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## **Strategic Cognition in Transition? Individual Mental Model Renewal in the Energy Sector**

### **ABSTRACT**

A turbulent environment requires organizations to adjust their strategy to changing circumstances. Accordingly, the managers responsible for strategic change need to make timely adjustments to their mental models. This study contributes to the managerial cognition literature by showing a process of mental model renewal and by revealing how this is affected by individual characteristics. We examine mental models in the turbulent Dutch energy industry and investigate why managers in this industry renew their mental model to different extents. To measure individual mental model renewal we use a staged approach. First, content analysis of newspaper articles on the energy transition reveals the variety of mental models that exist in this domain. Second, analysis of strategy workshops with 96 managers from that industry shows that these strategy workshops invoke different levels of mental model renewal. We find that overall, the strategy workshops result in mental model convergence. While general experience is not of influence, energy industry specific experience has a negative effect on mental model renewal.

### **Keywords:**

Mental models, cognition, strategy, change, causal mapping

## Strategic Cognition in Transition? Individual Mental Model Renewal in the Energy Sector

### INTRODUCTION

Managers *strategize*: they scan their organization's environment and based on the trends they perceive they look ahead and make plans 'for the longer-term survival and well-being of the organization' (Hodgkinson & Sparrow, 2002: xv). While this strategizing process is oriented towards the future, the outcome of the process depends on a manager's past (Weick, 1995: 24). Based on personal experiences managers may or may not *notice* certain trends and when noticed, their experiences influence what *meaning* they give to them (Daft & Weick, 1984; Thomas, Clark, & Gioia, 1993). These experiences accumulate in a cognitive construct that determines how environmental factors and a manager's plan for the future interrelate and this construct is called a manager's *mental model* (Kaplan, 2011; Narayanan, Zane, & Kemmerer, 2011; Walsh, 1995). These mental models have been shown to have a strong link with strategic action (Barr, 1998) and performance (Barr, Stimpert, & Huff, 1992; Gary & Wood, 2011; Kabanoff & Brown, 2008).

Previous research shows that mental models can be *enduring*. Numerous studies have shown how mental model renewal remained absent while an organization's environment changed drastically (Porac, Thomas, & Baden-Fuller, 1989; Hodgkinson, 1997; Tripsas & Gavetti, 2000; Serman, 1987). Holding on to mental models while they are no longer appropriate has been shown to explain strategic failure in a variety of industries (Barr, 1998; Gary & Wood, 2011; Hodgkinson, 1997; Kabanoff & Brown, 2008; Tripsas & Gavetti, 2000). Previous research also shows that, in opposition to enduring, mental models can be *renewed* (Barr, 1998; Barr et al., 1992), and various methods have been developed with the goal of supporting this mental model renewal. Interventions like a causal mapping task may help decision makers to 'break their

frame' (Hodgkinson, Bown, Maule, Glaister, & Pearman, 1999). In the present research, instead of studying either the absence or the presence of mental model renewal, we focus on different levels of mental model renewal on the level of individual managers. Our theoretical contribution consists of revealing how individual characteristics explain different levels of mental model renewal.

Our study is novel in its use of a staged approach based on content analysis as well as an analysis of strategy workshops. To know what the mental models that we want to study look like we qualitatively take stock of the variety of mental models in a first study. We use the outcome of this first study as a basis for measuring mental model renewal during the analysis of strategy workshops that forms our second study. To research mental model renewal in the second study we analyze 96 managers participating in facilitated strategy workshops in which they collaboratively construct causal maps. By analyzing such workshops we answer the call for work on "the process of frame breaking and the conditions under which it occurs" (Narayanan et al., 2011: 338). We provide a middle ground between descriptive field studies on the one hand and controlled experiments on the other by involving a large number of managers from the field in strategy workshops that were specifically designed for this research.

## **THEORETICAL BACKGROUND**

### **Similarities and Dissimilarities in Mental Models in a Turbulent Environment**

When strategizing, managers rely on their simplified understanding of the organization's environment, or mental model (Narayanan et al., 2011). This simplification is functional because the environment is extremely complex and ambiguous (Walsh, 1995), while individuals have limited data processing capabilities (Simon, 1947). Besides, managers do not need a full understanding of the environment to formulate a strategy that is 'good enough' (Cyert & March,

1963). Mental models as such save time and prevent managers to suffer from information overload (Hodgkinson & Sparrow, 2002). Despite these important functions in strategizing, mental models may become dysfunctional when these simplifications are no longer accurate (Barr et al., 1992). Especially in a turbulent environment mental model renewal becomes crucial: "...strategic mistakes are most likely to occur in turbulent environments because mental models are not updated quickly enough to keep pace with environmental change" (Reger & Palmer, 1996: 36, see also Nadkarni & Narayanan, 2007). The turbulence provides a signal that a sector is close to a 'strategic inflection point', after which the 'rules of the game' change, making strategies based on the former circumstances obsolete (Burgelman & Grove, 1996; 2007). Strongly held beliefs may be rendered obsolete by changing circumstances (Hodgkinson, 1997). Making the right adjustments to mental models in such a context is difficult because managers are confronted with an increasing amount of new information and these new cues are often equivocal, they can simultaneously have multiple meanings (Daft & Weick, 1984; Thomas et al., 1993). Because of the number of new cues with multiple meanings, we expect managers to develop dissimilarities in their mental models. Therefore we expect to find substantial dissimilarities in mental models in a turbulent environment.

Besides dissimilarities, we also expect to find substantial similarities in mental models in a turbulent environment. Several studies showed how mental models remained the same, even in drastically changing environments (Porac et al., 1989; Hodgkinson, 1997; Tripsas & Gavetti, 2000; Sterman, 1987). An important process explaining similarities in mental models is the social influencing process consisting of both formal and informal communication between managers. Because of this process, their mental models become more similar over time (DiMaggio & Powell, 1983; Chattopadhyay, Glick, Miller, & Huber, 1999). This process takes place in teams, organizations, and industries as a whole (Spender, 1989). Through communication the manager's

mental models influence each other (Salancik & Pfeffer, 1978), leading to a certain level of *shared cognition* (Mohammed, Ferzandi, & Hamilton, 2010). In a process of collective sensemaking managers discuss which trends are important and what meaning they should attach to these trends (Weick, 1995). Research showed that shared cognition leads to the emergence of *strategic groups* within an industry, groups of organizations of which the managers have similar mental models (Osborne, Stubbart, & Ramaprasad 2001; Porac et al., 1989). Although convincing examples of shared cognition and strategic groups have been described (Mohammed et al., 2010; Osborne et al., 2001; Porac et al., 1989; Reger & Huff, 1993; Weick, 1995), other research points at a lack of any homogeneity in mental models within or across organizations (Johnson, Daniels, & Asch, 1998). Whether strategic groups with similar mental models do or do not exist therefore remains an open question, even in stable environments (Hodgkinson & Sparrow, 2002).

In a turbulent environment processes of social influence may drive similarities in mental models, while the high number of equivocal cues may drive dissimilarities. Based on the research described above therefore, we expect to find a limited set of coexisting mental models in a turbulent environment. Hence, we hypothesize the following.

*Hypothesis 1: There is limited dissimilarity in mental models in a turbulent environment*

### **The Influence of Experience on Mental Model Renewal**

In this section we use the results of previous research on mental models to develop hypotheses on why managers differ in the extent to which they renew their mental models. Several studies have sought to explain why mental models may endure over time and from these studies we take that a manager's *experience* is an important factor explaining low levels of

mental model renewal. Below we discuss three arguments why experience influences individual mental model renewal. After discussing these three arguments, we distinguish between *general experience*, and *industry specific experience*.

A first argument is that managers use their past experience in the form of *reference points*. A study of the accuracy of inflation expectations shows how economists are biased towards their long-term experience of inflation (Sterman, 1987, 2000). Since 1946, economists provide expectations of inflation for the Livingston survey, named after the financial columnist that started conducting the survey (Carlson, 1977). While new information about a variety of economic variables becomes available to these economists every day, their expectations can to a large extent be explained by their past experience of inflation (Sterman, 1987). This process where expectations are biased towards reference points from the past is called ‘anchoring and adjustment’, the expectation is anchored on past experience and new information is only used to make small adjustments to that anchor. The anchor itself does change over time but because these changes are very small the analogy is made to a ‘sea anchor’, one that is not attached to the bottom of the sea and allows small movements of the ship (Sterman, 2000: 650). In this context mental models appear to change with new information becoming available, but at a very slow pace because of the prominence of reference points from the past. This is in line with the findings of Clarke and Mackaness, who suggest that senior managers use earlier decisions and analogies to simplify the information that they are confronted with (Clarke & Mackaness, 2001: 166).

A second argument is that managers *filter the cues* they receive from their environment based on their beliefs. A study of the Scottish knitwear industry in the eighties of last century shows how beliefs on business competition remain stable over time because these beliefs “constrain the flow of information back to decision-makers, thereby limiting their vision of the marketplace to that which has already been determined by existing beliefs” (Porac et al., 1989:

412). Managers in the Scottish knitwear industry focused on selling premium quality, expensive garments to high income consumers and adopted a narrow conception of competitive space that fitted this strategy: top quality garment suppliers. “This business definition reinforces and is reinforced by beliefs about the marketplace” (Porac et al., 1989: 406). In this context mental models are reinforced because they determine the cues that managers take into account when scanning their organization’s environment. This argument is supported by Reger and Palmer (1996: 34). After studying cognitive change in the financial intermediary industry they speculate that endurance of mental models may be caused by “interference from previous learned recipes (Spender, 1980), and routinized ways of thinking (Nelson & Winter, 1984)”.

A third argument is that managers *restrict their search pattern* for new solutions based on past experiences. While radical change in technology revolutionized the digital imaging industry, Polaroid lost its competitive advantage because they did not alter their beliefs on the appropriateness of their razor/blade business model (Tripsas & Gavetti, 2000). Because senior managers believed in their traditional business model they constrained efforts to develop capabilities that were not consistent with that belief. Although Polaroid possessed the technological capabilities necessary to compete in the digital imaging industry, they weren’t able to capitalize on these capabilities because senior managers held on to their prior business model (Tripsas & Gavetti, 2000: 1157). In this context mental models are enduring because they restrict the search pattern that falls outside the deep beliefs.

These three arguments have been found to contribute to the enduring character of mental models: managers use past experience as a reference point, they neglect cues that do not fit their mental model, and they restrict the search for new solutions. All three arguments have to do with time: over time managers accumulate experiences and these translate into reference points, rules of thumb, and proven recipes. Managers differ in this respect, some managers may have much

more experience than others. This may explain why “some managers adopt new mental models faster than others” (Reger & Palmer, 1996: 34). We reason that the more experience a managers has, the larger his or her reservoir of reference points, rules of thumb, and proven recipes, the more enduring his or her mental model is. The more experience a manager has, the more information is available to use as a reference point, the more time there was for ways of thinking to become routinized, and the more time there was for the results of actions to feed back to form a proven recipe. We differentiate between two types of experience: general experience and industry specific experience. Some scholars argue that managers use experience from other industries to make analogies, supporting decision-making in the industry they are currently working in (Gary, Wood, & Pillinger, 2012). General experience in that sense supports analogical transfer between new issues and previous issues from other industries. Other scholars argue that it is industry specific experience that supports a manager’s decision-making (Spender, 1989). Industry specific experience in that sense supports analogies between new issues and previous issues *within* the industry. We therefore hypothesize the following:

*Hypothesis 2a. A manager’s mental model renewal is negatively related to his or her general experience.*

*Hypothesis 2b. A manager’s mental model renewal is negatively related to his or her industry specific experience.*

### **The Influence of Collaborative Causal Mapping on Mental Model Renewal**

One way of initiating mental model renewal is for managers to engage in procedures that explicitly address their mental model. Numerous studies show how mental model renewal may be

aided with causal mapping, the drawing of cause-effect relations between variables (Axelrod, 1976; Eden & Ackermann, 1998; Huff, 1990; Markoczy & Goldberg, 1995; Narayanan & Fahey, 1990; Nicolini, 1999). The mere act of drawing causal relations has been shown to reduce reliance on existing frames, because it requires the manager to reflect on his or her patterns of thought (Hodgkinson et al., 1999). Causal mapping can also be done collaboratively in the form of workshops where facilitators help participants in following the procedures (Andersen & Richardson, 1997; Rouwette, Korzilius, Vennix, & Jacobs, 2011; Rouwette, Vennix, & Mullekom, 2002; Vennix, 1996, 1999). A strategy workshop as such facilitates collective sensemaking, acting as a catalyst for the process of social influence in which managers discuss which trends are of importance and what meaning they should attach to these trends (Weick, 1995).

Several scholars question the seemingly instrumental nature of strategy workshops. While the espoused purpose of these meetings may be to address strategic issues, in practice such events can be seen as highly ritualized procedures functioning to establish or confirm a social order between the participants (Eden, 1992; Johnson, Prashantham, Floyd, & Bourque, 2010). By suspending everyday routines, the usual hierarchical relations may be set aside while new relations may emerge (Hendry & Seidl, 2003). Even if such meetings produce outcomes that participants deem relevant within the context of the meeting, the question remains whether these outcomes have any value beyond the context of the meeting itself (Johnson et al., 2010, p. 1611). With outcomes of the meeting not implemented, the meetings run the risk of contributing to participants becoming cynical (Hodgkinson, Whittington, Johnson, & Schwarz, 2006).

We expect strategy workshops to facilitate mutual persuasion, with the result that the mental models of the participants renew and show more similarities after the intervention than

before. From the research described above it follows that it is not self-evident that strategy workshops result in these intended outcomes. Thus, we hypothesize the following:

*Hypothesis 3a. Strategy workshops lead to changes in the mental models of participating managers.*

*Hypothesis 3b. Strategy workshops lead to convergence of the mental models of participating managers.*

## **METHOD**

### **Case Description: The Energy Transition**

To study mental model renewal we turn to the energy sector, which experiences turbulent times in many countries. We use the Dutch energy sector as a case, which is a typical example of a sector where current beliefs are confronted with dissonant information. Typical for the Dutch energy system is the large gas reserve in the northern part of the country. The Dutch government currently derives a substantial part of its income from exploiting this reserve (Kern & Smith, 2008). Besides, the international fossil industry has a considerable representation in the Netherlands with the headquarters of the Anglo-Dutch multinational oil and gas company Royal Dutch Shell. Moreover, the captains of industry from the fossil energy sector have historically been involved with setting the Dutch energy policy (Kemp, Rotmans, & Loorbach, 2007: 325).

The Dutch government has been developing policies for renewable energy production since the 1973 oil crisis (Junginger, Agterbosch, Faaij, & Turkenburg, 2004; van Rooijen & van Wees, 2006). Recently it has set new goals for energy conservation and renewable energy production as a part of its 2012 coalition agreement (Cabinet Rutte-Asscher, 2012). The goals

imply considerable changes, with a goal for renewable energy production of 16% in 2020, compared to 4,7% in 2013 (Notenboom, Boot, Koelemeijer, & Ros, 2012). Because of the necessary changes the government speaks of an *energy transition* (Kemp, 2010). The term *transition* is defined as “a gradual, continuous process of change where the structural character of a society (or a complex sub-system of society) transforms” (Rotmans, Kemp, & Asselt, 2001: 16). The term *energy transition* came into wider use with the 2005 governmental ‘taskforce energy transition’, which described the energy transition as a structural change towards a more sustainable energy system (Smith & Kern, 2009). The historically grown nature of the Dutch energy system conflicts with the recent set goals and the industry is now in the middle of the social construction of the energy transition, with different parties competing on what sense should be given to the energy transition and its various elements (Hendriks, 2009: 346; Kemp et al., 2007: 316). This equivocal nature of the energy transition makes it a subject that is very suitable for examining mental model renewal (Weick, 1995).

## **Mental Model Renewal**

### **Strategic means and ends**

Previous studies examined various parts of managers’ mental models, including business definition (Porac et al., 1989) and strongly held beliefs about the appropriateness of a business model (Tripsas & Gavetti, 2000). For our study we sought a part of a manager’s mental model that is general enough to be comparable for different types of organizations in the energy sector. Therefore, we chose to study the importance that managers attach to strategic means and ends in the energy transition. Strategic means refer to a variety of ways in which the energy transition may be advanced, while strategic ends refer to a variety of goals that managers may deem as important when talking about the energy transition. We adopted our focus on strategic means and

ends from previous studies that analyzed shared cognition in this way (Kellermanns, Walter, Lechner, & Floyd, 2005; Mohammed et al., 2010).

### **Measuring mental model renewal**

As a measure of mental model renewal we seek to compare mental models over time. Measuring mental models is inherently difficult because of the idiosyncratic nature of mental models. Managers give meaning to certain cues based on their mental model but in addition, they also extract certain cues (and do not extract other cues) based on their mental model (Daft & Weick, 1984). Therefore, “the most fundamental challenge to researchers assessing a knowledge structure is to be certain they are measuring the subject’s knowledge structure and not their own” (Walsh, 1995: 308). Another difficulty in measuring mental models is the ‘mental model uncertainty principle’ (Richardson, Andersen, Maxwell, & Stewart, 1994: 191). As soon as one elicits a mental model, this mental model might alter because of this elicitation alone. Any method of elicitation runs the risk of distorting the exact construct that it tries to measure.

To cope with these difficulties of measuring mental models and to be able to assess changes we precede our study on mental model renewal by a study on the variety in content of the mental models on the energy transition. We take stock of this content by studying newspaper articles that mention the energy transition. By coding these articles we get a hold of the various strategic means and ends that can play a role in the mental models of the energy industry managers, whilst trying to avoid researcher subjectivity in the design of the instrument (Daniels & Johnson, 2002: 78). These means and ends subsequently form the basis for the structured questionnaires in our second study with managers in strategy workshops, where we use Likert-type items to assess their mental models as previously done by for example Sutcliffe and Huber (1998). Strategy workshops with collaborative causal mapping intends to induce mental model

renewal and we asked the managers to fill out the questionnaire before and after the intervention, as previously carried out by for example Liu, Friedman, Barry, Gelfand, and Zhang (2012). A great advantage of working with closed questions is that we do not have to rely on subjective measures of mental model renewal. If the managers were allowed to formulate their mental models more freely, this would come at the price of introducing a *rater bias* because then it would be necessary to compare these answers and choose which aspects are ‘similar enough’ to be counted as similar, or ‘dissimilar enough’ to be counted as dissimilar (Hodgkinson, 2002: 65). Potential downsides of our approach are that the mental models of managers might be more developed than what can be read in the newspaper, but the articles should be representative of what can be regarded as general knowledge. On the other hand, the closed questions might force participants to consider elements of the energy transition that they would not have thought of otherwise (Daniels, Johnson, & de Chernatony, 2002: 40), but by sticking to general knowledge this effect should be small.

By combining content analysis that takes stock of the variety of mental models with a quantitative survey during the strategy workshops to assess mental model renewal, we provide a ‘third-way’ approach that combines the strengths of ideographic and nomothetic procedures while minimizing their weaknesses (Hodgkinson, 2002: 70) and we extend the line of managerial cognition research that combines multiple methods (Daniels, Johnson, & de Chernatony, 1994, 2002; Liu et al., 2012). Our design partly follows the recipes as put forward by Hodgkinson (2002: 68) and Markoczy and Goldberg (1995: 309) and as carried out by Liu, et al. (2012). We also start with developing a ‘pool of constructs’ by performing a content analysis and we also use these constructs to elicit the mental models of the participants. A substantial deviation from their recipes (Hodgkinson, 2002; Markoczy & Goldberg, 1995) is that we do not ask our participants to identify *causal relations* between the items we present them with when eliciting their mental

model. One reason is that this would add a considerable burden on the participants because they would have to assess  $n(n-1)/2$  relations for  $n$  items (as we will see this would add up to more than one thousand relations in our case). Another reason is that we believe that causal relations are more complex entities than what a manager's mental model is made out of. If managers make analogies and use reference points based on *association*, asking them to formulate their mental model in terms of *causality* would already change their mental models in it self (Richardson et al., 1994). Indeed, we believe that formulating causal relations is so helpful in renewing mental models that we choose to use it during the strategy workshops to invoke mental model renewal.

### **Overview of Research**

To test our hypotheses we used a staged approach, summarized below. As described above, first, a study based on content analysis is used to take stock of mental models in a turbulent environment. Second, strategy workshops are used to analyze manager's mental model renewal. Taking stock of the variety of mental models in the first study is used to design a closed questionnaire that measures manager's mental models. The managers participating in the strategy workshops fill out this questionnaire both before and after the strategy workshop. An analysis of changes in their answers in these questionnaires provides us with a measure for mental model renewal in the second study. In summary, the research is staged as follows:

#### *Study 1:*

1. A content analysis is used to take stock of the variety of mental models in a turbulent environment, resulting in a pool of constructs. A manager's mental model is then operationalized as the importance that each of these constructs has in the view of this manager. The results are used to test hypothesis 1.

*Study 2:*

2. The pool of constructs resulting from the content analysis is used to develop a questionnaire with closed questions. Prior to participating in a strategy workshop, we ask managers to fill out this questionnaire in order to assess their mental model (T0).
3. Managers engage in discussions about what trends they deem important and what meanings should be attached to these trends in facilitated strategy workshops.
4. Right after the strategy workshop we again ask the managers to fill out the same questionnaire (T1).
5. Two months after the strategy workshop we again ask the managers to fill out the same questionnaire (T2).
6. To assess levels of mental model renewal we calculate distance measures between the different questionnaires.
7. Statistical analyses are used to relate the distance measures to individual characteristics of managers, namely their general experience and industry specific experience. The results are used to test hypothesis 2a and 2b.
8. The distances between T0 and T1 are used to analyze the level of mental model renewal during the strategy workshop. The distances between T0 and T2 are compared to the distances between T1 and T2 to analyze the extent to which the mental model renewal relating to the strategy workshop endures. These results are used to test hypothesis 3a and 3b.

Following the staged approach, below we first describe the methods and results of Study 1 based on the content analysis that takes stock of the variety of mental models in a turbulent

environment. After that, we describe the methods and results of Study 2 based on the closed questionnaire and the strategy workshops using collaborative causal mapping.

### **METHODS STUDY 1**

To take stock of the variety of mental models that may exist on strategic means and ends in the Dutch energy transition we analyzed articles in large Dutch newspapers that mention “energy transition”. We included all articles published before 21 June 2013. The first article that mentions the energy transition appeared in 2003. As shown in Table 1 below we analyzed a total of 162 newspaper articles. To diminish the risk of imposing our own mental model on the data we engaged in a process of coding in which we tried not to use prior expectations about the nature of the data. We consecutively performed one round of open coding and one round of selective coding, following the procedures as put forward in grounded theory (Glaser & Strauss, 1967). The round of open coding was used to analyze what *categories* of constructs there are on the energy transition. The round of selective coding was used to analyze what *constructs* within these categories there are on the energy transition.

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Insert Table 1 about here  
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### **RESULTS STUDY 1**

We predicted that there is limited dissimilarity in mental models in a turbulent environment. On the one hand, we expect similarities to exist because of social influence processes. On the other hand we expect dissimilarities to exist because of the equivocality of trends in a turbulent environment. In the newspaper articles on the energy transition we find that

there is a limited set of constructs, indicating similarity in mental models, but that newspaper articles typically discuss just a small portion of these constructs, indicating dissimilarity in mental models. This limited dissimilarity in mental models, on which we elaborate below, supports our hypothesis.

The first round of open coding was used to analyze what categories there are in mental models on the energy transition. This analysis resulted in the finding that there appear to be three distinct categories: *strategic ends* that may be served by the energy transition, *technological means* to bring about a more sustainable energy system (e.g. solar panels, blue energy) and *policy means* that could be implemented by different governmental bodies to speed up the transition (e.g. carbon taxation, subsidies on innovation). The second round of selective coding used this categorization as an input and produced a list of constructs in these three categories. This analysis resulted in the finding that there is a limited set of 47 means and ends mentioned in the newspaper articles. Within this set there are substantial differences. Some articles for example clearly state that they see ‘affordability of energy’ as the strategic end that may be served by the energy transition, while other articles focus on how the transition may help to prevent problems for future generations. These ends are not only very different, they also seem incompatible: increasing the efficiency of coal plants for example would help to keep energy affordable, but may add to climate change problems that future generations would have to deal with. This shows that, besides similarities, there are substantial dissimilarities in mental models on the energy transition.

We excluded items from the list of constructs that were mentioned only once or twice. Next, two experts from the energy sector assessed the face validity of the items during interviews. Based on the feedback of these experts we made minor changes and this resulted in the final list that is shown in Table 2 below.

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Insert Table 2 about here  
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In the total of 162 newspaper articles we find a pool of 47 constructs. The pool of constructs is less than a third of the number of newspaper articles and this is an indication of the similarity in mental models on the energy transition. In the total of 162 newspaper articles we find a total of 465 references to the 47 constructs. On average a newspaper article mentions less than three of the 47 constructs and this is an indication of the dissimilarity in mental models on the energy transition.

This list of items forms the basis for the questionnaire as used in Study 2, where participants in workshops answered the same questions both before and after the strategy workshops, as well as two months after the strategy workshop. The distance measures between the answers before and after the strategy workshops provide a measure for mental model renewal.

## **METHODS STUDY 2**

### **Participants and Procedure**

To study individual differences in mental model renewal we organized workshops where participants could share their thoughts on what cues are important and on the meaning they think should be attached to them. Managers strategize by translating trends into plans for the future. To know what trends are important and what their importance is, managers regularly participate in events (e.g. conferences, ‘awaydays’, workshops) where they meet other managers and discuss these trends (Johnson et al., 2010). We expect these kinds of events to be one of the places where

managers renew their mental model. Therefore, we created such an environment for managers by organizing workshops for discussing trends in the energy transition.

In a timeframe of two months we organized eight workshops. On the one hand we wanted to make sure that the workshops were small enough to provide enough opportunity for interaction, since it is this interaction that might lead to managers convincing each other of what cues to attend and what meaning to attach to them. On the other hand we wanted enough managers in our workshops to be able to infer conclusions. Therefore, we organized eight workshops for small groups of managers. The workshops had exactly the same design, the only difference being the participants that attended the workshops. We invited 329 managers from the energy sector, all relations of a Dutch distribution system operator that co-organized the workshops. The number of participants per workshop varied from eight to fifteen, with a total of 96 participants over all eight workshops. During the workshops the participants collaboratively worked on drawing causal maps. In each workshop two facilitators with expertise in the procedure of collaboratively drawing maps helped the groups with drawing them. The first and second authors of this paper are among those facilitators. The workshops took about five hours each.

## **Measures**

We measured the dependent variable *mental model renewal* (MMR) by comparing for each participant the questionnaires before and after the workshop. The questionnaires included the 47 items that resulted from Study 1. For each item the question was “how important is (*this item*) for you with regard to the energy transition?” The closed questions were formatted as seven points Likert items, ranging from *not important at all* to *extremely important*. Mental model renewal was then calculated for each participant as the Euclidean distance between the answers to

the items ( $i$ ) of the questionnaires before ( $p$ ) and after ( $q$ ) the workshop, see the formula below (Kellermanns et al., 2005).

$$MMR = \sqrt{\sum_{i=1}^n (q_i - p_i)^2}$$

*Mental model convergence* was measured by comparing the sum of the standard deviations for the answers of the whole group of 96 participants to all 47 items before and after the workshop (Kellermanns et al., 2005; Mohammed et al., 2010). This way we measure whether the spread in answers is different after the workshop compared to before, and whether the spread is larger or smaller.

The independent variable *industry specific experience* was measured by asking the participants in the first questionnaire when they started working in the energy sector. This was then translated into years of exposure by subtracting the answer from the year in which the workshops were held, 2013.

*General experience* was operationalized with the manager's age, measured by asking the managers for the year of their birth and subtracting the answer from the year in which the workshops were held, 2013.

## RESULTS STUDY 2

### The Influence of Experience on Mental Model Renewal

Table 3 shows descriptive statistics and correlations for the variables in this study. Individual differences in mental model renewal were considerable. The Euclidean distance

between before and after the workshop per participant over all 47 items ranged between 3.3 and 9.6 (with an average of 6.2 and a standard deviation of 1.5).

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 Insert Table 3 about here  
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We predicted that both general and industry specific experience result in lower levels of mental model renewal. While general and industry specific experience are strongly interrelated, only the latter correlates significantly with mental model renewal ( $p < .05$ ). Because general experience shows no correlation with mental model renewal, we did not find support for Hypothesis 2a. Because industry specific experience does correlate with mental model renewal, we continue with a simple linear regression model. Although with little explained variance, the simple linear regression model with mental model renewal as the dependent variable and industry specific experience as the independent variable reveals that industry specific experience indeed predicts lower levels of mental model renewal ( $p < .05$ , *adjusted R*<sup>2</sup> .04). This result supports Hypothesis 2b.

### **The Influence of Collaborative Causal Mapping on Mental Model Renewal**

We predicted that strategy workshops result in mental model renewal. More specifically, we expect that these strategy workshops result in mental model convergence between the participating managers. We find several signs that support these hypotheses. For each manager, we compared the Euclidean distance between their mental model right before the strategy workshops (T0) and right after the workshops (T1). Paired sample t-tests on all 47 constructs of mental models in the energy transition show that answers on ten out of the 47 items were

answered significantly different after the workshop compared to before ( $p < .05$ ). Moreover, the change in mental models seems to be lasting since the answers to a third survey with the same questionnaire two months after the workshop (T2,  $n = 19$ ) look more like the answers after the workshop (average Euclidean distance between T1 and T 2 = 6.7) than like the answers before the workshop (average Euclidean distance between T0 and T2 = 7.1). These results support Hypothesis 3a. The sum of standard deviations on the 47 items decreased from 56.7 before the workshop (T0) to 51.8 after the workshop (T1) showing that indeed there was mental model convergence. This result supports hypothesis 3b.

## DISCUSSION

In this study, we addressed the temporal nature of mental models by assessing individual differences in mental model renewal. Our results show how some managers have high levels of mental model renewal while other managers' mental models are more enduring. By analyzing strategy workshops in which managers collaboratively worked on causal maps, we responded to a recent call for studying the process of 'breaking the frame' (Narayanan, Zane, & Kemmerer, 2011). Below we describe both theoretical and practical implications that follow from our study.

### **Theoretical Implications**

The results of our study show that industry specific experience has a negative effect on mental model renewal. This finding supports previous studies that found a relation between industry experience and strategic change (Grimm & Smith, 1991) and shows how mental model renewal acts as a mediating factor explaining why industry experience influences strategic change: managers with high levels of industry experience show lower levels of mental model renewal, thereby reducing strategic change. Managers that have less industry specific experience

have less time to accumulate reference points, filters, and proven recipes. By linking managerial characteristics to mental models we thus synthesize research that links managerial characteristics to strategic change (Grimm & Smith, 1991) and research that links mental models to strategic change (Barr et al., 1992).

Some scholars argue that managers may benefit from general experience because analogical transfer across industries would support decision-making (Gary et al., 2012). We did not find a relation between a manager's general experience and mental model renewal, shifting the attention to *industry specific* experience (Spender, 1989). This implies that future studies should be cautious with using a single measure for a manager's experience. Our study showed the usefulness of distinguishing between general and industry specific experience by showing the effect of industry specific reference points, filters, and proven recipes on mental model renewal.

The results show that the strategy workshop, consisting of collaboratively working on causal maps, leads to mental model renewal and more specifically to mental model convergence between the participants. This finding is relevant for the debate in which the rationality of strategy workshops is doubted (Johnson et al., 2010; Hodgkinson et al., 2006). While strategy workshops may have a highly ritualistic and symbolic nature, this does not have to stand in the way of the espoused goal of making sense of recent trends and renewing participants' mental models.

Our study shows the usefulness of collaboratively causal mapping for supporting mental model renewal, in line with earlier studies (Andersen & Richardson, 1997; Rouwette et al., 2011; Rouwette et al., 2002; Vennix, 1996, 1999). Some scholars use causal mapping not as a technique for *changing* mental models, but as a technique for *eliciting* mental models (Hodgkinson, 2002; Markoczy & Goldberg, 1995). The transformational power of drawing causal relations implies

that future studies should be cautious with relying on causal mapping as a method for eliciting mental models, because it adds to the mental model uncertainty principle: measuring mental models by drawing causal relations increases the extent to which the measurement tool changes the construct that it tries to measure (Richardson et al., 1994).

The interpretation of our findings depends on the assumptions one has about the nature of the issue at hand, the energy transition. Adopting an objectivistic account of the energy transition, more experienced managers have gathered more information about the energy transition that is relevant to understand the importance of all its aspects. The workshops would then have facilitated a *transfer* of their *knowledge* to less experienced managers, who hereby *learn* about the issue. In this interpretation, the managers with high industry specific experience show little mental model renewal because they already knew much, while managers with low experience show high mental model renewal because they learned about the energy transition during the workshop.

We argue however that the nature of the energy transition is such that even speaking of *knowledge transfer* and *learning* is not appropriate. A first argument is that the equivocality and speed of change of the energy sector are very high, making information on issues obsolete while it is being gathered. A second argument is that the social construction of the energy transition has an effect on its own. Even if experienced managers have gathered much information, if managers without much experience attach a different meaning to aspects of the energy transition and initiate strategic change based on this different mental model, this would have consequences for the development of the energy transition and thereby for the validity of the mental models of the experienced managers. In this subjectivist account of the energy transition, different parties have different reasons to attach a certain meaning to what exactly the energy transition is and the

industry is in the middle of a competition of different frames. The results of such a competition will determine which frames will become dominant and which frames peripheral. Dominant frames will subsequently influence the behavior of the different parties that have a stake in the energy transition, and the energy transition itself is a result of this behavior. Mental model renewal in this sense is not so much ‘learning about new information’, but more of ‘adapting to frames that are gaining dominance’.

On the basis of this interpretation, we may now understand low mental model renewal by managers with high industry specific experience as cognitive inertia, a low capacity to adapt to frames gaining dominance. Managers with low industry specific experience did not have the opportunity to accumulate reference points, analogies, and recipes and are therefore less prone to cognitive inertia. In this interpretation low mental model renewal becomes a negative tendency that seems worthwhile to avoid. Low mental model renewal in this interpretation means that your mental model already is or soon will be out of date. This connects to other scholars that use the term cognitive inertia for a lack of mental model renewal to stress this negative aspect (Hodgkinson, 1997; Tripsas & Gavetti, 2000; Reger & Palmer, 1996). We base our practical implications on this interpretation.

### **Practical Implications**

The results of our study have important implications for managers with a responsibility for their organization’s strategy. Experience comes with many benefits, but a downside of this experience is that it may hinder mental model renewal. Although mental model renewal may be dysfunctional as well (Tripsas & Gavetti, 2000: 1159), earlier research shows that timely adjustments in mental models are crucial for organizational renewal (Barr et al., 1992). Our findings therefore support earlier suggestions on mitigating cognitive inertia. To mitigate

cognitive inertia organizations can allow for diversity in strategic cognition (Tripsas & Gavetti, 2000). Our findings suggest that for a strategy that is well adapted to recent trends, it deserves recommendation to allow for diversity in the process of formulating this strategy by including managers that have high levels of industry specific experience as well as managers that have low levels of industry specific experience. While the managers with high levels of industry specific experience may bring to table important references points, routinized ways of doing, and standard recipes, managers with low levels of industry specific experience may assess the validity of this repertoire in the current state of the industry.

To study mental model renewal we turned to a sector that is described to be in turbulent times: the energy sector. This domain is specifically relevant because, as some scholars argue, progress in this domain can especially be expected by changing mental models (Sterman & Booth Sweeney, 2007). Besides, the historically grown prominence of the Dutch fossil industry provides a munificent environment that makes organizations in the energy sector even more susceptible to cognitive inertia, because this benign environment might obscure the need for change (Barr et al., 1992: 27; Huff & Schwenk, 1990).

### **Limitations and Future Research**

The study provides middle ground between field studies and controlled experiments by involving a large number of managers in our interventions that were specifically designed for this research. As a result of this design we were dependent on the willingness of managers to participate in our workshops. As a consequence our participants are not a random sample of the energy sector as a whole. We had to rely on the network of the distribution system operator that co-organized the workshops. Moreover, just a small proportion of the managers accepted our invitation and to stimulate participation we even provided the possibility to forward our invitation

to colleagues that might be interested in participating in the workshops. Because participants had to free up a large part of a day to be able to participate, we expect that especially those managers participated that have a high affinity with the issue we discussed, the energy transition. The results therefore may be not generalizable to the energy sector as a whole, but mainly to those managers that have high affinity with the energy transition. Because their affinity makes it at the same time more likely that these managers are responsible for the strategy of their organizations in the energy transition, we find this selection bias not problematic. Future studies in other industries should test generalizability of our findings to other domains.

Working with managers meant that we had to choose carefully how we used their time. There was a limit on how many questions we could ask in our surveys. Future research without such limits may investigate the link of mental model renewal with other individual characteristics such as need for achievement (Hodgkinson & Sparrow, 2002), and need for closure (Liu et al., 2012).

## CONCLUSION

Our study introduced a closer look at the process of ‘breaking the frame’. We used content analysis of newspaper articles to take stock of the variety of mental models in a turbulent environment. As expected, we found limited dissimilarity between mental models. We used strategy workshops as an intervention to induce mental model renewal and as expected, collaboratively drawing causal maps led to mental model convergence. Findings showed that individual differences in mental model renewal are substantial and that general experience did not, but industry specific experience did decrease mental model renewal. We hope that our findings pave the way for future studies in this field.

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## TABLES

TABLE 1

**Articles in five large Dutch newspapers that mention “energy transition”**

Newspaper	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013 <sup>a</sup>	Total
AD	0	0	0	1	3	0	0	0	0	0	1	5
NRC	1	0	3	8	16	4	4	6	2	6	8	58
Telegraaf	0	0	0	1	5	2	1	3	2	3	3	20
Trouw	0	0	1	9	8	3	4	10	4	4	3	46
Volkskrant	0	0	0	5	8	5	1	9	3	2	0	33
Total	1	0	4	24	40	14	10	28	11	15	15	162

<sup>a</sup> up to 21 June 2013

**TABLE 2**  
**Constructs in energy transition mental models (frequency of occurrence between brackets)**

<b>Strategic ends</b>		
Affordability of the energy system (30)	Countering climate change (65)	Honoring international agreements (6)
Improving the job market by investing in the energy system (11)	Decreasing the dependability on other regions for energy (25)	Securing possibilities of future generations to meet their needs (3)
Improving the Dutch natural environment (13)	Setting an example for other regions (4)	Improving competitiveness by gaining a technological lead (16)
<b>Technological means</b>		
Carbon capture and storage (5)	Hybrid vehicles (3)	Solar panels (9)
Shale gas (2)	Intelligent traffic management (4)	Concentrated solar power (4)
Coal plants (9)	Biofuels (7)	Geothermal energy (2)
Gas plants (2)	Electric vehicles (2)	Wind power on land (13)
Nuclear energy (5)	Conservation in the industry (5)	Wind power on sea (3)
Biomass (5)	Conservation in buildings (19)	Combined heat and power (2)
Investing in electricity grids (6)	Using waste heat (3)	Energy storage (4)
Smart metering (3)	Aquifer storage and recovery (3)	
Hydrogen (9)	Blue energy (3)	
<b>Policy means</b>		
Subsidies for sustainable energy production (24)	Stricter regulations in the form of norms and obligations (22)	Decrease the frequency of changing energy policies (19)
Subsidies for energy conservation (8)	Improve the balancing of different stakes when defining energy policy (13)	Encourage new models of markets (7)
Fund for innovations in energy conservation and production (8)	Stricter certification of sustainable energy (4)	CO2 trading systems (10)
More ambitious international climate agreements (9)	Improving awareness by education (8)	
Higher taxes on fossil energy (19)	Take away barriers in rules and regulations (9)	

**TABLE 3**  
**Means, standard deviations, and correlations**

Variable	Mean	s.d.	1	2
1. General experience	44.8	10.9		
2. Industry specific experience	12.2	10.7	.66**	
3. Mental model renewal	6.2	1.5	-.15	-.24*

\*  $p < .05$

\*\*  $p < .01$