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de Vries, Gerdien

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How Positive Framing May Fuel Opposition to Low-Carbon Technologies: The Boomerang Model

Gerdien de Vries

Abstract

Low-carbon technologies are necessary to combat global warming. However, they are often opposed by members of the general public, causing costly delays and cancellations. In this article, I argue that language may be a relevant cause of such opposition. I introduce a theoretical model describing a boomerang effect in which positively framed communication about low-carbon technologies may actually lead to opposition in the long run. An example of positive framing is emphasising the climate benefits of a technology while neglecting to mention associated safety risks. I predict that, over time, people begin to perceive positive framing as an attempt to manipulate them into supporting a technology. In turn, this perceived manipulation may make them feel that their freedom to make their own decision to support or oppose the technology is under threat. To counter this behavioural threat, people may begin to oppose low-carbon technologies. My boomerang model further describes how certain characteristics of the source of information as well as of the recipient may influence both the direct and indirect effects of positive framing. I then discuss the model's implications for effective communication and indicate directions for future research.

Keywords

Framing, public opposition, low-carbon technologies, manipulation, psychological reactance

Corresponding Author:

Gerdien de Vries, PhD

Department of Multi-Actor Systems, Faculty of Technology, Policy and Management, Delft University of Technology, P.O. Box 5015, 2600 GA Delft, The Netherlands

E-mail: g.devries-2@tudelft.nl

Combating global warming is one of the greatest challenges facing the world today (United Nations, 1998; 2012; 2015). Many governments are stimulating the development of low-carbon technologies in order to reduce CO_2 emissions – the most important cause of global warming. These technologies enable us to generate power with substantially lower CO_2 emissions than those emitted by conventional fossil-fuel based power generation. One way of stimulating the development of low-carbon technologies is by reducing and simplifying implementation timelines (IEA, 2013). Despite this assistance, low-carbon energy projects are frequently delayed and sometimes even cancelled (Arentsen, 2006; Brunsting, de Best-Waldhober, Feenstra, & Milkunda, 2011). These delays and cancellations go hand in hand with long-term economic costs and increased climate risks (e.g., den Elzen, van Vuuren, & van Vliet, 2010; IEA, 2013; Luderer et al., 2013).

Public Opposition

A primary cause of delays to many low-carbon energy projects has been public opposition; that is, active resistance from citizens to prevent a project's implementation, ranging from signing petitions and forming or joining activist groups to participating in rallies (e.g., Arentsen, 2006; IEA, 2013). As an illustration, a pilot project for underground CO_2 storage in the Netherlands was cancelled in 2010 due to public opposition (Brunsting et al., 2011; Terwel, Ter Mors, & Daamen, 2012). Opposition also hindered the production of biomass (Negro, Hekkert, & Smits, 2007), the construction of offshore and onshore wind farms (see IEA, 2013; Jolivet & Heiskanen, 2010), and the extraction of shale gas through hydraulic fracturing (Rahm, 2011).

Poor Communication

It is widely known that people oppose the development of low-carbon technologies because of perceived threats to health or safety, economic issues, land-use conflicts, and aesthetic concerns (e.g., Fleishman, De Bruin, & Morgan, 2010; van Egmond & Hekkert, 2012; Wright & Reid, 2011). A less recognised, but still significant, reason for such opposition is poor communication (IEA, 2013) by stakeholders about technologies in terms of both the process and content of the communication.

There is a sizeable body of literature that discusses how poor communication processes can lead to opposition to low-carbon technologies, covering the effects of late dialogue with citizens (e.g., Brunsting et al., 2011), lack of transparency and diplomacy (IEA, 2013), and unfair decision-making procedures (Terwel, Harinck, Ellemers, & Daamen, 2010). However, only recently have researchers begun to empirically investigate specific pitfalls in the use of language (i.e., communication content) in this domain (e.g., de Vries, 2014). This has been inspired by the recent cancellation of low-carbon energy projects such as the aforementioned CO_2 capture and storage project in the Netherlands. It has been suggested that persuasive science communication (i.e., public communications introducing technological or science-related topics to non-experts) was one of the causes of opposition to these projects, as it emphasised environmental benefits while neglecting associated risks (e.g., Brunsting et al., 2011; de Vries, 2014; Terwel et al., 2012). In this article, I will elaborate further on how positive framing in communication concerning low-carbon technologies may lead to public opposition.

Emphasis Framing

Researchers from a variety of disciplines including communication, political science, and social psychology have revealed that in the short term, emphasis framing—presenting information in ways that advance one position over another—can be effective (e.g., Chong & Druckman, 2007; de Vries, Terwel, & Ellemers, 2016; Nelson, Clawson, & Oxley, 1997).[1] For example, people think more positively about CO_2 capture and storage when this low-carbon technology is framed as being beneficial for the climate than when its safety risks are emphasised (de Vries et al., 2016). The positive effects of emphasis framing may have increased the popularity of this persuasion technique among stakeholders aiming to influence their audience to support low-carbon technologies.

Accessibility

Two different cognitive processes can explain the effectiveness of emphasis framing in the studies mentioned above: accessibility and salience (Cobb, 2005). The accessibility process refers to the ease of information retrieval. When people are asked to say whether they would support or oppose a specific technology, for example CO_2 capture and storage, they rely on the information that is most easily accessible to them. Their answer is likely to be positive if, shortly beforehand, a message was presented promoting the environmental benefits of CO_2 capture and storage. They will ignore information related to this technology that they stored earlier, because it costs a great deal of effort to retrieve this information and people are "cognitive misers" – they tend to make as little cognitive effort as possible (Fiske & Taylor, 1991) unless they are closely involved with the topic (Petty & Cacioppo, 1986).

Salience

Salience refers to the process whereby a frame draws attention to a particular aspect of a topic (i.e., the benefits for the environment). This attention temporarily increases the perceived importance and quality of that aspect relative to other aspects (e.g., Nelson, Oxley, and Clawson, 1997). This works especially well when a frame appeals to a particular core value (Brewer, 2001; Cobb, 2005). For example, a frame claiming that CO_2 capture and storage contributes to mitigating global warming increases the salience of the core value 'environmental responsibility'. Increased salience makes this value the best and most important aspect of CO_2 capture and storage compared to other aspects. People who are asked to share their stance on CO_2 capture and storage right after reading this frame will likely give positive responses. This is because people perceive that the most important aspect of this technology is that it may help them to achieve something valuable (i.e., environmental responsibility).

Long-Term Effects of Framing

The cognitive processes of accessibility and salience are both useful for describing the short-term effects of emphasis framing. However, they seem less relevant when considering the long-term effects, about which little is known. To fill this knowledge gap, I propose a model describing a boomerang effect, which occurs after the initial effectiveness of positive framing and eventually leads to public opposition (see Figure 1).

[INSERT FIGURE 1 ABOUT HERE]

The boomerang model demonstrates that, over time, people encounter new information that becomes more salient and accessible than the positive frame they encountered earlier. In the case of CO_2 capture and storage, for example, people may

be exposed to negative messages about safety risks after initially being exposed to only positive claims concerning the climate. The literature on message 'sidedness' indicates that, when people gradually learn that there are two sides to the story, they may begin to suspect that negative claims were strategically omitted the first time. As a result, the source of the original frame is perceived as less credible and the positive, one-sided message becomes less persuasive than intended (e.g., Allen, 1991; Crowley & Hoyer, 1994). In line with this literature, I argue that people perceive positive framing as a manipulative attempt to lend unreasonable support to a technology. This supposed manipulation may easily trigger a perceived loss of freedom to make up their own minds about the technology. This so-called 'psychological reactance' may in turn lead to opposition to the technology—instead of support—because people want to take back control.

In summary, the cognitive processes that explain the short-term effectiveness of emphasis framing do not sufficiently describe the long-term processes. Positive framing in communications relating to low-carbon technologies eventually creates a boomerang effect that generates opposition instead of support. I will elaborate on this boomerang effect in further detail below. Furthermore, I will demonstrate how newly acquired information, expectations concerning sources and characteristics of information recipients may influence the chain of effects.

Contributions of This Article

Scientific Contribution

This article contributes to communication literature in general and framing literature in particular by expanding our knowledge of the cognitive processes underlying the

effects of emphasis framing. More specifically, it considers the long-term effects of one-sided positive framing in communications concerning low-carbon technologies.

Little is yet known about the long-term effects of framing. Most research in this field consists of one-shot experiments conducted within the controlled environment of a laboratory. The lack of longitudinal field studies is due to the fact that these are difficult to carry out. For example, it is difficult to statistically isolate the causes of shifts in people's attitudes or behaviour. If you present people with positively framed information about a low-carbon technology at a certain point in time, it is difficult to confirm or disconfirm that opposition months later was caused by the original frame. Other factors may (also) have caused that opposition. Furthermore, it is difficult to monitor the volume, direction and power of communication concerning low-carbon technologies that people encounter in their daily lives. However, in order to assess the influence of positive framing in the long term, researchers must take the effect of these communications into account.

In this article, I formulate hypotheses regarding the psychological processes triggered by emphasis framing in the long term and discuss research for testing these hypotheses.

Societal Contribution

This article investigates a relatively obscure, yet relevant potential trigger of opposition to low-carbon technologies: positive framing. Such investigation is necessary due to the fact that public opposition is a primary cause of delays to low-carbon energy projects, which are very costly for society in terms of both money and climate risk (e.g., den Elzen et al., 2010; IEA, 2013; Luderer et al., 2013).

Examining positive framing as a potential cause of opposition may help low-carbon technology stakeholders to improve their science communication. Effective communication may in turn enable citizens to make a well-informed decision as to whether to support or oppose a given technology. Of course, well-informed citizens may still offer opposition, for instance if they perceive a technology to be a threat to their health or safety. However, it can be argued that it is better for opposition to be fuelled by reason rather than emotion (Zhang, 2014).

Boomerang Model

Perceived Manipulation

The first stage of the boomerang model describes the effect of emphasis framing in creating perceived manipulation. More specifically, I argue that people feel manipulated when they are presented with information about a low-carbon technology that emphasises only the advantages, while known risks go unmentioned.

Support for this assertion comes from two series of experimental studies on the effects of framing in communications regarding CO_2 capture and storage (de Vries, Terwel, Ellemers, & Daamen, 2015; de Vries et al., 2016). The first study revealed that participants felt significantly more manipulated when presented with a one-sided news article that emphasised either only the environmental benefits or only the safety risks of a low-carbon technology, than when presented with a balanced article that explained both the environmental benefits and the safety risks (de Vries et al., 2016).

The second study focused on the persuasive framing technique of ‘corporate greening’, which involves presenting reasons for investing in low-carbon energy projects based on environmental friendliness (de Vries et al., 2015). Stakeholders such

as oil and gas companies may ‘green’ these investments because they anticipate positive effects on support of projects as well as on their reputation (Alniacik, Alniacik, & Genc, 2011; Sen & Bhattacharya, 2001). The greening study tested the hypothesis that greening can have a backfire effect and may lead to a perception of being manipulated (i.e., ‘greenwashing’). The rationale behind this hypothesis is that industrial investments in low-carbon technologies are typically regarded as being driven by self-serving motives—such as profitability—instead of public-serving motives such as caring for the environment (Spangler & Pompper, 2011; Terwel, Harinck, Ellemers, & Daamen, 2009a). The results of the study clearly demonstrate that people feel manipulated when industrial stakeholders frame their involvement in low-carbon technologies positively. Interestingly, the results indicate that, even without any public communication on the matter, people become sceptical when organisations whose primary function is producing energy by burning fossil fuels adopt low-carbon technologies (de Vries et al., 2015).

Taken together, these two studies support the contention that emphasis framing may lead to perceived manipulation. However, these studies consisted of a series of one-shot experiments and the participants’ perceived level of manipulation was assessed immediately after the frames were presented. The question remains as to whether in the long term these perceptions remain constant, weaken or become stronger. I posit that they become stronger based on the indication that, over time, people get better at recognising and evaluating attempts at persuasion, including framing. This is partly due to wider personal experience (Friestad & Wright, 1994). The extent to which attempts at persuasion are perceived as manipulative depends on factors such as the motives people anticipate for persuasion, their cognitive capacity, and their dispositional scepticism (e.g., Campbell & Kirmani, 2000; de Vries et al.,

2015, 2016). However, since people perceive emphasis framing to be fairly manipulative even in one-shot laboratory experiments, it is likely that they would perceive positive framing in actual communication relating to low-carbon technologies to be strongly manipulative in the long term, especially after encountering other attempts at persuasion or learning about a technology's risks from other sources.

In summary, I assert that, in the long term, people perceive positive framing of low-carbon technologies as being manipulative.

Psychological Reactance

The second stage of the boomerang model describes how perceived manipulation may lead to psychological reactance.

Psychological reactance is a form of emotional arousal that is often activated after individuals experience a threat to a behavioural freedom. This arousal—a combination of anger and negative cognitions—motivates people to protect and restore the threatened freedom (Brehm & Brehm, 1981; Burgoon, Alvaro, Grandpre, & Voulodakis, 2002; Dillard & Shen, 2005).

I contend that people experience a threat to their freedom to make their own decision to support or oppose a low-carbon technology when they feel manipulated into approving of it. I am not aware of any research investigating this having been conducted in relation to low-carbon technologies in particular. However, there is some support from research carried out in the domain of healthcare. An experimental study on campaign messages promoting organ donation showed a moderate correlation between perceived manipulation and reactance ($r = .64$, $p < .01$). In this study, students who read information describing what happens if you do not sign up to be an organ donor (a loss-framed message) reported stronger perceptions of manipulative

intent and higher levels of psychological reactance than those who read information describing what happens if you do sign up as a donor (gain-framed message: Reinhart, Marshall, Feeley, & Tutzauer, 2007).

The organ donation study did not investigate any causal relationships between perceived manipulation and psychological reactance. Therefore, the question remains as to whether perceived manipulation leads to reactance or vice versa. That being said, the literature is clear about the fact that perceptions of being manipulated are often the cause—instead of the consequence—of a range of unfavourable effects (Campbell, 1995). This strengthens my assertion that psychological reactance is the consequence of perceived manipulation instead of the other way around.

Therefore, I argue that people experience psychological reactance when they perceive positive framing of low-carbon technologies as being manipulative.

Public Opposition

The final stage of the boomerang model describes how psychological reactance may create public opposition to low-carbon technologies.

Reactance theory states that the adverse state of arousal that is activated by behavioural threats motivates people to restore their freedom (Brehm & Brehm, 1981; Burgoon et al., 2002). This can be accomplished by means of cognitive reorganisation, for instance by evaluating omitted information (i.e., the risks associated with a given low-carbon technology) more positively than the frame presented (i.e., the advantages of the technology). However, restoration of freedom can also be accomplished by rebelling or exhibiting opposition (Brehm & Brehm, 1981).

I will attempt to respond to a gap in our knowledge in this area by focusing solely on public opposition as an effect of psychological reactance—instead of broadening the focus out to take account of attitudes or opinions—and by defining my use of the term 'public opposition' more clearly. I use this term to refer to active resistance by citizens to prevent the implementation of a project, ranging from signing petitions and forming or joining activist groups to participating in rallies. Devine-Wright (2007) has been urging researchers to be clear about what measures they use in research on low-carbon technologies and to stop using measures and terms interchangeably, because it complicates translating valuable research findings into practice, since some practitioners are under the false impression that the different terms and measures mean the same.

There are two reasons for my focus on public opposition. Firstly, as described earlier, public opposition has been specifically identified as a primary cause of low-carbon technology projects being delayed or cancelled (IEA, 2013). This makes it more socially relevant to investigate the causes of opposition than, for example, the causes of public attitudes. The second reason is more scientific than social; empirical evidence of the effects of psychological reactance on opposition to low-carbon technologies is lacking, but there is already some scientific support for its effects on attitudes (Terwel, Harinck, Ellemers, & Daamen, 2009b).

Despite the lack of empirical evidence, there are indications that psychological reactance may fuel opposition to low-carbon technologies. For example, the previously mentioned organ donation study implies that people are less willing to become a donor in the future due to reactance (Reinhart et al., 2007). Furthermore, reactance can explain the discovery that people actually drink more after being warned about alcohol consumption (Ringold, 2002). Similarly, reactance has been

identified as the reason why consumers avoid the advertisers behind pop-up advertisements on the internet (Edwards, Li, & Lee, 2002).

Although other processes may come into play when deciding whether to become an organ donor, drinking alcohol or buying products on the internet than when deciding whether to support or oppose low-carbon technologies, these studies provide some support for the notion that people will oppose low-carbon technologies if they experience behavioural threat.

Hypotheses on Direct and Indirect Effects

Based on the arguments above, I have formulated three hypotheses to test the boomerang model:

> *Hypothesis 1:* Positively framed information on low-carbon technologies is perceived as being manipulative.

> *Hypothesis 2:* Psychological reactance occurs when positively framed information on low-carbon technologies is perceived as being manipulative.

> *Hypothesis 3:* Psychological reactance resulting from perceived manipulation leads to opposition to low-carbon technologies.

Moderators of the Boomerang Model

The hypothesised direct and indirect effects of positive framing do not only depend on the content of a given frame, they also interact with certain characteristics of the frame's source and recipient. This relationship can be explained by dual process

models such as the heuristic-systematic model (Chaiken, 1980) and the elaboration likelihood model (Petty & Cacioppo, 1986). These models suggest the existence of two routes of information processing: a systematic (or central) route and a heuristic (or peripheral) route. Information that is processed systematically mainly persuades people because of its content, due to the accessibility and salience of such frames. In contrast, heuristically processed information persuades people as a result of peripheral cues that ease the recipient's cognitive load, such as cues about the source of the frame. People are more likely to process information heuristically when they are less involved with the topic, or when they are not particularly motivated or able to process the information (Chaiken, 1980; Petty & Cacioppo, 1986).

Characteristics of the Source

Although the influence of the source of a frame is particularly strong when the frame is processed heuristically (Pornpitakpan, 2004), characteristics of the source always play an important role in how information about low-carbon technologies is perceived and evaluated (e.g., de Vries et al., 2015, 2016; Rabinovich, Morton, & Birney, 2012; Ter Mors, Weenig, Ellemers, & Daamen, 2010; Terwel et al., 2009a).

People's expectations in relation to a given source may be one of the drivers of the predicted framing effects. For example, research indicates that people find it highly manipulative when oil and gas companies positively frame CO_2 capture and storage as an environmentally friendly technology, although they accept being manipulated because they expect this type of source to deliberately frame their messages (de Vries, 2014; de Vries et al., 2016).[2] In contrast, when news agencies emphasise the climate benefits of CO_2 capture and storage, people consider this

perceived manipulation to be unacceptable because news agencies are expected to cover issues in an unbiased manner (de Vries, 2014; de Vries et al., 2016).

In brief, I suggest that expectations of particular sources moderate the impact of positive framing on perceived manipulation, to the extent that when a source is expected to emphasise certain aspects of a technology in its communications, the impact is weaker than for sources that are expected to provide balanced, two-sided information.

Characteristics of Recipients

Differences between individuals, such as how closely involved they are with low-carbon technologies or how prone they are to psychological reactance, can make them more or less sensitive to the effects of positive framing, as described in the boomerang model (e.g., Petty, Cacioppo, Strathman, & Priester, 2005).

Involvement

As demonstrated by dual process models, level of involvement determines the extent to which information is processed. Closer involvement leads to deeper (i.e., more systematic) processing (Chaiken, 1980; Petty & Cacioppo, 1986). Therefore, communications concerning low-carbon technologies are likely to be processed more systematically by individuals who are closely involved, for instance residents who live near a (proposed) energy production site or people who work on a technology, than by individuals who are less concerned or affected. Because systematic processing can limit the power of framing (Brewer, 2001; Joslyn & Haider-Markel, 2002), this supports the likelihood that the effect of positive framing on perceived manipulation would be weaker for those who are closely implicated.

However, local residents are generally more likely to oppose low-carbon energy projects in their municipality than support them, because they often believe that property values will fall and that accidents could occur (Terwel et al., 2012). As a result of selective exposure—the tendency to pay attention to arguments that support existing views while ignoring information to the contrary—local residents may be highly focused on arguments against the technology in question (Frey, 1986; Hart et al., 2009; Smith, Fabrigar, & Norris, 2008). Consequently, they may perceive science communication regarding the technology that emphasises benefits but ignores risks as being strongly manipulative. The effect of framing on manipulation is therefore likely to be stronger rather than weaker for people who are closely involved. On the other hand, people who work on a technology and are positive about it may focus more on positive information than negative also due to selective exposure and perceive less manipulation when confronted with positively framed information than people who are less involved.

In short, I predict that level of involvement in a technology does affect the impact of framing on perceptions of manipulation, although research is needed to explore whether (and when) it makes the effect stronger or weaker.

Reactance Proneness

Another characteristic of information recipients that is likely to interact with the boomerang model is how prone they are to reactance. Psychological reactance was originally regarded as a situation-specific state; however, it was later determined that some people are more likely to exhibit psychological reactance than others based on four characteristics. These characteristics are: (1) level of emotional response to the restricted option (i.e., supporting a low-carbon technology), (2) level of reactance to

compliance, (3) ability to resist the influence of others, and (4) level of reactance to advice and recommendations (Shen & Dillard, 2005). Based on this research, I posit that the effect of perceived manipulation from framing on psychological reactance will be stronger on people who are more prone to reactance than those who are less prone. Therefore, reactance proneness strengthens the effect of perceived manipulation on reactance.

Hypotheses on Moderating Effects

I have formulated three hypotheses to test the predicted moderating effects of source and recipient characteristics in the boomerang model:

> *Hypothesis 4:* The predicted effect of positively framed information on perceived manipulation is weaker when the source of the information is expected to frame than when the source is not expected to frame.

> *Hypothesis 5:* The level of an individual's involvement with a low-carbon technology affects the impact of positive framing on perceived manipulation.

> *Hypothesis 6:* The predicted effect of perceived manipulation from positive framing on psychological reactance is stronger for people who are more prone to reactance than those who are less prone.

Discussion

This article introduces a theoretical model—the boomerang model—that identifies positive framing (in this case, emphasising climate benefits) as a potential cause of

public opposition to low-carbon technologies. This is relevant because public opposition has been identified as a primary cause of costly delays to and cancellations of low-carbon technology projects. The predicted long-term effect of positive framing is that the underlying psychological response is to feel manipulated into supporting a technology when presented with a one-sided positive frame. This, in turn, supposedly threatens people's freedom to decide for themselves whether to support or oppose the technology. The boomerang model further describes how people's expectations of a source of information and their own personal characteristics may weaken or strengthen the impact of positive framing.

The boomerang model helps to create a useful roadmap for how the science of language can improve how scientific language is translated into communication to inform different types of stakeholders, including scientists, the general public and policymakers (the purpose of this Special Issue). This roadmap is needed because, to date, little attention has been devoted to how language shapes public reactions to the advantages offered by new science and technology. The contribution of this article is to apply scientific knowledge about the effects of language in a theoretical model dealing with the impact of framing on public reactions to low-carbon technologies.

The boomerang model focuses on the potential long-term effects of emphasis framing in relation to low-carbon technologies. However, it can be argued that the processes outlined in the model also apply to other complex, controversial technologies including robotics, drones, nanotechnology and genetically modified (GM) food. These technologies, too, are strongly debated in the public domain by proponents and opponents with similar interests to those involved with low-carbon technologies. Furthermore, framing effects have indeed been identified for these other types of technology (Cobb, 2005; Druckman & Bolsen, 2011). In the case of less

complex or controversial issues, different effects may be at work. This is because it is easier for people to form an opinion about these issues, and they may feel less manipulated by one-sided messages in these areas.

It should be noted that the predicted boomerang effect of positive framing in my model may also occur for negative framing. Research indicates that when, for example, activist groups focus only on the risks associated with a low-carbon technology while neglecting the benefits, citizens can perceive this as being just as manipulative as when only benefits are conveyed (e.g., de Vries et al., 2016).

Future Research

In order to test the hypotheses derived from the boomerang model, it is necessary to investigate causal framing effects in the long term. Although this is a challenging area to examine, as discussed above, I will suggest directions for tackling it.

An effective way of testing long-term causality is by means of a longitudinal randomised experiment. In a typical experiment of this type, participants are randomly assigned to one of two groups. One group receives an experimental treatment, while the other receives no treatment (control condition). After this stage, participants are monitored for a certain length of time and frequently surveyed.

In order to test, for example, the effects of positive framing in communication relating to low-carbon technologies, a representative sample of members of the public could be divided into two groups, one of which is presented with a positive framing of a technology while the other group receives no information. Subject pairs could be matched in terms of proneness to reactance and level of involvement with the technology, since those characteristics are expected to interact with the effects of positive framing.[3] Participants' perceptions of manipulation and level of psychological

reactance could be frequently assessed, in addition to their level of opposition to or support of the technology. Validated scales could be used to assess perceived manipulation and psychological reactance (e.g., Reinhart et al., 2007). Public opposition could be operationalised according to the definition put forward above.

It is also important to monitor the volume, direction, power, and source of communications relating to the technology that participants encounter during the research period. This is because learning about the technology's risks is a potential contributor to perceived manipulation. Communications encountered could be monitored using mobile diaries; participants could record and code all such encounters on their smartphone, for instance. I am not aware of any framing research that has used mobile diaries, but diaries are a frequently used tool in clinical psychology research.

Finally, it would be useful to also assess participants' concerns regarding threats to health or safety, economic issues, land-use conflicts, and aesthetics in relation to the technology. Such concerns are well-known causes of opposition to low-carbon technologies (e.g., Fleishman et al., 2010; van Egmond & Hekkert, 2012; Wright & Reid, 2011).

Implications

Although it first needs to be tested, the boomerang model raises awareness of certain pitfalls in communication concerning low-carbon technologies. The processes outlined in the model indicate that stakeholders in favour of these technologies should be cautious about using positive framing to avoid unwanted opposition. Communication may be more effective when arguments in favour of a technology are balanced with opposing arguments. Two-sided messages have the potential to be more

persuasive and can lead to positive long-term effects, such as increased trust in the source (e.g., Crowley & Hoyer, 1994; de Vries et al., 2016; cf. Terwel et al., 2009b). However, balanced messages also have their pitfalls and can even appear to be propaganda (i.e., persuasion under the cover of education: Jowett & O'Donnell, 2012).

Effective science communication may help citizens to make well-informed decisions on whether to support or oppose low-carbon technologies, but, as stated above, well-informed people may still offer opposition. However, the public debate will become fairer when opposition is fuelled by reason instead of emotion. Moreover, some types of individual may support low-carbon technologies when well-informed but oppose them when poorly informed. Therefore, effective science communication could increase the net amount of public support for low-carbon technologies, which may in turn reduce costly delays and cancellations. The boomerang model may help to achieve effective communication.

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Notes

1. Another well-known type of framing is equivalency framing. Equivalency framing refers to ways in which logically equivalent alternative phrases (e.g., "75% fat free" versus "25% fat") can lead to different effects (e.g., Levin, Schneider, & Gaeth, 1998; Tversky & Kahneman, 1981).
2. Oil and gas companies are perceived as being less manipulative when they frame their involvement in low-carbon technologies in terms of their responsibility to innovate and maintain prosperity than in terms of commitment to the environment (de Vries et al., 2015). Although both frames favour the technology in question and relate to core values, the first frame is more credible and in line with what people expect from this type of organisation than the latter one (e.g., de Vries, 2014; Terwel et al., 2009b).
3. A matched pairs design can be used when an experiment has only two treatment conditions and when it is useful to have an equal distribution of certain characteristics. Subjects are grouped into pairs based on these characteristics. Within each pair, subjects are randomly assigned to different treatments.

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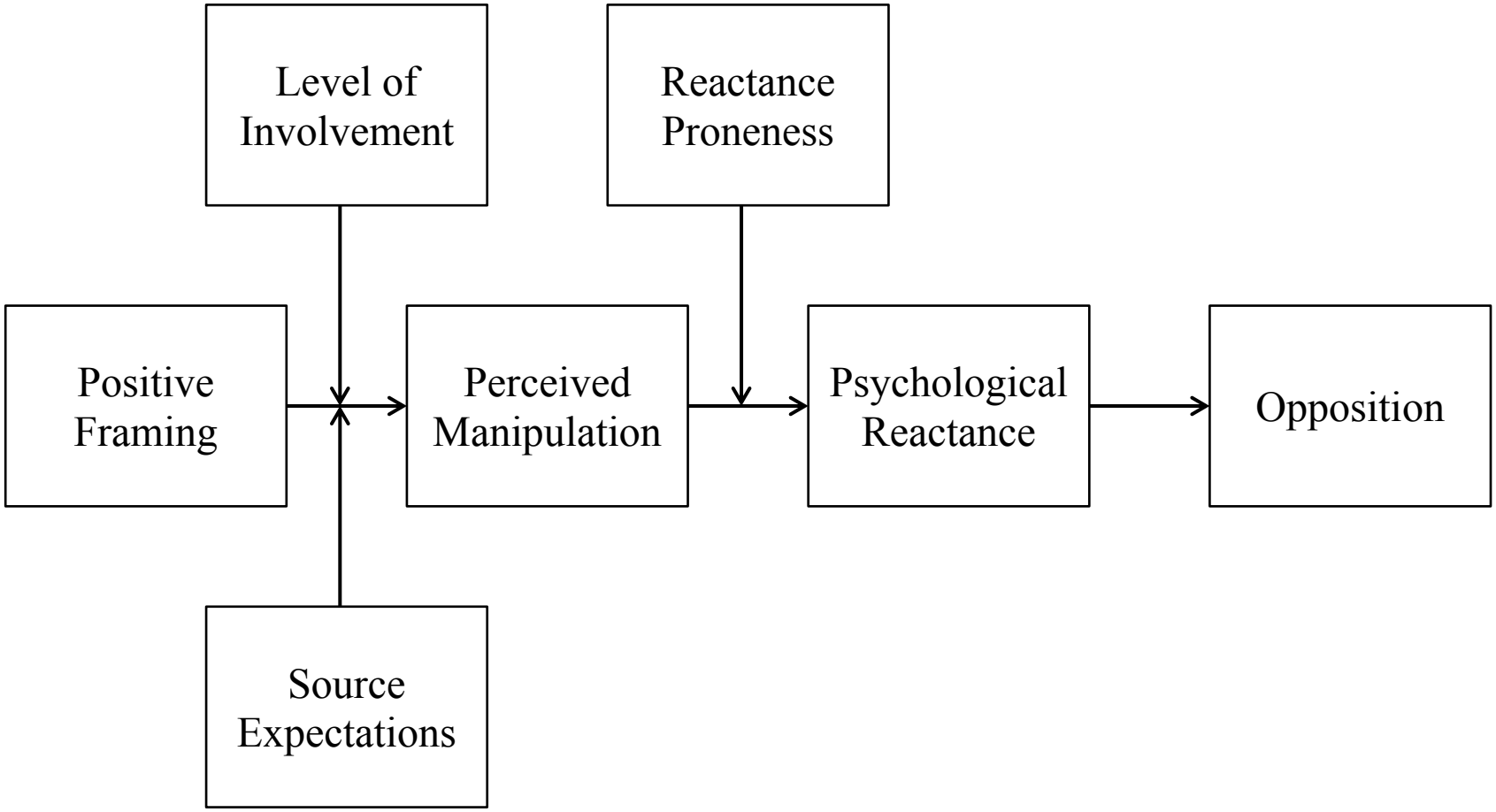

Figure 1. The boomerang model, showing direct and indirect effects of positive framing on public opposition due to perceived manipulation and psychological reactance, moderated by source expectations, level of involvement and reactance proneness.

Author biography

Gerdien de Vries is Assistant Professor of Organisation and Public Management at Delft University of Technology in the Faculty of Technology, Policy and Management. She has an MPhil in Social and Organisational Psychology, and a PhD in Social and Behavioural Sciences. Her research centres on the use of persuasion techniques in interactions between stakeholders of large socio-technical systems. She also trains policy officers and communications professionals in the application of behavioural insights in policymaking.