Chapter 5
Media and Influence

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The public information media provides information on current events (news), entertainment (programming), and opinions offered by trusted public sources (e.g., business, academic or religious spokespersons, journalists, and government officials). Consequently, it is a major force in shaping a populace's attitudes toward significant social issues and of great interest to intervention planners. The chapter attempts to provide modelers and intervention analysts alike with sufficient understanding of media mechanisms and current research that they can begin contributing to, and benefiting from this important area of study.

The chapter begins by exploring the effects that accrue from information disseminated through public media, and the conceptual mechanisms that may contribute to these effects. The discussion also introduces the terminology needed to characterize media influence.

The chapter then explores the evolution of models for analyzing the influence of media-based communication on public attitudes. It discusses key theories that have been developed to understand how media influences public attitudes and illustrates how media influence theories have evolved in an attempt to keep pace with the expansion of media and its public reach.

Next, the chapter surveys computational models and methods that have been developed to explore media influence. As is stressed, these models – and any current media models – should be viewed as exploratory in purpose. Each was developed to enable controlled, computational experiments to help understand and characterize mechanisms that are thought to contribute to media influence.

The subsequent section provides a detailed look at one model that the author worked on, the Media Influence Model (MIM) (Bennett 2009; Waltz 2008), and chapter concludes with a brief look at analytic cases which illustrate the use of MIM.

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1 Media Influence Mechanisms and Effects

1.1 Defining Key Concepts

An informed public forms opinions toward political, social, and economic themes using the information it accesses through a *public information environment* (PIE) (Goidel et al. 1997). A modern, sophisticated PIE provides public access to many types of media through various distribution channels. The public's perception of topical issues can be shaped by its preferred access patterns to media and information provided by influential sources.

The media is said to *influence* public opinion whenever its coverage on topical opinions is followed by a noticeable change in public attitude. Although other factors may also contribute to public attitude, it is the *innovation* or change in attitude due to media that is its effect.

Individual public segments evolve access patterns to information sources through preferred media channels. Media outlets produce content to satisfy information needs of public segments with special interest in political, social, or economic themes. This self-sustaining relationship is the foundation of public trust in media.

Media refers to recorded information produced for distribution to an audience. It may be formatted using print, video, text, audio, or other formats. *Media outlets* produce media content for distribution on one or more channels. The information contained in media is said to be in the *public information domain*.

Media is distributed to the public through channels; e.g., newspaper circulation, television or radio broadcast stations, magazines, and websites. A communication channel is a means of transmitting a message from a source (or sender) to an audience (or receiver). Media channels distribute content designed for consumption by a target audience. Many other forms of communication that do not involve distribution of media exist. For example, a conversation between two or more individuals conducted over a telephone produces no legitimate record of the information that is available to the public. It produces no public record. In contrast, a conversation that takes place over a public radio transmission may produce a transcript that falls within the legitimate public information domain. We will consider media to be any information format that is designed to be accessed by the public.

Broadcast media is produced by professional media outlets for transmission to a broad audience. The production format is often carefully tailored to the distribution channel. Media produced for broadcast on television, radio, or newsprint channels is formatted appropriately. Broadcast media is produced to reach a broad audience by containing themes of broad interest and balance that will maintain audience interest and loyalty.

Generally, both media channels and media outlets are managed by a professional enterprise that must survive in a competitive PIE. Whether they are publicly endowed or commercially funded, they survive by maintaining reach to their targeted audiences. A media channel may employ editorial policies that select content and produce media formats tuned to its target audience.

Other forms of media may also contribute to a PIE. The term *gray media* is often used to describe media that is produced for limited distribution to a narrow audience segment. Gray media may not be viewed as credible or interesting to a broad audience. Examples might include bulletins produced for religious, social, or civic organizations for distribution to its membership. Typically, the content is less professionally produced, more culturally biased, and narrowly targeted. Hence, although it is in the public information domain, its potential influence is typically narrower than broadcast media.

Communication theory provides the general principles for studying media influence. In this chapter, we consider several conceptual models derived from communication theories that describe causal mechanisms of media influence. We then illustrate how to build a computational (simulation) model to perform analysis of influence effects within a PIE.

Let us consider a conceptual model (Fig. 1) that represents several mechanisms believed to contribute to media influence. First, an information source (sender) communicates to a public audience (receiver) by issuing a statement (message) to one or more media outlets. Second, a media outlet produces media content that places the source statements in the context of other public information. During production, the media outlet may incorporate an original source statement together with related statements or news reports to provide balanced coverage of the issue. Media production encodes message meaning by referencing a subject and providing rhetorical emphasis (sentiment) through its editorial process. Third, a media channel shapes the message-related information for distribution to its target audience through its selection, placement, and further editorial emphasis. The editorial,

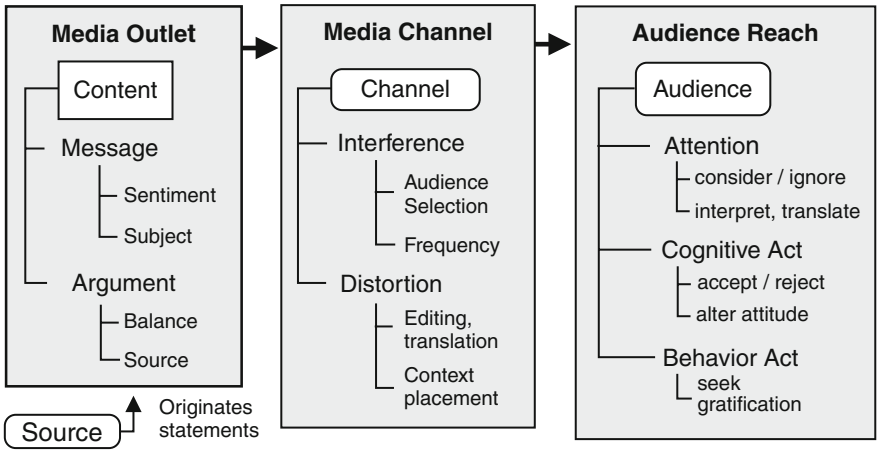

Fig. 1 Media influence communication model

production, and distribution process can either aid in the interpretation of the message or distort the intended meaning. It can also distort original message meaning. A media channel may introduce message interference by editing content presentation or positioning to satisfy its target audience interests. It will adapt distribution frequency within its programming and may place the message adjacent to interfering media content.

An audience that is exposed to media distributed through one or more channels and elects to access the information is said to be *reached*. An audience may then expend some cognitive effort to consider the media content, determine the message, and adopt its position toward the subject. The cognitive process leading to influence is driven by the extent of attention and active consideration given by the audience. The audience cognitive process extracts meaning from the media content. The decoded message (interpreted meaning) may differ from source statement position due to distortion during production and distribution. Audience attitude influence may depend on its acceptance or rejection of the decoded message and its trust in the message source.

An influence effect is evident if the audience changes its attitude toward the message subject in response to the information. Normally, influence must be determined through an independent measurement such as a poll. An influence effect may result in opinion movement toward either agreement or disagreement with the source statement depending on whether the message resonates or conflicts with the audience sentiment toward the subject and the source. Agreement influence can result if alignment of source trust and position are acceptable to the receiver. Disagreement influence may result if either are in conflict with receiver sentiment.

Public segments that rely on information access from multiple channels may experience a range of content emanating from an initial news report. When an issue resonates in a PIE, the expanded coverage can lead to both enhanced coverage and opportunities for message distortion. On one hand, resonance in the PIE provides the public with enhanced access to issue-related information. On the other hand, this mechanism can distort message content and confound the intended influence effect of the message source.

1.2 Media Influence Terminology

Media influence within a PIE can be characterized in terms of variables that represent dynamic changes in media content contributing to public opinion. Public opinion is a variable that represents an aggregated state of opinions contained within a public segment toward a subject. Polls, surveys, and focus group assessments are often conducted to estimate audience segment opinions towards various subjects. An opinion is often measured as a categorical choice (e.g., multiple-choice selection) and is typically characterized as *hard* (strongly held), *soft* (partially formed), or *neutral* (undecided) and as *positive* (supportive) or *negative* (opposing).

A public or audience segment holds a distribution of opinions. *Attitude* is a variable that represents the distribution of opinions held within a public segment toward a subject.

The media influences public opinion by providing access to content. Media content includes messages that intend to inform or persuade. Persuasive messages may intend to shape public behavior by encouraging compliance with guidelines (e.g., "no smoking," "speed limits strictly enforced," or "recycling benefits all"). Persuasive messages may also intend to shape public opinions toward subjects, e.g., "support government officials advocating policies that strengthen family values."

A persuasive message may express intent by encoding meaning directly or indirectly; e.g., using a metaphor. A message carries influence if the receiver can decode the communication and interpret the opinion expressed by its *source* toward the *subject*. A carefully formed message will encode the desired intensity of opinion in its *tone*. Often, message tone is used to gain audience attention by emphasizing sensational aspects of the information. The variability of message *influence* on the formation of public opinion depends on several aspects of the message and its communication that can affect the ability of the public to access, decode, and interpret the message intent. Audience receptivity to message influence often depends on its initial sentiment toward the subject. Audience receptivity can alter the outcome of influence, resulting in attitude trends that may accept, reject, or ignore the message intent.

A message that contains an unambiguous identification of the source – i.e., *source attribution* – is more likely to be viewed as legitimate, and hence improve audience receptivity. A message expressing an opinion by unnamed sources typically will have less influence than a message containing a named source.

Sentiment is the state of existing belief underlying opinions expressed by a public segment in a poll or survey. An opinion can change as a result of exposure to influence and can be measured in polls.

A media channel distributes content associated with themes with varying placement and frequency. *Theme coverage* of a media channel represents the allocation of access and transmission frequency of content expressing opinions about theme subjects. Coverage can be measured per unit of production (e.g., a journal issue) or by unit of time exposure (e.g., per week). A media channel can exhibit a *theme tone* in its coverage depending on the net tone of messages carried about the theme subject. A media channel's strong tone in its coverage of certain themes may indicate bias toward themes' subjects.

Public information access and diversity in a PIE can be characterized in terms of factors and parameters that define the range of subjects, breadth of opinions, and accessibility to the public. A *sophisticated PIE* provides coverage of a broad range of themes and public access to information through a wide range of media channels.

A *public segment* (also called *audience segment* or *target*) is a population group delineated by its demographic profile (e.g., age, education, wealth, political or religious affiliation, etc.), cultural affiliation, or geospatial attributes. One goal of

media influence analysis is to identify differences in how opinion formation on common subjects occurs among different public segments. Information campaigns conducted by corporations, political parties, and government agencies often begin by *audience segmentation*. Segmentation seeks to divide public audiences into groups or segments according to demographics or other attributes that help characterize each group's receptivity to information sources, channels, and content.

A *PIE* is often characterized by the persistent themes carried by media channels. A *theme* is a pattern of consistent, recurring emphasis (i.e., coverage) and tone of content expressing opinions toward a set of subjects. A PIE is characterized by the set of all subjects addressed by its persistent media themes. Subjects within a PIE are represented as named entities. Thus, a theme expressing opinion on political legitimacy of an incumbent politician gains influence by focusing an opinion toward the named incumbent.

A *public information source* is a named entity that provides information content within a PIE directed toward one or more public segments. Sources can be actors that contribute content such as public affairs officers, press secretaries, journalists, scholars, authors, charismatic political or social leaders, etc. A PIE is further characterized by the set of its information sources.

A public segment will often develop a dependent relationship with a set of information sources that it views as credible and trustworthy. Information sources tend to tailor content production toward its constituent audience segments. We will refer to such a relationship as a *line of communication* (LOC).

In communication theory, a channel carries a message from a sender to a receiver. We view a PIE as a network of *media channels* that host content from multiple sources and provide access to public segments. A media channel is an information service that is managed to distribute content to certain public segments, viz. subscribers. A media channel can be managed by a corporate enterprise such as a media outlet, news service, or other commercial enterprise, or it can be managed by a cooperative enterprise (e.g., wiki) or by an individual (e.g., weblog). In each case, the entity responsible for the management of the channel exerts some control over content and audience reach. Media channels are managed so as to provide target audiences with access to content from sources and to maintain audience reach. A media channel is said to have *reach* to a public segment if that segment accesses content from the channel. It is a mutually reinforcing relationship that depends on the media channel's ability to provide content that satisfies the audience. A well-managed media channel maintains its reach to its target audience. Hence, we can treat reach as a parameter in the PIE.

Once content is published to the PIE, it is said to be in the public domain, i.e., it is available for redistribution (as long as appropriate attribution policies are followed). The extent to which a media channel tailors its coverage of content in the public domain through editorial selection and rhetorical emphasis is seen as evidence of *media bias*. Often bias (or *spin*) is merely an attribute of how the channel adapts content to its target audience. In a modern PIE, public exposure to content can be so broad that content tailoring reinforces perceptions of bias. The message distortion that occurs when content originating on one channel is

repackaged and tailored by adjacent channels can lead to complex reactions in media influence.

The media may distort statements provided by a source in its coverage of themes. Any distortion that alters the message subject or sentiment associated with a media channel or outlet is taken as evidence of bias. One view (Allen 2008) characterizes media bias as purposeful filtering of message transmissions on a public media channel depending on an intrinsic sentiment held by the media channel management.

In the next section, we will review key conceptual models that derive from communication theories of media influence. Among the most important are the concepts of agenda setting, priming, and framing. *Agenda setting* describes the effect of broadcast media on what issues the public addresses in forming opinions (McCombs and Shaw 1972). Media emphasis on themes provides a forcing function for the public to prioritize its consideration of important social, political, or economic issues. This effect is often evident, for example, during political campaigns (Scheufele and Tewksbury 2007). Coverage dominance, placement, and use of peripheral cues are often sufficient to stimulate agenda setting. *Priming* is a related effect in which media content encourages the public to recall aspects of an emerging issue that help the public to reach an informed decision or opinion as the issue is further developed in the media (Goidel et al. 1997). The causal model of priming is a time-sensitive response to media coverage. *Framing* describes the effect of media content on influence. The framing effect is seen when small changes in message presentation lead to significant changes in influence (Chong and Druckman 2007). Another possible goal of public communication is to establish a broad and sustained public understanding and supportive opinion toward a subject entity. In particular, *branding* is a communication strategy to reinforce, sustain, and perhaps extend a desired, positive public opinion held toward a subject. Business marketing practice refers to a brand as the strong association of identity that the public sometimes forms toward a subject. An effective media model should be capable of representing how agenda-setting, priming, message framing, and branding effects contribute to achieving desired objectives and avoiding unintended consequences.

2 Theoretical Underpinnings for Modeling Media Influence

2.1 Communication Penetration Theory

Media communication theory has evolved through phases in response to changes in media and public access (McQuail 2005; Perse 2001). As a first step in understanding media influence, the *communication penetration theory (CPT)* (Berlo 1960; Stone et al. 1999), illustrated in Fig. 2, was developed to explain why messages in broadcast media sometimes fail to reach an audience. An audience may fail to pay any attention to media presentation. It may pay attention but reject the message. Even messages containing valuable and important information may be subject to audience negligence

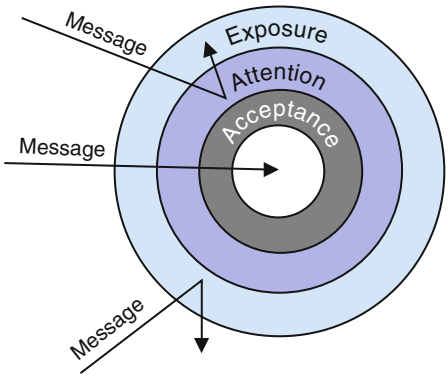

Fig. 2 Communication penetration model

and inattention. The theory evolved to address several questions related to how media influence might fail.

What fraction of media is actually considered by an audience? What factors alter the effectiveness of media to reach certain audiences? Why do some media campaigns fail to get any public attention or consideration? Is the audience unable to understand the message or just unwilling to allocate any effort to consider it? An audience might be overexposed to media and unable to make collective rational decisions on how to allocate attention. CPT offered little understanding of how public attention might be allocated or how to assess media presentation effectiveness in gaining attention other than by elevating rhetorical tone and saturating media coverage.

CPT offers an early, conceptual model of public communication in which the public is a passive and somewhat inattentive receiver of information (Berlo 1960). In this model, the public is viewed as overexposed to media and unprepared to receive and process the information. The capacity of the public to attend to and consider any specific message carried in the media is limited. CPT recognizes that not all media messages reach the desired public audience. Strategies for message reach emphasize placement, frequency of coverage and rhetorical emphasis. Placement may elevate the likelihood that the public will pay attention to the message; e.g., front-page news. Rhetorical tone and emphasis can often affect public priority for selection by appealing to audience strongly held beliefs to gain acceptance.

2.2 Source–Message–Channel–Receiver Model

Another early attempt to understand media influence described the process by which an audience interprets and understands a message contained in media that it has decided to consider. What characteristics of media messages contribute to influence? What are the factors that may impede the effectiveness of media as a form of communication?

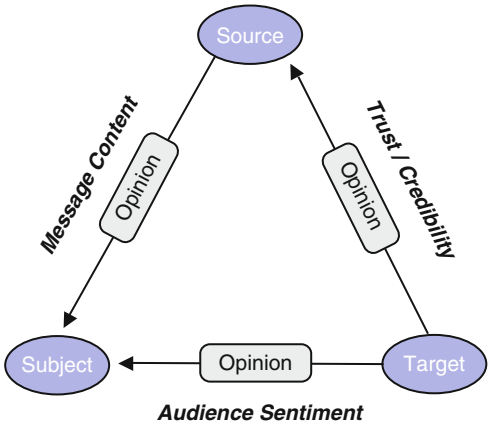

Fig. 3 SMCR model of persuasive communication

Media influence can be understood as a form of persuasive communication (Stone et al. 1999). The *source–message–channel–receiver (SMCR)* model of Berlo et al. (1969) provides a conceptual representation of communication from a sender to a receiver over a channel. In this conceptual model, a source attempts to send a message to an audience by producing media that contains the message. Production encodes meaning in the media using language, presentation, style, and rhetorical tone. The media may use a blend of stylized text, prose, images, or audiovisual content to encode the message. The media is transmitted through a channel that may alter the content that is received by the audience. In this model, the audience receives and considers the media. The receiver attempts to decode the message contained in the media by interpreting its meaning. Any difference between the message as understood by the receiver and the sender constitutes a *communication channel distortion effect*. SMCR theory posits that the risk of message distortion is mediated by the common understanding or *coorientation* between the sender and receiver toward the message subject. Coorientation can be established through the media content by appealing to common references or by placement of the media message within a context that aids in establishing a common understanding. Figure 3 illustrates the SMCR model (Stone et al. 1999; Berlo et al. 1969).

2.3 Opinion Leadership Theory

In public communication, a target audience is a heterogeneous group that is likely to have a range of sentiment, interest in media communications, and ability to interpret content. One early attempt to understand the receptivity of a public audience to a media message examined the difference between social reactions to a message that can lead to influence. What audience characteristics contribute to the development and propagation of influence? What audience characteristics contribute to the

differences in receptivity between two audiences? When might the same media create different influences in each of two or more separate audiences?

Opinion leadership theory (OPT) (Katz and Lazarsfeld 1955) describes how influence trends develop and propagate within an audience. Opinion leaders or *gatekeepers* represent the fraction of the audience that adopt the media message influence and elect to promote the innovation within the society. Gatekeepers are often journalists, political activists, or community leaders who have both strong social ties and access to communication channels that reach the public. Gatekeepers contribute to the development of trends within an audience by promoting the message through social relationships that we refer to as an LOC.

Chaiken (1987) studied how public audiences consider and form opinions in response to media influence. The study explored how information consideration is complicated by the pace of modern life and its cognitive load. The resulting model asserted that little time is reserved for consideration of public issues, and a mix of mindful and mindless responses to debate on public issues characterizes public receptivity to media. Different public segments can be more or less receptive to media influence depending on their cognitive capacity to absorb information. Such demographic factors as literacy, education, age, health, wealth, etc., can provide indicators for the psychocultural capacity and desire to process information.

Audience receptivity to media influence can depend on access to gatekeepers. This theory explains the propagation time lag from audience exposure to media content and noticeable change in public attitude. Demographic factors such as education, age, health, etc., have been associated with the prevalence of gatekeepers within an audience and hence the audience's receptivity to attitude innovation. More recently, the diffusion of innovation business model (Rogers 2003) has been developed to describe the process by which early adopters contribute to mass acceptance of innovative commercial products. In OPT, the influence of media is an innovation or change in public attitude.

2.4 Social Judgment Theory

Social influence theory (SIT) (Latané 1981) has evolved to explain the mechanisms by which social interaction within an audience contributes to the change in attitudes. Social judgment theory (SJT) (Sherif et al. 1965) describes the social process of assimilation or rejection between social communities that hold differing attitudes. SJT has evolved to explain the mechanisms leading to either consensus or polarization of opinion within a social community. Initially, both SIT and SJT evolved separately from media influence theory. This line of theoretical work addresses how social structures affect the formation of public attitudes. What attributes of social structure may lead to either consensus or polarization in attitude?

A public community within a nation or a region may be composed of separate cultural segments of the public that access information through a common PIE. Formation and propagation of public opinions can change in response to cross-cultural interaction between public segments that occur through the PIE and the exogenous influence of

media. SIT describes social influence as the pressure to alter the attitude of social entities (i.e., individuals or groups) exerted by other social entities. Influence is communicated through social relationships that are either direct or indirect. A direct relationship is an immediate social contact or communication between two entities. An indirect relationship occurs when influence is propagated between two entities that have no direct social relationship through intermediaries.

Weisbuch et al. (2002) extended SIT by adding an agent behavior model of information sharing and decision-making. The theory describes how influence propagates in a social network of communicating agents and explains the phenomenon of opinion polarization in response to influence within a heterogeneous population. In SIT, an agent attitude represents an absolute (binary) decision.

SJT (Jager and Amblard 2004) further develops SIT by describing attitude influence as a decision with several levels of confidence in response to message sentiment. In SJT, an agent that receives a message can elect to assimilate, contest, or defer a commitment to the influence. The innovation decision response of the receiving agent depends on how confidently it agrees or disagrees with the message sentiment. If its agreement is within the agent latitude of indifference, then the message influence is assimilated. If the agreement exceeds the latitude of rejection, then the influence is to contest the influence and reinforce an opposing view. If the agreement exceeds the latitude of indifference but does not exceed the latitude of rejection, then SJT predicts that the receiver will not commit to any influence.

2.5 Media Agenda-Setting Theory

Media sets the agenda for public consideration of issues through its emphasis, placement, and rhetorical tone applied to its coverage of important issues. *Agenda-setting theory* (AST) (McCombs and Shaw 1972) posits that mass media influences public opinion formation by driving the public consideration of issues. They argued that the effect of media was less in telling people what to think and more in telling people what to think *about*. During an election campaign, broadcast media will provide coverage that attempts to elevate and focus public discourse, debate, and consideration of related issues. The agenda-setting effect is then to draw the public's attention toward developing well-informed opinions.

How does the public decide how to allocate cognitive capabilities in utilizing the information provided in media? What issues or themes receive priority in public consumption of media information, and how is this agenda for consideration affected by the emphasis placed in media presentation? AST suggests that the public agenda for consideration of issues is driven directly by media presentation. This theory suggests that the selections made in media presentation drive penetration. It reaffirms the passive nature of audience participation in public communication through media.

Agenda-setting effects have been seen as a significant influence on the outcome of political campaigns in the past (Scheufele and Tewksbury 2007). Recent expansion in media access and growth in diversity and sophistication of the public audience

has called into question the influence of broadcast media in agenda setting. Nevertheless, in a less sophisticated PIE the agenda-setting effect can still be a significant driver in influencing public opinion. To what extent agenda setting may extend to a modern PIE involving active public access to information through other, nontraditional media channels such as internet remains an open question.

2.6 Media Priming and Framing Effects

Priming and framing theories were developed to help understand how the audience predisposition toward subject and presentation of a message can affect media influence. Why are certain presentations of a media message more effective in one audience than in another? Why does a small change in the presentation of a media message often lead to significant change in influence? Both priming and framing theories were developed to understand how an audience participates in acceptance or rejection of media influence.

Priming theory (Goidel et al. 1997) posits that the public forms attitudes by drawing on those elements of information that are most accessible at the time. It is a psychosocial theory that describes the cognitive process of decision-making as derived from an aggregate of multiple lines of consideration aligned with an audience belief structure. This model is an application of expectancy value theory (Ajzen and Fishbein 1980). Here, a decision is said to be derived by combining independent lines of consideration according to the value assigned to each.

Media can influence public belief structure by incrementally building arguments along separate lines of consideration in presenting information on an issue. *Priming* is a media effect that activates public awareness of selected information elements that can be used to form an opinion on some issue. It functions by influencing public sentiment along individual lines of consideration that relate to social, economic, or political beliefs toward an issue. Priming effects are more likely to be evident in a sophisticated audience that actively participates in a PIE (Goidel et al. 1997). Both priming and agenda-setting effects in a PIE are driven by the change in theme coverage, message focus, and distribution to audience segments over time.

Framing is a media effect (Chong and Druckman 2007) that is evident when the same message, when produced in a media in two slightly different ways, results in significantly different influence effects. For example, an opinion in support of a new economic policy may be offered by espousing the benefits of the policy. In a second rendition, the same message of support states that the new policy will reduce negative factors such as current unemployment. *Framing theory* describes how frames that appeal to negative aspects are generally more effective than frames with positive appeal (Chong and Druckman 2007). Framing arguments used in media often draw relationships between issues and attributes of current audience appeal. Framing uses language references to build these references. Framing is often associated with the “spin” employed in media that associates new references to the argument or presentation of an issue. Framing effect can shift emphasis between audience lines of consideration and thereby affect influence.

One example of the impact of media framing is the use of "night letters" by the Taliban to influence the political debate in Afghanistan from 2003 to 2006 (Johnson 2007). These strategically posted written communications often argue the illegitimacy of the Karzai government by glorifying the long history of struggle against invaders and occupying forces in Afghanistan. This argument frames public political consideration toward Afghanistan government legitimacy by drawing attention to the international support for the Afghan national government as a negative reference.

Priming and framing effects often interact within a PIE. One way to understand this interaction is to appeal to the concept of expectancy value (Ajzen and Fishbein 1980). In this concept model, the attitude an entity forms toward an issue is a summary of a set of component beliefs held toward the subject. An attitude is derived as a summary of individual lines of consideration aligned with beliefs. Each consideration (or belief) has a sentiment with a strength and valence. The summary attitude is weighted by a salience factor applied to each consideration. A priming effect alters the belief structure by influencing component sentiments. Hence, priming builds memory over time that the public can access to form opinions. Framing (Chong and Druckman 2007) affects the process but through a slightly different mechanism. A framing argument emphasizes relationships between lines of consideration and an issue. A framing effect influences the salience factors that prioritize the contribution along lines of consideration to the attitude influence.

In summary, priming effects influence belief structure (and hence knowledge contained) along the existing lines of consideration. Framing effects influence salience factors used to derive an attitude by building the importance of consideration dimensions into the argument. Both priming and framing effects are seen when a sophisticated audience considers arguments expressed in media content rather than merely reacting to peripheral cues that are used in the media to grab the audience's attention. While agenda-setting theory describes how media effects what issues people think about, priming and framing theories describe how media shapes what people think about issues (Perse 2001, Scheufele and Tewksbury 2007).[1]

2.7 Elaboration Likelihood Theory of Persuasion

Producing media content involves making choices in how to present a message to achieve an effect within a target audience. We have discussed how priming and framing effects may be understood as contributing to how media influences what the public can think about issues. How should we characterize the content of media to achieve these effects? What factors in media message presentation contribute to audience appeal? What factors in media presentation affect how long an attitude change might persist? How might media content mitigate the risk of public inattention to an important message?

[1] Scheufele and Tewksbury (2007) provide an insightful comparison of three aspects of media impact: *agenda-setting*, *priming*, and *framing*.

Elaboration likelihood theory (ELT) (Petty and Cacioppo 1986) describes a conceptual model for how an audience processes information obtained through media and its impact on attitude change. ELT posits that an audience can follow one of two cognitive paths in responding to a media communication. In the first path, a receiver chooses to consider carefully the arguments contained in the media presentation. Thoughtful elaboration of the merits presented in support of an opinion leads to a strong, informed basis for attitude change. This path is deemed the *central path*. In contrast, a receiver may elect to limit cognitive processing to consider only the peripheral items in the media presentation of a particular message. Any resulting change in attitude is obtained not with thoughtful consideration of the merits of an argument but rather in response to one or more peripheral cues (e.g., references to an attractive source, simple anecdote, testimonial, or other reference).

The second or *peripheral path* offers an often expedient mechanism for processing information that demands less cognitive effort and can often appeal to an audience that is poorly prepared to consider an elaborate argument. Instead, the attitude change may be induced in response to indirect references that help the audience reach a satisfactory attitude. ELT posits that the effect of media influence results from a combination of both paths that coexist in an audience according to its ability to comprehend the argument contained in the message and its resonance with peripheral cues. The theory describes factors in the message presentation and the audience cognitive state that contribute to the *elaboration likelihood*. A media presentation that is designed to stimulate high elaboration likelihood anticipates that the audience will expend cognitive effort in considering its content. Educational material is often presented using high elaboration style of presentation. In contrast, a message that is designed to achieve a quick impact through short exposure may rely on the use of peripheral cues: testimonials, iconic references, or framing devices that target audience appeal. The theory posits that an influence that is achieved through the central path is likely to persist longer than an influence achieved through the peripheral path.

ELT describes a set of three qualitative factors that characterize media presentation: argument quality, peripheral cues, and attitude. These factors can be used to assess media content potential influence on a target audience. The target audience elaboration likelihood depends on its cognitive ability, subject knowledge, and distraction. Rucker and Petty (2006) used ELT to define a process to create effective (i.e., influential) media presentations.

3 Methods for Modeling Information Influence

3.1 Overview of Models and Methods

We now review several computational models described in the literature and highlight the extent to which these models represent the theories and media effects described in the previous sections. We start by summarizing the underlying

theories in Table 1. Table 2 summarizes how exploratory models described in this section represent the theories.

Table 1 Communication theories underpinning media influence

Theory/effect	Hypothesized mechanism or effect
Communication penetration theory (CPT)	Messages contained in media will reach only a limited fraction of public with access to media channels
Source–message–channel–receiver theory (SMCR) (Berlo et al. 1969)	A media message that is received by an audience may be accepted or rejected depending on its agreement with message sentiment and trust in message source
Opinion leadership theory (OLT) (Katz and Lazarsfeld 1955)	Trends in opinion formation are led by a small fraction of gatekeepers within a public segment. Gatekeepers act to select and reinforce media influence within a public segment. Gatekeepers establish receptivity to influence within a public segment
Social judgment theory (SJT) (Jager and Amblard 2004)	Opinion formation within the public is driven by the social interactions between public segments An influence on public segment attitude represents collective confidence and strength of opinion held within a social group
Agenda-setting theory (AST) (McCombs and Shaw 1972)	Media coverage of themes encourages public consideration leading to attitude influence within the public
Priming theory (PT) (Goidel et al. 1997)	Media coverage of topics can inform the public and prepare it to reach informed decisions
Framing theory (FT) (Chong and Druckman 2007)	Frames of reference used in form arguments contained in media can alter public influence
Elaboration likelihood theory (ELT) (Petty and Cacioppo 1986)	Both argument quality and use of peripheral cues contained in media message content can influence the acceptance and retention of influence in a public audience depending on its ability to consider argument details. Public attitudes formed through elaborate consideration of media content will persist longer than attitudes formed in reaction to peripheral cues

Table 2 Relations between theories and selected computational models of media influence

	Influence theories							
Computational model	CPT	SMCR	OLT	SJT	AST	PT	FT	ELT
Rational choice model (Weisbuch et al. 2002)			X	X				
Social judgment model (Jager and Amblard 2004)			X	X				
Public education and broadcasting model (Gonzalez-Avella et al. 2005)	X	X	X	X				
Media influence model (Bennett 2009)	X	X	X	X	X	X	X	
Elaboration likelihood model (Mosler et al. 2001)					X	X		X

3.2 Rational Choice Model

If SIT suggests that the attitude of individuals tends to become more similar due to social interactions, then why do not we observe consensus more commonly? The *rational choice model* (RCM) (Weisbuch et al. 2002) is a computational model of social opinion dynamics that was developed to explore the consequences of SIT using a simulation. It represents the influence of social relationships on attitude distribution within a population. The purpose of this model is to explore the conditions leading to either diversity or uniformity of opinion in a social system comprised of agents that interact by exchanging opinions with adjacent social agents within a social network. An agent opinion is represented as a binary, rational choice of agreement or disagreement with adjacent entity influence. The model represents opinion leaders as highly connected entities of the social network.

RCM is implemented as a *multiagent simulation* (MAS) model that represents the behavior of a larger number of social entities in response to interaction events. RCM agent behavior represents how people dynamically adapt their attitude by exchanging information with others. An agent with limited personal knowledge of a subject may rely on opinions already formed by other agents to adopt its attitude; i.e., it exhibits bounded rationality. An agent may also be encouraged to adopt an opinion it perceives as common to the majority of a social group; i.e., it responds to external influences. RCM agent behavior models both bounded rationality and external influences (Weisbuch et al. 2002) using an SIT framework. It explores the impact of factors involving the strength and distribution of opinion and social identity on attitude movement toward either consensus or polarization in a social organization.

An RCM instance is constructed by representing a population as a multiagent system. Agent behaviors are defined by a decision threshold parameter. The model is initialized by setting the attitudes of all agents and the social network links. At each time update agent attitudes are updated and shared with other agents through their social network links. RCM is executed recursively to simulate the dynamic evolution toward opinion consensus or polarization. Typical output identifies the communities of common opinion within the population after a sufficient number of simulation iterations needed to reach a steady-state opinion distribution.

3.3 Social Judgment Model

Social judgment model (SJM) (Jager and Amblard 2004) is an agent-based model that extends the rational choice model by describing an explicit agent message assimilation behavior in response to both pejorative and ameliorative information exchanges about opinions. The purpose of this model is to explore the mechanisms of attitude formation consistent with SJT.

The model uses a multiagent representation in which agents interact within a fixed, regular lattice structure to develop social affiliations based on the impact of common judgments represented as commonality of opinions. Agent interactions represent information sharing between adjacent agents. There is no explicit representation of communication channels.

SJM is implemented as a MAS and instantiated similar to RCM. SJM introduces a continuous variable for each agent representing the strength or confidence of opinion. It requires additional data to establish the attitude decision thresholds of each agent consistent with SJT. SJM produces outputs that are similar to RCM but can extend the analysis to determine the strength of opinion within population segments once steady state is reached. SJM has been shown to produce different consensus and polarization community results than RCM under similar conditions due to the representation of opinion confidence (Jager and Amblard 2004).

3.4 Public Education and Broadcasting Model

The *public education and broadcasting model* (PEBM) (Gonzalez-Avella et al. 2007) is an extension of a model of cultural diversity developed by Axelrod (1997) that represents media influence. PEBM was developed to explore the emergence of communities of common culture under the influence of media communication feedback into the social process. The model uses an MAS that extends the Axelrod model by incorporating media communication feedback.

Axelrod (1997) represents culture as a set of attributes (e.g., cultural values or traits) that are influenced by social interactions. An agent culture state describes the trait assigned to each of its cultural features. Each trait represents an agent attitude toward the cultural feature and can take on one of a finite set of values. Agents with common traits are said to have cultural overlap. A pair of agents can interact according to a probability that increases in proportion to the degree of cultural overlap. Cultural overlap between a pair of agents is computed from the number of common agent cultural feature traits.

PEBM (Gonzalez-Avella et al. 2005) extends the culture model by incorporating a separate agent that represents media. The media agent shares information on culture state among other agents using one of two interaction mechanisms: direct and indirect media influence. Direct media influence represents the impact of information originated by the media that disseminates global information on culture to all agents. Indirect media influence represents feedback from the social entities through media that provide local feedback within communities with a common culture.

The purpose of this model is to explore and compare the impact of local (intercultural) and global (cross-cultural) information sharing on cultural diversity. This model represents an early attempt to explore the implications of media information coverage on cultural diversity. This model treats media as an unbiased agent and neglects communication penetration effects that may limit media reach.

PEBM is instantiated as an MAS with considerations for input data that are similar to both RCM and SJM. PEBM introduces media communication as a new type of agent that can be configured to represent either direct or indirect communication influence. Output data obtained includes the distribution of attitudes of all agents representing the population.

3.5 Elaboration Likelihood Model

In Mosler et al. (2001), a computer-simulation model of ELT is developed. This model formulates a computational model that estimates the elaboration likelihood of a receiving agent that is exposed to a message. The model characterizes a message using variables to represent source attitude, source argument quality, and use of peripheral cues. The model computes the elaboration likelihood and determines the contributions to change in attitude from the central and peripheral paths in accordance with ELT.

In Mosler et al. (2001), the model is instantiated as a two-agent communication interaction through a noisy channel that introduces random distortion to the messages transmitted by each agent. The simulated communication interaction between agents operates as follows. One agent initiates a message offering an opinion with a mix of argument quality and use of peripheral cues. The second agent receives the message, determines its elaboration likelihood, and updates its attitude and argument knowledge. The second agent then issues a message to the first agent using its newly formed argument knowledge and attitude. Messages are transmitted through a noisy channel that perturbs the variables that describe attitude and argument quality. The cycle of bidirectional communication is updated recursively.

This form of simulation model introduces a more complex, psychosocial behavior for each agent and an uncertain result due to a noisy channel. Analysis (Mosler et al. 2001) explores the process leading to consensus or polarization of attitudes as influenced by attributes of the message and audience elaboration behavior. This type of model offers analytical advantages that may aid in developing communication strategies. However, it is typically more difficult to obtain data from opinion polling surveys that can address the attributes that contribute to elaboration ability as described in ELT.

3.6 Media Influence Model

In Bennett (2009), we described a simulation model of media influence that was developed to analyze the effect of persuasive media messages on public attitude change. The model represents the impact of media outlets on message distortion and the dissemination of media through channels that reach certain public audience

segments. Media message content is represented as expressing opinion toward a subject. The message contains sentiment and source attribution. Media effects are computed as media channel sentiment on each of several issues or themes, source statement sentiment, and public segment attitude. We discuss this model in more detail in the next section.

4 A Computational Model of Media Influence

Having reviewed briefly several computational models of media, let us take a detailed look at one particular computational model, a *media influence model* (MIM) (Bennett 2009) that represents major media effects in a PIE.

MIM is a part of a planning and analysis tool (Waltz 2008), a suite of computational models designed to represent political, social, military, economic, and information influence effects (Waltz 2009). The MIM employs a hybrid, computational modeling approach that blends MAS of communications with a system-dynamic model of media influence. This approach represents the subjects, sources, audience targets, and media channels that comprise a PIE. It represents the causal flow of influence from source statements that are issued in a PIE to the change in attitude toward subjects and confidence in sources.

Figure 4 illustrates the causal flow represented by MIM. One or more media outlets pick up statements issued by sources that offer opinions toward subject actors. An outlet produces a media message that frames the statement toward the subject by expressing sentiment along social, political, or economic lines of consideration. The message may include source attribution that is either explicit or indirect (e.g., unnamed sources). Media channels select distribution to audiences and placement given competing media content and audience interest. When a message reaches an audience, it may elect to accept or reject the message it extracts from media depending on its existing attitude and source confidence. Accepted influence can result in an attitude innovation that causes a trend to emerge in the audience. A sustained trend will result in a change in audience attitude. A similar causal loop represents how message influence can alter confidence in a source. The four causal loops identified in the figure are described in this section.

4.1 Media Themes

AST (McCombs and Shaw 1972) suggests that mass media plays an important role in setting the agenda for public debate by elevating attention to certain salient themes. For example, media outlets may strive to inform the public about the function and performance of government, industry and civic leadership by providing content that draws attention to the statements and actions of selected leaders. Media

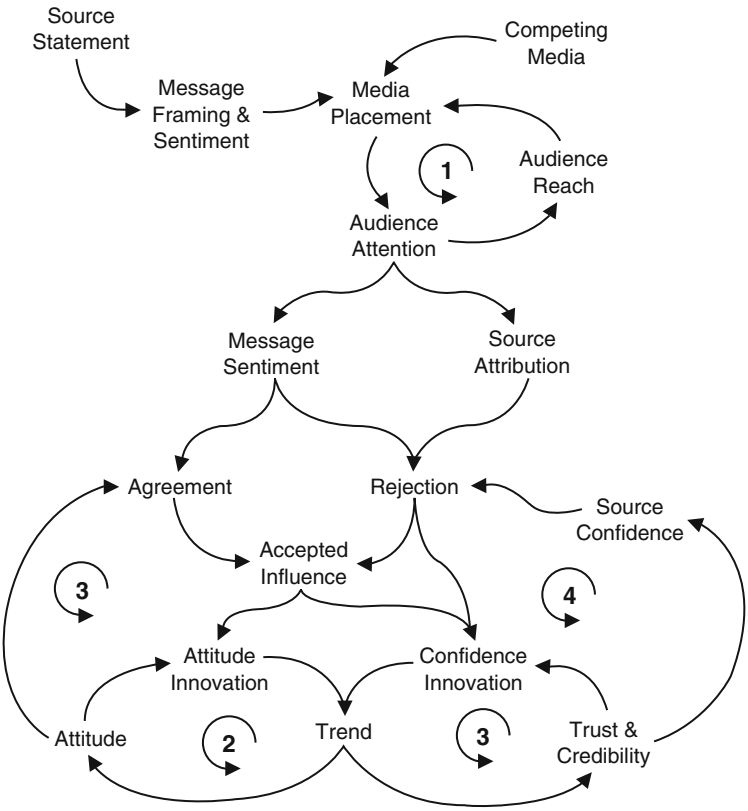

Fig. 4 Causal flow of media influence in a PIE

content emphasizes themes by elevating attention to positions expressed toward subject actors.

A *media theme* (or issue) is a recurring, pervasive, and general category of statements and messages expressing a common position toward one or more subjects that are identifiable to the public. For example, a theme expressing concern for personal security in a region draws attention to the performance of a police or military organization and may raise doubts about its capabilities or performance. A media message is an expression of opinion toward a subject actor having an established identity within the PIE. Media coverage of a theme subject is said to be *on-message* if the net sentiment and framing is consistent with the theme. Professional public communicators often strive to maintain media *voice share*, defined as the fraction of on-message coverage of their desired theme. MIM models a theme as a statement of opinion toward a subject entity. Next, we examine how to represent message content using a computational model.

4.2 Message Sentiment and Framing

MIM represents the sentiment contained in a statement using a five-point scale of intensity. A statement expressing an opinion toward a subject can take one of five possible positions: *Hard Opposition (HO)*, *Soft Opposition (SO)*, *Undecided (UD)*, *Soft Support (SO)*, or *Hard Support (HS)*. Media content can contain many statements, references, and cues that contribute to its net sentiment. MIM represents media sentiment as variable taking values on a continuous *attitude scale* as shown in Table 3.

The sentiment an audience holds toward a subject can also be positioned on the attitude scale. An opinion poll could determine the distribution of opinion within an audience. Attitude scale represents consensus of opinion (i.e., strength) that a public segment holds toward a subject. The attitude value represents the opinion intensity and degree of audience consensus.

Integer attitude values in MIM represent opinion consensus as shown in Table 3. Nonintegral attitude values represent balance between audience opinions as shown in Fig. 5. For example, an attitude value of 1.5 implies that 50% of the population group holds an opinion of *SO* while the remaining 50% hold an opinion of *HS* toward the subject. In a similar manner, the attitude expressed in media content represents the balance in statements contained in an article or publication.

MIM represents message framing by expressing sentiment along three independent *lines of consideration* called *legitimacy*, *affinity*, and *competency*. A statement that argues support for the legitimacy of a subject entity is appealing to a political line of consideration of an audience. Even though an audience may consider an actor a legitimate political candidate, that does not mean they will vote for his election.

Other lines of consideration (Chong and Druckman 2007) often contribute to the net sentiment an audience holds or is willing to express in a poll. An argument may appeal to social affinity of a subject entity by expressing sentiment toward the alignment or social affiliation of the subject with friendly or opposing social groups. Sentiment expressed along the affinity line of consideration attempts to label the

Table 3 MIM opinion and attitude scale

Opinion	Hard opposition (HO)	Soft opposition (SO)	Undecided (UD)	Soft support (SS)	Hard support (HS)
Attitude	−2	−1	0	+1	+2

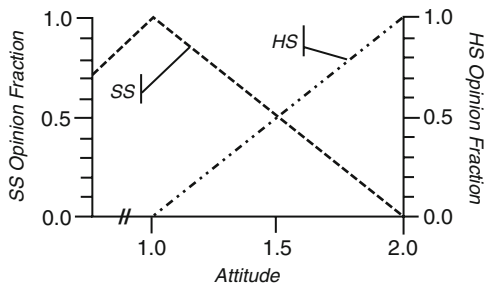

Fig. 5 Attitude representation of opinion consensus

subject as either a trusted ally or an adversary. Even if a subject entity is deemed a friend, he may not be viewed as competent and hence worthy of strong sentiment. Likewise, an antagonist with limited capability to threaten a person is not likely to be the object of strong opposing sentiment. An argument may then also appeal to considerations of the *competency* of a subject entity in expressing sentiment.

A message in MIM is also represented as containing its source attribution. Source attribution can be explicit (e.g., a named entity is quoted in the message statements) or indirect (e.g., an unnamed source is quoted as offering the opinion).

4.3 Communication Penetration

CPT describes how reach is affected by the intensity, framing, and placement of a media message. In any given PIE, the competition between themes, media channel coverage, and information sources sets the threshold for voice share needed to penetrate and gain audience attention. MIM represents communication penetration by comparing media sentiment and audience sentiment for all active subjects associated to issues in PIE. Now let us consider the computational model in more detail in the following development.

MIM computes the attitude $a(P,S) = \{a_c\}_{c \in C}$ of a public group P toward a subject S along three independent *lines of consideration* (see discussion on expectancy value theory in Ajzen and Fishbein (1980) and discussion in Chong and Druckman (2007) on its interpretation in framing theory) or *framing contexts*, $C = \{legitimacy, affinity, competency\}$. Each attitude element can take a value in range of numbers [–2, +2]. The sentiment of media content is represented as an attitude $a(T,S)$ expressed by a source (transmitter) T toward subject S. A public segment P also holds an attitude $a(P,T)$ that represents its confidence toward the source T. Figure 6 illustrates how message and audience sentiment contribute to penetration. The source's intended message, $a(T,S)$, is the sentiment expressed by the source T toward the subject S.

A message can gain audience attention when the tone of media content is sufficiently strong relative to competing messages in the PIE. The tone of media content is the dominant sentiment expressed toward a message subject along all lines of consideration,

$$\left\| a(T,S) \right\| = \max \left\{ c \in C : \left| a_c(T,S) \right| \right\} \tag{1}$$

Following SJT, a message whose tone exceeds a *latitude of indifference*,

$$\left\| a(T,S) \right\| \geq d_1 \tag{2}$$

can overcome the competition for attention and gain audience attention.

CPT describes how a message's intended influence can differ from audience-accepted influence. When an audience pays attention to and properly interprets media content, it extracts an interpretation of the message to consider. It can choose to accept, reject, or ignore the interpreted message. In SJT, the decision is based on

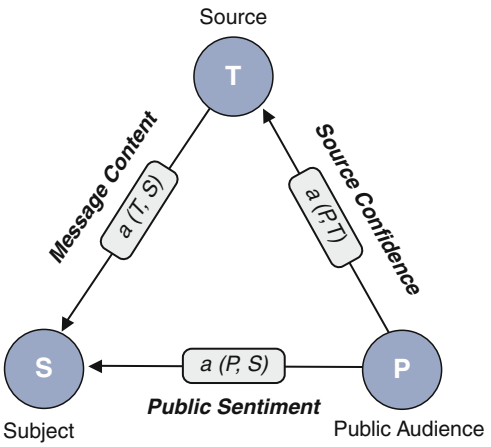

Fig. 6 MIM representation of source-subject-public attitude

the size of the *message innovation* (difference between interpreted message and audience sentiment),

$$e_m(P,S) = a(T,S) - a(P,S) \tag{3}$$

An audience exposed to media messages can completely accept the intended message influence whenever the innovation satisfies a *latitude of acceptance*,

$$\|e_m(P,S)\| \le d_A, \tag{4}$$

and completely ignore the intended influence whenever the innovation exceeds a *latitude of rejection,*

$$\|e_m(P,S)\| > d_R. \tag{5}$$

Whenever message innovation exceeds the latitude of acceptance but does not violate the latitude of rejection, the accepted influence will be proportionally diluted. MIM computes a proportional message accepted influence as

$$I_A(P,S) = c_A\left(e_m(P,S)\right)e_m(P,S) + a(P,S) \tag{6}$$

where the *coefficient of partial acceptance* is computed as

$$c_A(e) = \begin{cases} 1, & \|e\| \le d_A \\ \left(\|e\| - d_R\right)\left(d_A - d_R\right), & d_A < \|e\| \le d_R \\ 0, & \|e\| > d_R \end{cases}$$

4.4 Message Rejection and Source Confidence

Source attribution contained in a message has an effect on audience-accepted influence. If an audience has confidence in a source, then it is more likely to accept

its influence. On the other hand, if an audience distrusts a source, it is more likely to reject the influence and may adopt an opinion contrary to the message content. Let us explore a computational model that represents how message acceptance and rejection is related to source attribution. The following model implements SMCR theory to estimate the impact of source attribution. It represents confidence as dependent on the attitude held by the audience toward the source.

An audience segment P derives its confidence in source T from the trust and credibility it holds toward the source. Let *trust* $\alpha_T(P,T)$ and *credibility* $\alpha_C(P,T)$ be defined as

$$\begin{aligned}\alpha_T(P,T) &= \left(1-C_{TC}\right)a_{\text{Affinity}}(P,T)+C_{TC}\alpha_{\text{Competency}}(P,T)\\ \alpha_C(P,T) &= \left(1-C_{CC}\right)a_{\text{Legitimacy}}(P,T)+C_{CC}\alpha_{\text{Competency}}(P,T)\end{aligned} \tag{7}$$

where C_{TC} is a coefficient of trust dependence on competency and C_{CC} is a coefficient of credibility dependence on competency.

The confidence P holds toward T is a combination of its trust and competency

$$\alpha_S(P,T) = \left(1-C_{SC}\right)\alpha_T(P,T)+C_{SC}\alpha_C(P,T) \tag{8}$$

where C_{SC} is a coefficient of credibility importance to source confidence.

MIM computes accepted message influence due to source confidence by refining (6) as

$$I_A(P,S) = c_R\left(\alpha_S\right)c_A\left(e_m(P,S)\right)e_m(P,S)+a(P,S) \tag{9}$$

where the *coefficient of message rejection*, c_R, depends on the audience confidence in source α_S:

$$c_R(\alpha_S) = \begin{cases} 1, & \text{if } \alpha_S \geq d_\alpha \\ \dfrac{\alpha_S - d_\rho}{d_\alpha - d_\rho}, & \text{if } d_\rho < \alpha_S < d_\alpha \\ \dfrac{\alpha_S - d_\rho}{d_\rho + d_\rho}, & \text{if } -d_\alpha < \alpha_S < d_\rho \\ -1, & \text{if } \alpha_S \leq -d_\alpha \end{cases} \tag{10}$$

Source confidence is reinforced when messages are accepted and diminished when message influence is rejected. Thus, message acceptance influences source confidence dynamically. The amount of confidence innovation depends on the magnitude of accepted innovation for the message and impacts confidence toward source. MIM computes influence toward source confidence as:

$$I_S(T,S) = c_R(\alpha_S)\left|I_A(P,S)\right| \tag{11}$$

4.5 Attitude Influence

Public opinion formation evolves over time under the influence of media and social interactions. MIM is designed to explore the causal mechanisms that explain time lag between media coverage and emergence of trends and shifts in public attitude. It represents the dynamic interactions that explain attitude intransigence (unwillingness to change), attitude retention (ability to retain attitude change after media coverage ceases), and influence receptivity (ability to transfer influence acceptance to strongly held attitude that can be verified in public polls and surveys).

MIM uses an MAS to represent a public response to media influence that influences public perception of themes. It extends agent behavior of SJT (Jager and Amblard 2004) to represent the time evolution of attitude change due to audience resistance. MIM computes attitude and trend change at each time update for each audience agent toward each subject agent.

To illustrate the agent attitude model behavior, let us consider a single audience segment and subject. Let $a(t)$ represent the attitude of the audience segment toward the subject at time t. Let $I_a(t)$ represent the accepted influence due to exposure to media content. OPT (Berlo 1960) suggests that the dynamics of opinion change are driven by trends that originate from opinion leaders. Let $\tau(t)$ be the trend at time t, representing the amount of attitude change within the population group over a time interval T_s (say, 1 week). For example, a trend value of 0.1 represents an increasing attitude movement within 10% of the audience since the last update.

Trends develop in proportion to the innovation contained in accepted influence. As accepted influence agrees with existing sentiment, a media fatigue effect sets in and the trend will diminish. The magnitude of a trend is modulated by audience *receptivity R* (also called *coefficient of resistance* (Schumann et al. 1990)). Audience receptivity represents its learning and retention ability. Demographic factors such as age, level of education, literacy, affluence, and culture can affect audience receptivity.

Here, we simplify notation and drop the explicit representation of attitude source, subject, or target. The accepted innovation at time t obtained from a message is

$$e_m(t) = I_A(t) - a(t) \tag{12}$$

and the accepted innovation toward the source confidence is

$$e_s(t) = I_s(t) - \alpha_S(t) \tag{13}$$

MIM attitude propagation model updates the trend and attitude at each simulation time step according to the following pair of equations

$$\begin{aligned} \tau(t+1) &= R_s e_s(t) + R_m e_m(t) \\ a(t+1) &= a(t) + T_s \tau(t) \end{aligned} \tag{14}$$

which are updated for all audience attitudes toward all subjects in response to each influence innovation.

Table 4 summarizes MIM parameters and variables that are updated using (8) and (11)–(14) at each simulation time step.

The model extends the behavior of SJM agents (Jager and Amblard 2004) while retaining two important properties. It is both causal and well posed, i.e., the mathematical properties are qualitatively consistent with the evolution of trends and attitudes in public sentiment analysis. It is scalable to a desired granularity of population segmentation; i.e., any number of source, subject, and target entities can be represented.

Affecting opinion change in a PIE can often be limited by audience exposure to dissonant information content representing conflicting, indecisive, or weakly expressed attitudes. Whenever accepted influence is weak, the trend will be negligible.

Audiences tend toward intransigence in opinion change when confronted with dissonant or indecisive information. MIM represents audience attitude intransigence by augmenting the evolution (13) with an opinion state transition model illustrated in Fig. 7. The model restricts transition between opinion states

Table 4 Attitude propagation model nomenclature

Type	Notation	Description
Variable	I_A	Accepted message influence
	I_s	Influence toward source confidence
	e_m	Innovation accepted toward message subject
	e_s	Innovation accepted toward source confidence
	τ	Trend toward message subject
	a	Audience attitude toward message subject
	α_s	Audience confidence toward source
Parameter	R_m	Receptivity to message innovation
	R_s	Receptivity to source confidence innovation
	T_s	Time step to next model update

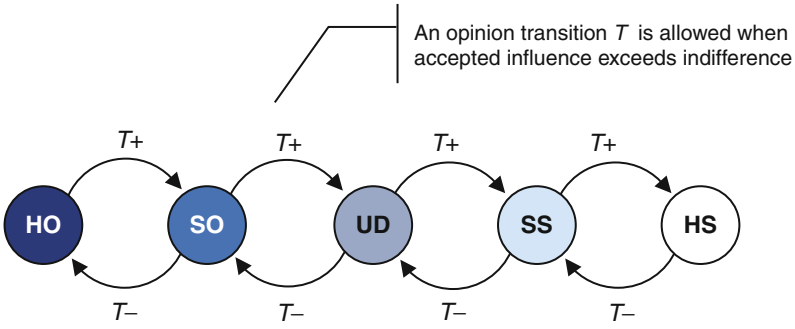

Fig. 7 The intransigence of public opinion resists impact of dissonant influence

whenever the magnitude of accepted influence is less than a *latitude of opinion indifference*, $\|I_A\| < d_1$.

For example, consider an audience that holds a strong positive opinion of HS on some subject. Assume it is exposed to media coverage that carries dissonant sentiment toward the subject with net influence, $I_A = 0$. The audience attitude will drift toward value $a = 1.5$ representing a split consensus of *HS* and *SS*.

4.6 Media Channel Reach

A media channel distributes content to the public. MIM represents media distribution as a communication channel from the source (sender) to the audience (receiver). Each channel is characterized by its reach.

The *reach* of a media channel to a target audience is the fraction of the audience that is exposed to content carried by the channel. Reach is a mutual relationship of reliance between a public segment and a media channel. The public segment relies on a media channel for information, and the media channel relies on the public segment subscribership for its media status. Reach represents the fraction of time or attention that the target audience allocates to the media channel. Media channels function to maintain reach to their target audience. Reach is a key competitive factor in media. Media outlets and channels manage production and distribution to maintain desired reach. MIM assumes that media channels attempt to track their target audience attitudes and will modify coverage to satisfy audience interests and maintain trust.

Consider a hypothetical media poll that measures the interest of a public segment to each of available channels 1, 2, or 3. The poll finds that the audience allocates 30% attention to channel 1, 60% to channel 2, and 10% to channel 3. Then, channel 2 has 0.6 reach to the target audience segment.

Figure 8 illustrates the MIM media channel reach model. The model defines reach for each channel to the target audience segments. MIM uses the audience preference interpretation of media channel reach. For each target audience, the sum of channel reach across all channels to that audience should total less than unity. Each source has a defined access to media channels. The figure illustrates typical channel types. Each channel can provide a maximum exposure frequency to all its subscribers.

4.7 Media Channel Distortion

A media outlet production and distribution can be modeled as a communication channel between a source and an audience. Both production and distribution can alter the intended source message by placing source statements in the context of other statements that may alter the sentiment, framing, or subject. The audience's

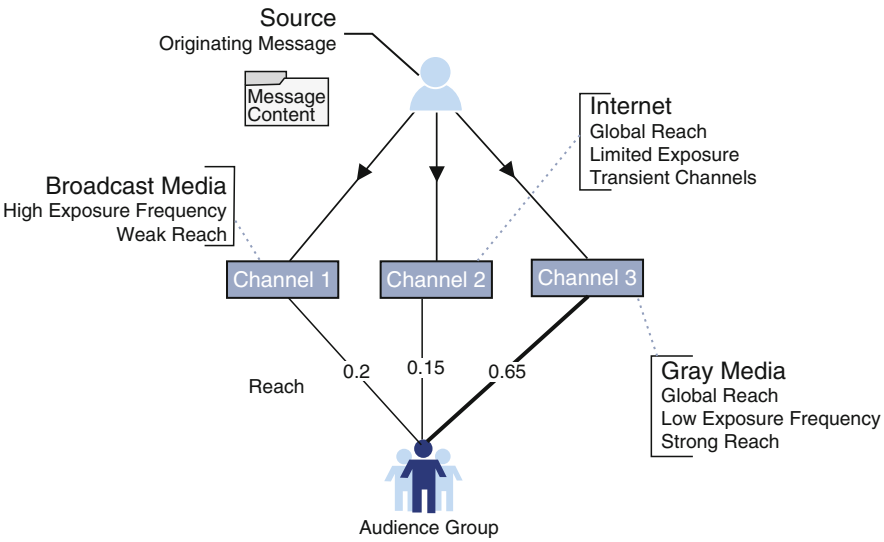

Fig. 8 Media channel source access and audience reach

ability to interpret the message correctly depends on its cognitive ability and exposure to the message. A message can be obscured by its placement in media distribution that is adjacent to similar messages that create interference. For example, a front-page story is often isolated for emphasis, whereas a story buried on page ten may be difficult to find and discriminate from adjacent articles. Often the intensity of the sentiment provides the discrimination that enables the audience to find and interpret the message.

MIM incorporates a hypothetical model for a media channel based on communication theory (Cover and Thomas 1991) to estimate the on-message distortion of a media channel. The following factors are computed to define a media channel message distortion.

A target audience influence depends on the frequency of its exposure to a message carried on a media channel. *Exposure Frequency* (F_e) by a target audience depends on the product of two factors, $F_e = R_C F_M$. *Channel Reach* (R_C) is the fraction of target audience exposed to messages carried on the channel. *Message Frequency* (F_M) is the frequency of distribution of *on-message* media content carried on the distribution channel.

Media channels carry content covering a wide range of messages. A receiver that is concerned about a particular subject must find the information of interest in the media content to correctly interpret the message influence. A receiver who wishes to determine the subject, sentiment, framing elements, and source attribution contained in the message is faced with a problem of reducing his initial uncertainty. He may need to receive and attend to several media transmissions over time to extract meaning and reduce his uncertainty. Communication theory (Cover and Thomas 1991) defines information as the ability of a message to

reduce uncertainty measured as the entropy in the receiver's decision. If each media channel carried only one message at a time, there would be no distortion. However, an audience must extract and interpret message meaning from a channel that is broadcasting many simultaneous messages that cause distortion. Communication theory describes information distortion on a communication channel using a very general computational model that quantifies the reduction of given the complexity of interfering messages. A detailed discussion of communication theory and entropy is beyond the scope of this chapter. We refer the reader to Cover and Thomas (1991) for more details. The following summarizes the definitions and computational model used to represent distortion in a media channel.

Message Information (I_M) is the amount of information that must be encoded in media content for the audience to interpret the full meaning of the message. *Channel Noise* (N_c) is the amount of competing information, unrelated to the message, that is carried on a channel at any time that causes interference in interpreting the meaning of the message.

Signal-to-noise ratio (SNR) is a characteristic of a channel and the information content covering a message

$$SNR = \frac{I_M^2}{N_C^2} \tag{15}$$

A large SNR (greater than unity) implies that the message has strong sentiment compared to other messages on the channel.

Channel Capacity (C_C) is the amount of information that can be distributed successfully to audiences at each time. It is computed Cover and Thomas (1991) as

$$C = F_e \log_2 \left(1 + \frac{SNR}{F_e} \right) \tag{16}$$

Information Environment Entropy (E) represents the complexity of the potential content carried on any media channel operating within a PIE. It represents the complexity of all possible combinations of subjects, themes, sources, and message frames that must be discriminated for a receiver to decode the correct interpretation of a message.

Received Message Information (I_{RM}) is the amount of distributed on-message information that can be recovered by the target audience from exposure to media distributed over a channel. The target audience must discriminate the message within the media content it receives from all the competing messages.

According to communication theory, received information may be limited by the channel capacity if its value does not exceed the entropy in the information environment. It is computed as

$$I_{RM} = \min \left\{ C_C, -E \right\} \tag{17}$$

Channel Distortion (D_C) is the distortion in interpreted message obtained from media content due to the capacity of a channel and complexity of the message. It is computed as

$$D_C = \frac{2^{-E} - 2^{I_{RM}}}{2^{-E}} \tag{18}$$

Interpretation Channel Factor (c_c) is the fraction of correctly interpreted message influences that can be decoded by the target audience over a channel. It is computed as

$$c_c = 1 - D_C \tag{19}$$

MIM models channel distortion of accepted message influence as

$$I_A = c_c c_R(\alpha_S) c_A(e) e + a \tag{20}$$

Media channel distortion is a conceptual model that is incorporated in MIM to explore the impact of mechanisms that create distortion and confusion in message interpretation whenever media channels are carrying a high volume of distinct media themes and messages.

4.8 Media Outlets

Media outlets can alter the sentiment contained in source statements by its coverage of themes. Media campaigns are often frustrated in their ability to anticipate and account for media distortion and bias. No single theory that describes a simple mechanism to account for media bias has emerged. Allen (2009) describes bias as purposeful filtering of messages carried on media channels (P. D. Allen (2008), "Accounting for Bias in Broadcast Media Message Acceptance," *IO Sphere, the Joint Information Operations Warfare Command*). Other studies have recognized that media bias often exists but have provided no concrete models (Scheufele and Tewksbury 2007; Schumann et al. 1990; McQuail 2005; Perse 2001). Understanding mechanisms for media bias is potentially an important contribution of exploratory analysis. In this section, we describe one hypothetical model that characterizes bias as a behavior of an agent representing a media outlet.

A media outlet manages production to maintain reach to its target audiences. It selects coverage and placement of messages consistent with its priority themes. It also uses editorial processes and policies to adjust tone of its content to satisfy the interests of its target audience. A media outlet will select and emphasize coverage of messages that are aligned with its priority themes and deemphasize other messages.

Media outlet behaviors: MIM models media outlet bias effects by representing several behaviors that are typical of media outlet production and channel distribution policies. MIM represents a media outlet actor as having five distinct behaviors.

Behavior 1: A media channel will balance the sentiment of content it carries in an attempt to satisfy the message-sentiment latitude of acceptance of its target audience.

A media outlet will develop and retain a profile of the attitudes of its target audiences for theme subjects. A media outlet then adapts the tone of its coverage of source statements to comply with its *standard subject tone* $a(M_c, S)$ toward the subject S.

A *media outlet agent* determines its *standard subject tone* as a reach weighted average of its target-audience $P(M_c)$ sentiment toward S:

$$\begin{aligned} a(M_c,S) &= \sum_{k\in P(M_c)} \mu_c(P_k)\cdot a(P_k,S) \\ \mu_c(P_k) &= \frac{R_c(P_k)}{\sum_{k\in P(M_c)} R_c(P_k)} \end{aligned} \tag{21}$$

A media outlet agent will adapt the tone of the content it distributes on a channel *MC* to balance between the source statement and the media channel content norm as needed to capture the attention of its target audience. MIM computes the sentiment carried on media channel *MC* as

$$a^{MC}(T,S) = (1-C_M)a(T,S) + C_M a(M_c,S) \tag{22}$$

where $0 \le C_M \le 1$ represents the fractional shift in message tone or balance factor needed to satisfy the target audience latitude of acceptance

$$\left\| a^{MC}(T,S) - a(M_c,S) \right\| \le d_A \tag{23}$$

Behavior 2: Each media channel will prioritize its coverage and distribution of content according to its intrinsic priority themes. A media channel emphasizes coverage of messages that express opinions toward subjects contained in its intrinsic priority themes. Media emphasizes coverage by elevating placement and exposure frequency.

Behavior 3: A media outlet will carry statements exclusively from a list of its legitimate (authorized) sources.

Behavior 4: Each media channel has a limited capacity of messages it can carry during a time interval. A media outlet will fill the capacity of its media channels with content according to two selection criteria as follows.

A media outlet will prioritize selection of content to:

1. Prefer messages having strong tone to capture audience attention,

$$V_1 = \left\| a^M(T,S) \right\|$$

2. Prefer messages that can impact its target audience

$$V_2 = \left\| a^M(T,S) - a(P_{\mathrm{M}},S) \right\|$$

A media outlet selects content in order of increasing priority given by:

$$V = (1-w_2)V_1 + w_2 V_2$$

where $0 \le w_2 \le 1$ is a weighting factor for priority message selection.

Behavior 5: Media channels interact in a PIE creating potential conditions for resonance. Once distributed by a media channel, media is in the public domain and hence accessible by other adjacent media outlets. Whenever a media outlet obtains publicized content offering an opinion toward one of its priority themes, it may adapt the content for its own message distribution. The media outlet may also adapt the tone of the new distribution to satisfy its own target audience interest. Resonance can occur when adjacent media outlet coverage extends the distribution beyond the target audience and distribution time of the originating channel. Resonance can involve message distortion as each media channel adapts its own content and selects its own coverage. This resonance behavior is represented in MIM when a channel picks up content from an adjacent public channel and issues new content carrying coverage of the original message.

Media outlet behavior is based on a conceptual model of the media outlet production process that has not appeared previously in the literature. MIM incorporates this model to enable exploratory analysis of media influence when media bias effects are of concern.

4.9 Source Lines of Communication

Public relations practice is to analyze, develop, and maintain desired relationships between an organization and its target public segments through sustained communication outreach. Techniques for building trusted communication relationships vary. They continue to be adapted to the modern information environment of media and to the growing need to develop cross-cultural relations. Understanding mechanisms that describe how a source will adopt its statements to achieve audience resonance is potentially an important contribution of exploratory analysis. In this section, we describe one hypothetical model that characterizes the behavior of source agents in a PIE. This conceptual model has not previously appeared in the literature.

MIM represents a trusted relationship between an information source and a public segment as an LOC (see Fig. 9). An LOC source issues statements to media to maintain influence on its target audience. A source strives to maintain positive influence but does not typically control media distribution. Instead, it must rely on distribution through media channels that provide access to its target audience.

Source actor behavior: A source has a relationship with a target audience defined by an LOC. A source actor *T* issues statements expressing its opinion toward a subject *S* if either of two conditions hold (Table 5):

1. *T* holds a strong opinion toward subject *S*
2. The opinion held by *T* differs sufficiently from that of its target audience *P*

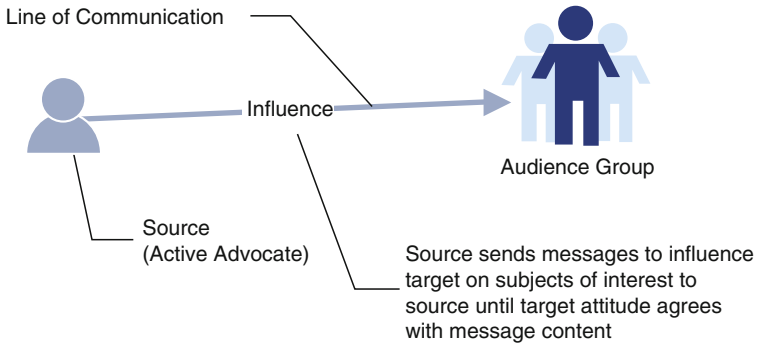

Fig. 9 MIM line of communication

Table 5 MIM source behavior conditions

	Source behavior condition	Model condition
1	Opinion strength of source statement exceeds its latitude of indifference	$\|a(T,S,C)\| \geq d_{\mathrm{I}}$
2	Opinion strength of source statement and target audience sentiment disagree by d_{T}	$\|a(T,S,C) - a(P,S,C)\| \geq d_T$

5 Illustrative Example

Here, we illustrate how MIM can be used to analyze message influence effects using three cases. The example considers the conditions for successfully influencing attitude within a public segment by issuing a message through a media channel.

In the first case, a source releases a public message statement expressing an opinion toward a subject actor. The message is covered by a media channel that reaches a particular target audience. Let us assume a media outlet distributes content covering this message without distortion or bias to the audience for 21 days (3 weeks).

In the second case, the target audience is also exposed to a dissenting opinion from a second source during the same 3-week period. In both cases, the audience initially holds a neutral (undecided) opinion of confidence in both sources prior to exposure to media coverage. The audience develops or withholds confidence depending on how it interprets and accepts the message influence.

In the third case, we examine the response when the audience holds an initial attitude of distrust toward the source.

MIM can be used to analyze conditions that can lead to accepted influence, attitude change effect, and development of source confidence. The modeler introduces explicit assumptions about the strength of initial audience sentiment, message tone, framing contexts, and the duration of exposure leading to influence. Table 6 summarizes the hypothetical model parameters used in the example to describe the assumed response of a public audience to media information exposure. Table 7 summarizes the audience sentiment and message tone for this example.

Table 6 Assumed parameters.

Symbol	Parameter	Value
d_{I}	Latitude of indifference	0.4
d_{A}	Latitude of acceptance	2.4
d_{R}	Latitude of rejection	3.0
d_{α}	Latitude of source confidence	0.4
d_{ρ}	Latitude of distrusted source opposition	−0.2
R_{m}	Receptivity to message influence	1/6
R_{s}	Receptivity to source confidence influence	1/12
d_{I}	Latitude of opinion indifference	0.5

Table 7 Message and public sentiment

	Message sentiment		
	Audience sentiment	Original source	Dissenting source
Framing contexts			
Subject legitimacy	SO	HS	SO
Subject affinity	SS	HO	SS
Subject competency	UD	UD	UD

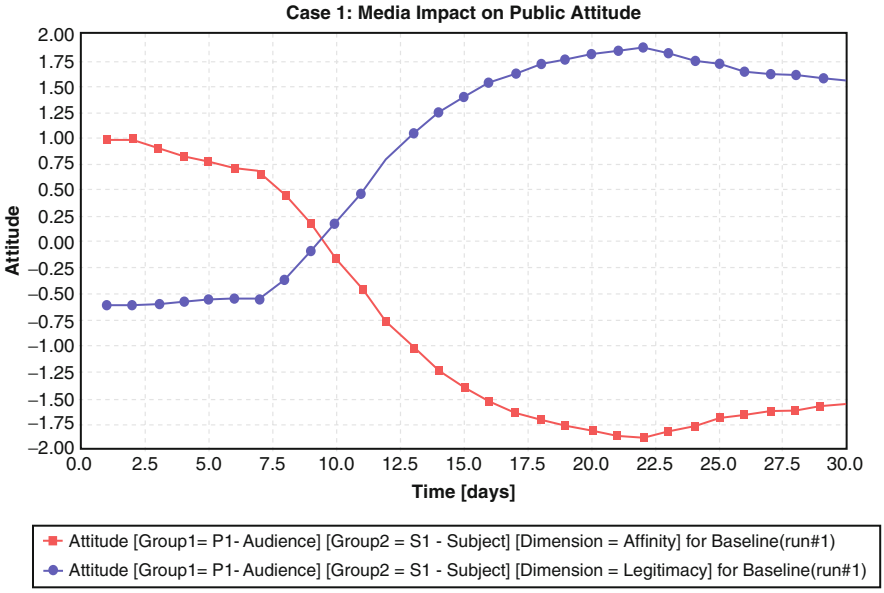

Fig. 10 Case 1 – public attitude impact

Figure 10 illustrates the attitude change in the audience in response to the message exposure in the first case. The simulated response shows that the target loses its conviction toward the subject within 11 days and adopts a new attitude within 21 days under these assumptions. Figure 11 illustrates the change in audience accepted

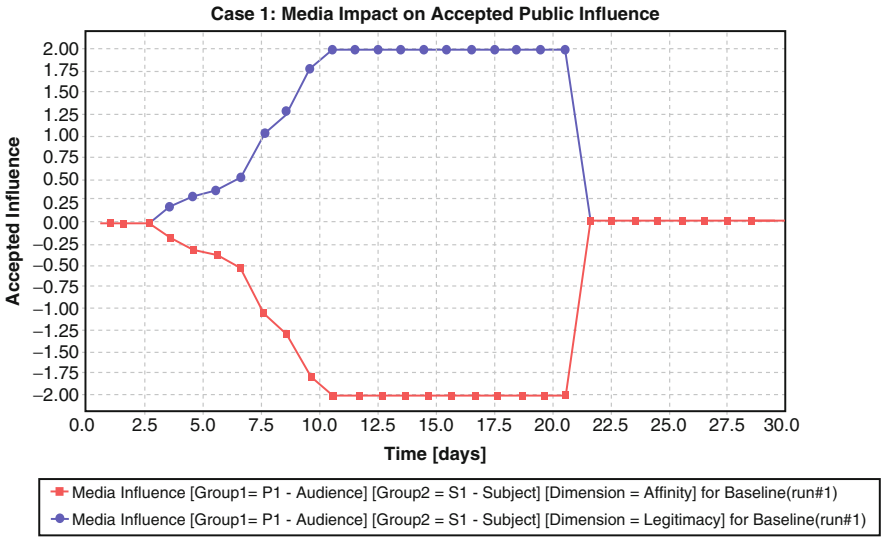

Fig. 11 Case 1 – audience accepted influence

influence as the target is exposed to the message. Within 6 days of exposure, greater than 50% of the target population understands and accepts the message influence. The full influence of the message tone is experienced within the population within 10 days of exposure. In the first case, we assume that the target audience is not exposed to any dissenting opinion, media channel distortion is negligible, and the target confidence in the source is neutral. Hence, the target is poised to accept influence on the subject from this source.

Figure 12 illustrates how the target audience develops confidence in the source as it interprets and accepts the message. In this scenario, media information affects the reversal of public opinion within 21 days of media message exposure.

The second case considers the impact of exposure to dissenting media coverage during the message exposure period. Figure 13 shows that public attitude is affected and opinions are reversed, but the public does not reach full agreement with the tone of the message content before the message coverage terminates. This case illustrates the effect of public dissonance resulting from exposure to dissenting influence. Figure 14 illustrates the level of dissenting content exposure.

The third case considers the impact of initial distrust in the source. Figure 15 illustrates how attitude change is suppressed in this case. Figure 16 plots the fluctuations in accepted influence resulting from source mistrust and the tendency to oppose message opinion. Figure 17 plots the degradation in source confidence that results. Note that under these assumptions, an initial 20% population negative source confidence is sufficient to lead to this failure in reaching the intended effect or even reversing initial sentiment. Table 8 summarizes the qualitative analysis from these three exercises.

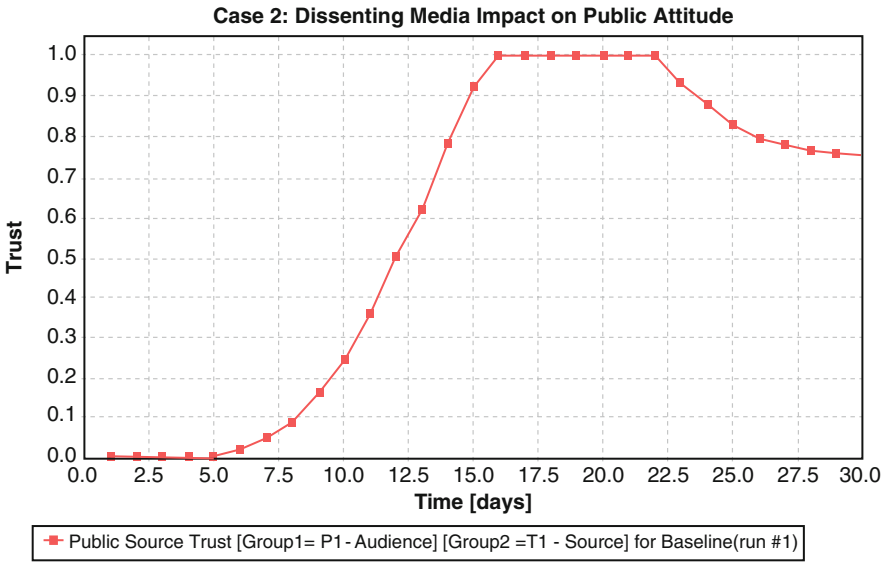

Fig. 12 Case 1 – audience confidence in source

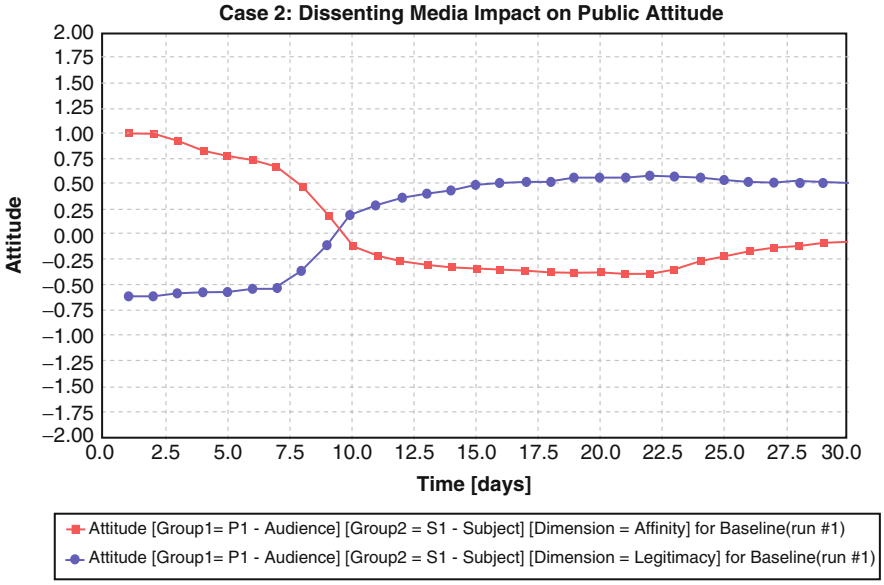

Fig. 13 Case 2 – public attitude impact of dissenting message exposure

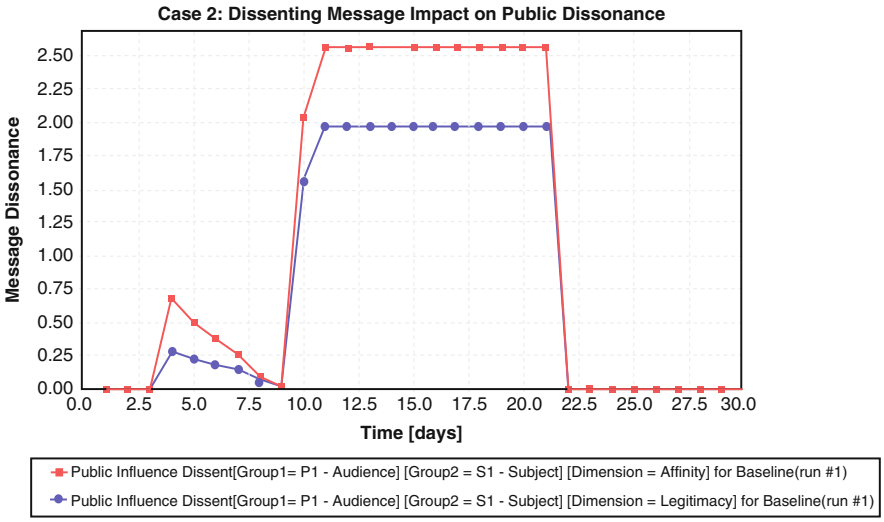

Fig. 14 Case 2 – public exposure to dissonant influence

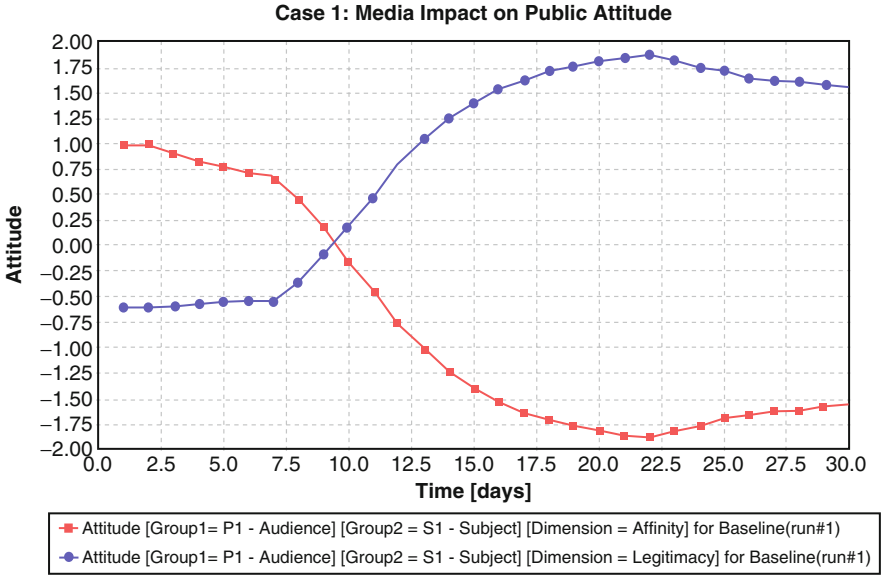

Fig. 15 Case 3 – attitude impact of source distrust

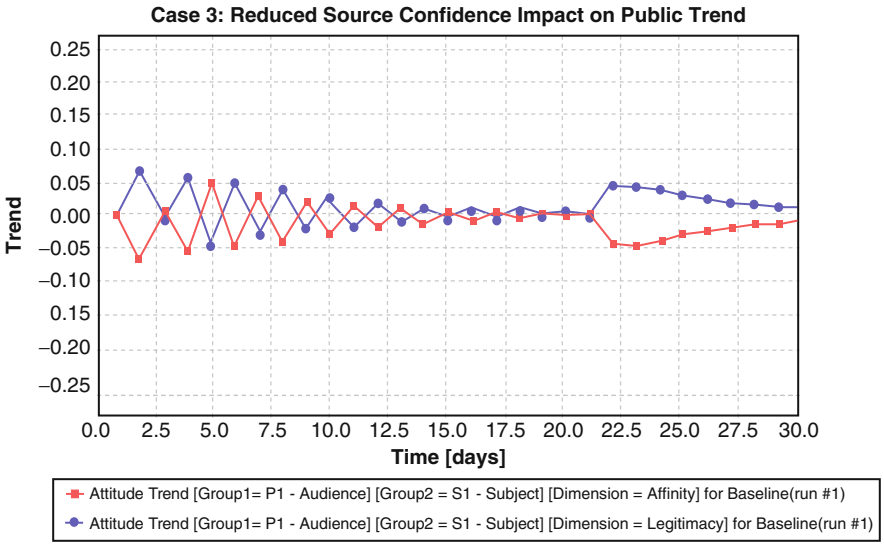

Fig. 16 Case 3 – public trend fluctuations due to source distrust

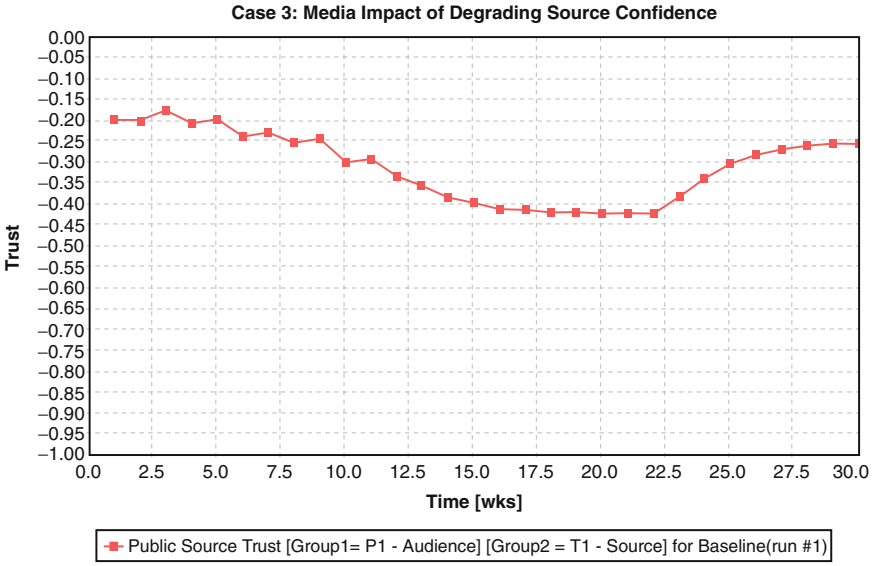

Fig. 17 Case 3 – source confidence degraded

Table 8 Summary assessment

Qualitative state	Case 1	Case 2	Case 3
Target adopts opinion consistent with message tone	Yes, in 21 days	No. Dissonant influence leads to uncertain public opinion	No change in audience opinion
Target reverses opinion toward subject	Yes, in 10 days	Yes, in 10 days	No change in audience opinion
Target interprets and accepts intended message influence	Yes, in 11 days	No. Dissent leads to dissonant influence	No. Influence is inconsistent and counter to message intent
Target adopts 50% trust in source	Yes, in 11 days	No	No. Trust degrades as message intent is rejected

6 Practical Tips

- Begin your modeling project by conducting research to identify the salient themes that resonate in the media within the country or region of interest. Developing an understanding of what will constitute salient media themes for your modeling project will drive much of the modeling process. Your goal at this stage should be to build understanding of the existing public information environment in the client's region of interest. In any country or region having a sophisticated media, the range of themes that may be covered can be vast and change rapidly. Concentrate building your understanding around those themes that are relevant to the client's analytical interest. These may be a blend of political, social, or economic interests that represent regional, national, or district issues.
- Plan to develop an understanding of the client's analytical goals during the early stages of the modeling project. What metrics, level of resolution, and bread of coverage does the client expect to see in the final analytical product. Remember that model will be a tool that will support analytical studies. It may not answer all the analytical questions explicitly, but it should provide insights and derived metrics that enable the client's needs, otherwise the modeling effort will be deemed irrelevant. It is important to set consistent expectations with the client about the time scale of the model validity and to draw out any inconsistencies with the analytical time scale that the client requires. Multiple modeling or model revisions may be necessary to support the client's analytical horizon. Only after you understand the client's analytical goal adequately and the available situational knowledge, can you make an informed value judgment on the modeling fidelity and time scale of validity.
- Plan part of your effort to build a knowledge base to support model instantiation and validation. Place initial emphasis on research to gain an understanding of the breadth of knowledge that is available. The modeling effort should focus on representing the common knowledge to be credible.

Conduct research using credible sources. Be sure to conduct knowledge elicitation from subject matter experts (SME's) who are deemed credible to the client. In many cases, the client will recommend SME's. But be sure to vet any SME's with client before you expend effort to represent their knowledge in the model. Determine the availability of any key SME's and budget your access time wisely.

- Use a combination of broad and shallow analysis to gain confidence with client. Do not push details as single answer analysis. Involve client stakeholders and SME's early in model development and seek to establish an appreciation of the scope and granularity of the modeling process that is consistent with the analytical objectives of the project. Remember that you, the modeler, will soon become a knowledgeable stakeholder in the analysis. Do not neglect your role as analyst. You may become the key SME as you gain insight from model analysis of the domain.
- One key issue in populating any media influence model will involve representing the audience segments and influential media channels to be consistent with available knowledge. You may need to extrapolate from knowledge sources and available data to instantiate an executable model. This baseline model configuration can then form a basis for further elicitation with SME's that will aid in ringing out any inconsistencies or knowledge gaps.
- A substantial aspect of the domain knowledge base will likely be acquired through active elicitation from SME's. Be careful to recognize the knowledge limits of each SME that you engage. The knowledge obtained from any individual SME can often be dated, inaccurate and inconsistent with other SME's. Most SMEs have little appreciation of their own knowledge limitations and have difficulty characterizing the extent of their knowledge uncertainty. Many are uncomfortable with any quantitative representation that may call into question their knowledge. Although the model can often be helpful in reaching consensus on common knowledge, it should not be used as a tool to confront or contest SME's judgments. The model and derived analytic products will be deemed valid if the SME common knowledge is viewed as consistent with the model.
- Analytical studies for clients will most often involve understanding impact of information actions that might contribute to an intervention. Work with the client to understand the nature of information actions that might be taken to shape the media environment in the near to mid-term future. Develop a clear understanding of what types of media shaping actions are to be represented in the analysis. This will aid in selecting the sources and subject that should be represented in the model. Complete this level of representation by conducting research to identify valid knowledge or analytical assumptions about the existing lines of communication from sources to target audiences.
- Conducting research on media channel reach and bias can often require access to data that is proprietary or otherwise restricted. It is important to reach an understanding with the client about the level of model fidelity that can be achieved with available resources. Discuss with the client how the model can be

modified or refined to represent conditional assumptions where data is unavailable or highly uncertain.
- Analytical studies involving models often use multiple models to gain broader insights. Be careful not to mix incompatible assumptions and expect compatible results. Media influence effects are best analyzed via ordinal comparison, either to a baseline reference or between pairs of alternative or competing opinions. Keep in mind the limitations of media influence time scale analysis. Media influence theory has evolved as communication technology has evolved. Any model that pretends to predict influence over decades is fundamentally flawed due to lack of understanding of impact of continual evolution of technical communications and social implication of increasing access to media.

7 Summary

The public information media provides information on current events (news), entertainment (programming), and opinions offered by trusted public sources, e.g., business, academic or religious spokespersons, journalists, and government officials. It is a major force in shaping a populace's attitudes toward significant social issues. Theoretical approaches to media influence include Communication Penetration Theory, Source–Message–Channel–Receiver Model, Opinion Leadership Theory, Social Judgment Theory, Media Agenda-Setting Theory, and Elaboration Likelihood Theory of Persuasion. Computational models make use of the theories and include Rational Choice Model, Social Judgment Computational Model, Public Education and Broadcasting Model, and Elaboration Likelihood Model. For example, the Media Influence Model (MIM) employs a hybrid, computational approach that blends multiagent simulation of communications with a system dynamic model of media influence. This approach models the subjects, sources, audience targets, and media channels that comprise a Public Information Environment (PIE), and relates the causal flow of influences from source statements (in a PIE) to changes in attitudes toward subject actors and to degree of source confidence. The model represents the impact of media outlets on message distortion and the dissemination of media through channels that reach certain public audience segments. Media message content is represented as expressing opinion toward a subject. The message contains sentiment and source attribution. Media effects are computed as media channel sentiment on each of several issues or themes, source statement sentiment and public segment attitude. Three cases illustrate MIM analysis of message influence effects (1) the influence of a public message in which the source has expressed an opinion toward an actor, (2) the target audience is exposed to a dissenting opinion from a second source, (3) an audience that initially harbors distrust toward the source. The timing and extent of influences differ significantly in each case. Although the influence of the media on public opinion can be modeled with credible results, current media models should be viewed as exploratory in purpose.

8 Resources

1. Pointers to modeling and simulation tools

   NetLogo an open source library for ABM,
   http://ccl.northwestern.edu/netlogo/

   Repast an open source library for ABM,
   http://repast.sourceforge.net/

   Swarm, an open source library for ABM,
   http://www.swarm.org/

   VenSim, commercially supported stand alone platform for developing SDM,
   http://www.vensim.com/

   SimBLOX, commercially supported development environment for ABM and SDM,
   http://www.simblox.com/

   AnyLogic, commercially supported development environment for ABM and SDM,
   http://www.xjtek.com/

2. Pointers to data sources for instantiating model of audience segments

   CIA world fact book
   www.cia.gov/library/publications/the-world-factbook

   Conflict Research Consortium
   www.colorado.edu/conflict/peace/treatment/opencomm

   The Pew Research Center for the People & the Press
   http://people-press.org/

3. Pointers to data sources for instantiating models of issues, themes, and public opinions

   The Pew Global Attitudes project,
   http://pewglobal.org/

   Center for Strategic and International Studies,
   www.csis.org

   Freedom House,
   www.freedomhouse.org

   United Nations News Centre,
   www.un.org/News/

   InterMedia,
   www.intermedia.org

4. Pointers to data sources to instantiate models of media outlets and channels

   InterNews
   www.internews.org

Internet World Stats
www.internetworldstats.com

ABYZ News Links
www.abyznewslinks.com

Mondo Times
www.mondotimes.com

The Association for International Broadcasting
www.aib.org.uk

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