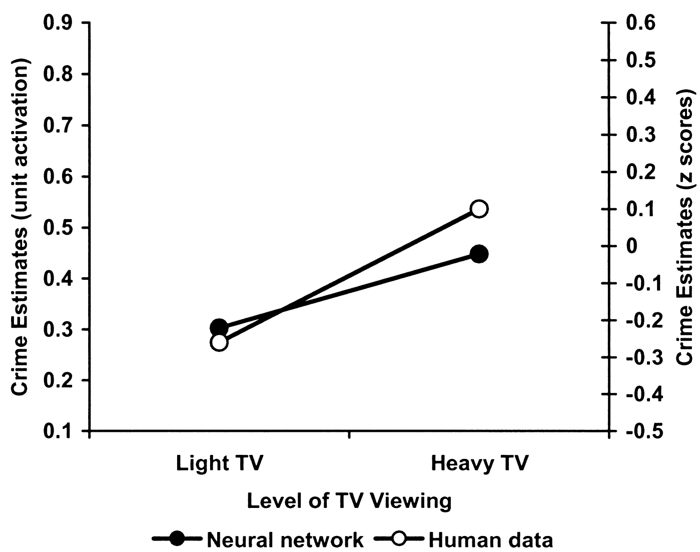

FIGURE 2 Social reality crime estimates as a function of level of TV viewing for the neural network and actual human data from Shrum (2001). Here, heavy viewing habits increased crime estimates for both the model and actual participants. These higher estimates suggest a response biased toward the TV response.

Thus, connectionist networks that are in essence general-purpose learners show evidence that television viewing does indeed increase construct ability.

The second test concerned whether the same networks would show evidence that television exemplars are not discounted when making cultivation-related decisions, as suggested by Proposition 3. This was tested two ways. First, the results for Proposition 1 provided evidence that these models do exhibit the cultivation effect. Due to the fact that the architecture of these networks makes it difficult to test this proposition in the same manner as previous studies, it was first of interest to show whether TV exemplars were being used by comparing the no-prime condition with a small TV source prime. Another set of 80 models (40 heavy and light viewers) were simulated using a small (i.e., 0.3 unit activation) prime of the TV source unit. This is akin to priming the models to actually try to use TV memories in decision making. Not surprisingly, this condition showed much greater activation of TV-related constructs ($M = .40$, $SD = .07$) than the condition where no source primes were used ($M = .29$, $SD = .08$), $F(1, 156) = 85.17$, $p < .001$, $\text{eta}^2 = .35$. More importantly, however, is that the same cultivation effect is seen. There is no interaction between TV prime and viewing level, $F(1, 156) = .15$, $p = .70$, $\text{eta}^2 = .00$. If models primed for TV memories and models with no prime exhibit the same cultivation effect, this suggests that TV memories are *not* being discounted when no source is primed.

Because that claim depends upon a logical inference, Proposition 3 is examined a second way. The no-prime data from Proposition 1 are compared with a condition where each trial receives a random prime. If the cultivation effect is due to ignoring TV exemplars—as Proposition 3 claims—then random primes should mediate or eliminate the cultivation effect. Indeed, this is the case. When a random source prime (i.e., equal probability of direct experience, interpersonal, or TV) is provided before each dependent variable, TV viewing has no effect on social reality estimates, $F(1, 156) = .70$, $p = .41$, $\text{eta}^2 = .00$. In this instance, light viewers ($M = .19$, $SD = .09$) are not discernibly different from heavy viewers ($M = .20$, $SD = .10$). Taken together, these results suggest that when these models exhibit the traditional cultivation effect, TV exemplars are not discounted. Priming TV exemplars causes increases in TV-related social reality estimates but does not increase the difference between heavy and light viewers. Conversely, priming random memory sources eliminates the cultivation effect altogether.

Finally, Proposition 4 states that the cultivation effect will be minimized when employing systematic processing, or trying to make a good decision by focusing on sources from the real world. Indeed, the same simulated models (i.e., light viewers and heavy viewers) do eliminate the cultivation effect when using real world sources as decision cues, $F(1, 156) = 6.98$, $p = .009$, $\text{eta}^2 = .04$. See Figure 3, where model data are plotted against human data from Shrum (2001). The more interesting and unexpected finding is that not only did this model eliminate the cultivation effect when processing

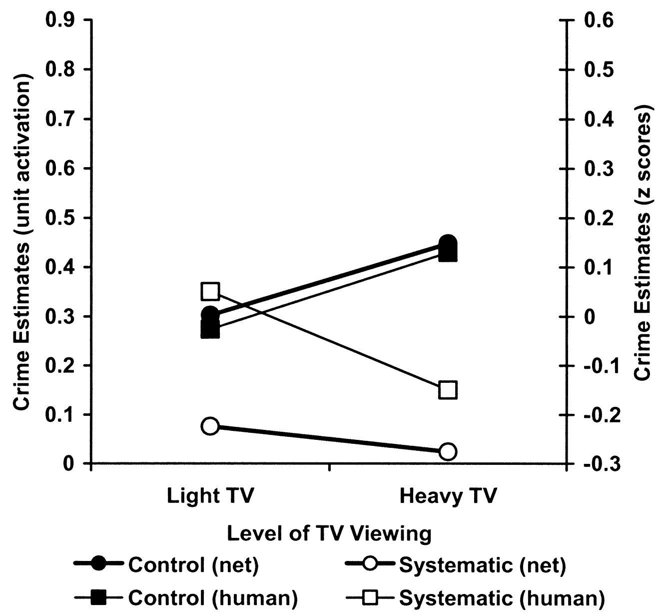

FIGURE 3 Social reality crime estimates as a function of level of TV viewing and instructions for the neural network and actual human data from Shrum (2001). Here, heavy viewing habits increased crime estimates for both the model and actual participants when given no instructions. When attempting to process systematically, humans reverse this pattern, and the model showed the same pattern when cued to use memories from actual real-world sources.

systematically like humans, but it also *reversed* the effect for heavy viewers, a finding also seen by Shrum before (Shrum et al., 1998). That is, for both human participants and model data, heavy viewers gave lower crime estimates than light viewers when processing systematically. This negative slope appears to be something of an over-correction. Thus, the minimalist model in Figure 1 accounts for yet another finding from the cognitive construction of social reality literature.

DISCUSSION

The relationship between television and viewer is complicated and multifaceted; yet, recent research tackling the question from the cognitive perspective has begun to illuminate the processing aspect of this media effect. Shapiro (1991) first proposed an associative network model of memory to account for social reality decisions, and Shrum (2001) offered availability as a mechanism for the cultivation effect. Both authors implicated source memory. Bradley and Payne (2004) showed that the ability to remember remote TV information over time predicts the opposite of a cultivation effect. Those participants who could accurately remember TV information answered social reality questions less like the TV answer despite the fact that the improved memories would appear to result from increased viewing. Here, modeling source memory as a decision cue closely fits human data. By exploring this effect in a connectionist network, we see that a model of memory constructed in accordance with theories of social reality construction does perform as humans perform and offers converging evidence (Shapiro, 2002) in support of those underlying theories.

Despite the fact that earlier attempts to model the cultivation effect as a learning phenomenon were unsuccessful, here a general-purpose learner loosely modeled on human cognition did demonstrate the cultivation effect. More importantly, the model not only eliminated the cultivation effect when focusing on source information, but it over-corrected as humans do. This was an unanticipated finding in these model simulations. Thus, the cultivation effect can be learned, and attention to source can eliminate the effect. This finding accords with human data (Bradley & Payne, 2004; Shapiro, 1991; Shrum, 2001), and it provides a model that fits human data as well as processing information in the way that humans are theorized to process social reality information. This body of work continues to show that to varying degrees, source memory is stored and available, and this memory can be drawn upon to prevent the biasing cultivation effect. This has implications for those interested in media literacy, as the data suggest that media users should concentrate on memory source before making decisions.

Connectionist modeling has been prevalent in fields such as linguistics for approximately two decades, yet relatively little use has been made of these models in the communication literature. In addition to informing the discussion regarding the social construction of reality, the study attempts to show that communication theories can be modeled using the techniques of neural networks. As the communication field has evolved from concentrating closely on just the effects of the media (e.g., Bandura, 1965; McCombs & Shaw, 1972), communication scientists have searched for an understanding of the cognitive processes that underlie media effects (e.g., Basil, 1994; Lang, Bolls, Potter, & Kawahara, 1999; Lang, Newhagen, & Reeves, 1996; Shapiro & Chock, 2003; Shrum, 2001). Connectionist models allow a venue to implement communication theories in a further effort toward theory refinement. Models such as the one in Figure 1 allow us to ask questions such as whether our theoretical explanation of a phenomenon can occur *how* we theorize that it occurs without concentrating solely on the outcome variable. It is hoped that this approach can help further much of the good work that is being done in our field.

Future Research Directions

The model presented here successfully accounts for three of Shrum's (2001, 2004b) propositions underlying the heuristic processing model of cultivation effects. The other two propositions cannot be meaningfully tested given the structure of the current model. Work is ongoing to parsimoniously expand the model simulations to account for the remaining two propositions. Part of the elegance of the current model is that it accounts for the cultivation effect in a connectionist model's most basic form. This neural network model is "off the shelf," so to speak, and does not have special addendums contrived to account for human behavior. Thus, model expansion is primarily focused on simple, realistic expansions to account for processing over time, for example. This will allow other propositions to be simulated.

Shrum's model has led to numerous studies on the cultivation effect, and these data suggest that the model is a useful tool to continue probing this effect. In addition to the traditional areas of violence, occupational frequency, affluence frequency, and marital satisfaction, cultivation-based research is extending into areas such as materialism (e.g., Shrum, Burroughs, & Rindfleisch, 2005). These data suggest that cognitive processing-based cultivation research continues to help researchers understand the complicated relationship between media exposure and resulting effects.

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REFERENCES

Bandura, A. (1965). Influence of film-mediated aggressive models. *Journal of Abnormal and Social Psychology, 66*, 3–11.

Basil, M. D. (1994). Multiple Resource Theory I: Application to Television Viewing. *Communication Research, 21*, 177–207.

Bradley, S. D. (2007). Dynamic, embodied, limited-capacity attention and memory: Modeling cognitive processing of mediated stimuli. *Media Psychology, 9*, 211–239.

Bradley, S. D., & Payne, B. D. (2004, May). *Television, remote memory, and social reality estimates: A cognitive neuroscience approach*. Paper presented at the meeting of the International Communication Association, San Diego, CA.

Busselle, R. W. (2001). Television exposure, perceived realism, and exemplar accessibility in the social judgment process. *Media Psychology, 3*, 43–67.

Gerbner, G., Gross, L., Morgan, M., & Signorielli, N. (1994). Growing up with television: The cultivation perspective. In J. Bryant & D. Zillmann (Eds.), *Media effects: Advances in theory and research* (pp. 17–41). Hillsdale, NJ: Erlbaum.

Hawkins, R. P., Pingree, S., & Adler, I. (1987). Searching for cognitive processes in the cultivation effect. *Human Communication Research, 13*, 553–577.

Lang, A., Bolls, P., Potter, R. F., & Kawahara, K. (1999). The effects of production pacing and arousing content on the information processing of television messages. *Journal of Broadcasting & Electronic Media, 43*, 451–475.

Lang, A., Newhagen, J., & Reeves, B. (1996). Negative video as structure: Emotion, attention, capacity, and memory. *Journal of Broadcasting & Electronic Media, 40*, 460–477.

Mares, M. L. (1996). The role of source confusions in television's cultivation of social relaity judgments. *Human Communication Research, 23*, 278–297.

McClelland, J. L., & Rogers, T. T. (2003). The parallel distributed processing approach to semantic cognition. *Nature Neuroscience, 4*, 310–322.

McCombs, M. E., & Shaw, D. L. (1972). The agenda-setting function of mass media. *Public Opinion Quarterly, 36*, 176–187.

Murnane, K., & Shiffrin, R. M. (1991). Word repetition in sentence recognition. *Memory & Cognition, 19*, 119–130.

Palazzolo, E. T., Serb, D. A., She, Y., Su, C., & Contractor, N. S. (2006). Coevolution of communication and knowledge networks in transactive memory systems: Using computational models for theoretical development. *Communication Theory, 16*, 223–250.

Potter, W. J. (1991). Examining cultivation from a psychological perspective: Component subprocesses. *Communication Research, 18*, 77–102.

Reeves, B., & Nass, C. (1996). *The media equation: How people treat computers, television, and new media like real people and places*. Stanford, CA: CSLI.

Rumelhart, D. E. (2000). The architecture of mind: A connectionist approach. In J. Haugeland (Ed.), *Mind design II: Philosophy, psychology, artificial intelligence* (2nd. ed., pp. 205–232). Cambridge, MA: MIT Press.

Rumelhart, D. E., Hinton, G. E., & Williams, R. J. (1986). Learning internal representations by error propagation. In D. E. Rumelhart & J. L. McClelland (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition* (Vol. 1, pp. 318–362). Cambridge, MA: MIT Press.

Rumelhart, D. E., & McClelland, J. L. (Eds.). (1986). *Parallel distributed processing: Explorations in the microstructure of cognition* (Vol. 1). Cambridge, MA: MIT Press.

Shanahan, J., & Morgan, M. (1999). *Television and its viewers*. Cambridge: Cambridge University Press.

Shapiro, M. A. (1991). Memory and decision processes in the construction of social reality. *Communication Research, 18*, 3–24.

Shapiro, M. A. (2002). Generalizability in communication research. *Human Communication Research, 28*, 491–500.

Shapiro, M. A., & Chock, T. M. (2003). Psychological processes in perceiving reality. *Media Psychology, 5*, 163–198.

Shapiro, M. A., & Fox, J. R. (2002). The role of typical and atypical events in story memory. *Human Communication Research, 28*, 109–135.

Shapiro, M. A., & Lang, A. (1991). Making television reality: Unconscious processes in the construction of social reality. *Communication Research, 18*, 685–705.

Shrum, L. J. (1995). Assessing the social-influence of television—A social cognition perspective on cultivation effects. *Communication Research, 22*, 402–429.

Shrum, L. J. (1996). Psychological processes underlying cultivation effects: Further tests of construct accessibility. *Human Communication Research, 22*, 482–509.

Shrum, L. J. (1997). The role of source confusion in cultivation effects may depend on processing strategy—A comment on Mares (1996). *Human Communication Research, 24*, 349–358.

Shrum, L. J. (1999). Television and persuasion: Effects of the programs between the ads. *Psychology & Marketing, 16*, 119–140.

Shrum, L. J. (2001). Processing strategy moderates the cultivation effect. *Human Communication Research, 27*, 94–120.

Shrum, L. J. (2004a). The cognitive processes underlying cultivation effects are a function of whether the judgments are on-line or memory-based. *Communications, 29*, 327–344.

Shrum, L. J. (2004b). Magnitiude of effects of television viewing on social perceptions vary as a function of data collection method: Implications for psychological processes. *Advances in Consumer Research, 31*, 511–513.

Shrum, L. J., & Bischak, V. D. (2001). Mainstreaming, resonance, and impersonal impact: Testing moderators of the cultivation effect for estimates of crime risk. *Human Communication Research, 27*, 187–215.

Shrum, L. J., Burroughs, J. E., & Rindfleisch, A. (2005). Television's cultivation of material values. *Journal of Consumer Research, 32*, 473–479.

Shrum, L. J., & O'Guinn, T. C. (1993). Processes and effects in the construction of social-reality—Construct accessibility as an explanatory variable. *Communication Research, 20*, 436–471.

Shrum, L. J., Wyer, R. S., & O'Guinn, T. C. (1998). The effects of television consumption on social perceptions: The use of priming procedures to investigate psychological processes. *Journal of Consumer Research, 24*, 447–458.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probablity. *Cognitive Psychology, 5*, 207–232.

Tversky, A., & Kahneman, D. (1990). Judgment under uncertainty: Heuristics and biases. In P. K. Moser (Ed.), *Rationality in action: Contemporary approaches* (pp. 171–188). New York: Cambridge University Press.

Weisberg, M. (2007). Who is a modeler? *British Journal for Philosophy of Science, 58*, 207–233.

Yang, M., Roskos-Ewoldsen, B., & Roskos-Ewoldsen, D. R. (2003, May). *Testing the Landscape Model of text comprehension*. Paper presented at the annual meeting of the International Communication Association, San Diego, CA.

Zillmann, D. (1991). Television viewing and physiological arousal. In J. Bryant & D. Zillmann (Eds.), *Responding to the screen: Reception and reaction processes. Communication* (pp. 103–133). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

APPENDIX

Scenario	Direct experience	Other people	TV response
Woman walks park alone	Woman asks time	Woman watches birds	Woman mugged by man
Child plays park alone	Child watches birds	Childs make friends	Child is kidnapped by man
Woman seriously harmed	Criminal is acquaintance	Criminal is acquaintance	Criminal is stranger
Man seriously harmed	Criminal is acquaintance	Criminal is acquaintance	Criminal is stranger
Police arrive crime scene	Police take report	Police take report	Police shoot suspects
Man in murdered	Criminal is acquaintance	Criminal is acquaintance	Criminal is stranger
Woman is murdered	Criminal is acquaintance	Criminal is acquaintance	Criminal is stranger
Woman rides subway	Woman reads newspaper	Woman reads newspaper	Woman mugged by man
Man rides subway	Man reads newspaper	Man asks time	Man mugged by man
Man breaks into house	Man steals valuables	Man steals valuables	Man rapes woman
Woman stays home alone	Woman watches TV	Woman reads newspaper	Woman raped by man

Note: To make the model's task slightly more difficult and to encourage generalization rather than memorization, these scenarios were constructed so that sometimes the direct experience and other people columns would agree and sometimes they would disagree. Furthermore, the same was considered for "man" subjects and "woman" subjects.