

Defining and Identifying Uncertainties in Organizations

Uncertainty is about not knowing for sure. In organizations, this may concern daily business and entail questions such as: Will the material be delivered on time for next week's express orders? How many doctors should be scheduled to cover the demand in the shock trauma centre over the holiday season? Will the newly hired product development team cooperate well? On a more strategic level, uncertainty is encountered in decisions such as: Should we spend more on research and development? Which qualifications do our employees need to improve customer orientation? Should we increase the level of standardization in our production processes? Uncertainty is also involved in many personal decisions: Should I follow the production schedule even though it is suboptimal? Will the new job offered to me allow me to develop my career better?

In trying to handle uncertainties, one needs to know first of all which kinds of uncertainties one is currently facing. Also, it is important to address future uncertainties, which adds to the complexity; one is now uncertain about uncertainties. In order to carry out such an analysis, the very first step is to define what one is looking for, that is, to define uncertainty.

In the following, a general framework will be developed that distinguishes causes, sources, contents, and consequences of uncertainty, as well as different actors involved in the management of uncertainty. It centres on the uncertainties' effects for controlling action towards achieving certain outcomes. The framework's elements can be applied to analyze conditions of managing uncertainty from a strategic and an operational perspective and examples for both will be provided. Moreover, the framework allows the adoption of a rationalistic, objective stance on managing uncertainty, but also the consideration of the impact of individual and collective enactment and sensemaking. The overall aim of the analytic framework is to help the decision-makers in organizations to sketch an uncertainty landscape that supports informed decisions on managing these uncertainties so as to achieve desired outcomes. At the end of the chapter, an example of an analysis carried out within the suggested framework will be presented.

2.1 Definitions of Uncertainty

Turning to organization science for a definition of uncertainty, one quickly finds that there is no easy answer. As the smallest common denominator, one can take the first sentence of this chapter “uncertainty is about not knowing for sure”. To state this definition somewhat more scientifically: uncertainty is the absence of information and more specifically, the difference between the amount of information required to perform a task and the amount of information already possessed by the organization (Galbraith 1973). Additionally, the ambiguity of existing information in terms of the multiplicity of meanings that can be imposed on a situation, has been considered an element of uncertainty, sometimes also referred to as equivocality (Weick 1979; Daft and Lengel 1984; Leifer and Mills 1996).

In order to make these definitions operationally useful, one needs to specify further what information or lack thereof is relevant for the functioning of an organization. Given the multitude of attempts to do just that in academic literature, it becomes obvious that rather than looking for *the* definition of uncertainty, it is important to choose a definition that fits the nature of the organization and the nature of the question studied (Kreiser and Marino 2002). The following review of approaches to defining uncertainty is intended to help researchers and practitioners who are interested in studying uncertainties in organizations to develop a definition of uncertainty that is both sound and fits their needs. For that purpose, different perspectives on uncertainty as found in the scientific literature, are discussed and examples – mostly from classic studies in the field – given on how researchers have selected the perspective and corresponding definition most useful for a particular analysis of uncertainties.

The overall framework suggested for the analysis of uncertainties is presented in Figure 2.1. Its rationale is developed in the following sections and an example for its use in an actual analysis of uncertainties contained in train operations is given at the end of the chapter.

2.1.1 Content of Uncertainty

Frequently, uncertainty is described as a characteristic of decisions that individual decision-makers in organizations have to take (e.g., Beckert 1999; Eisenhardt 1989; Lipshitz and Strauss 1997; Palmer and Wiseman 1999; Sitkin and Pablo 1992). Decisions are understood as a choice being made between alternatives differing in the usefulness and likelihood of their outcomes, that is in their expected utility. From this perspective, uncertainty may concern the probability of an event (state uncertainty), a lack of information about the outcomes of an event and the underlying cause-effect relationships (effect uncertainty), or a lack of information about response options and their likely consequences (response uncertainty) (Milliken 1987). In Milliken’s original work, the three contents of uncertainty are described in terms of environmental uncertainty, so for instance, effect uncertainty is understood only as uncertainty about impacts of environmental events on the organization. Here the distinction is used more broadly to define the different contents of what the decision-maker is uncertain about, that is, any state,

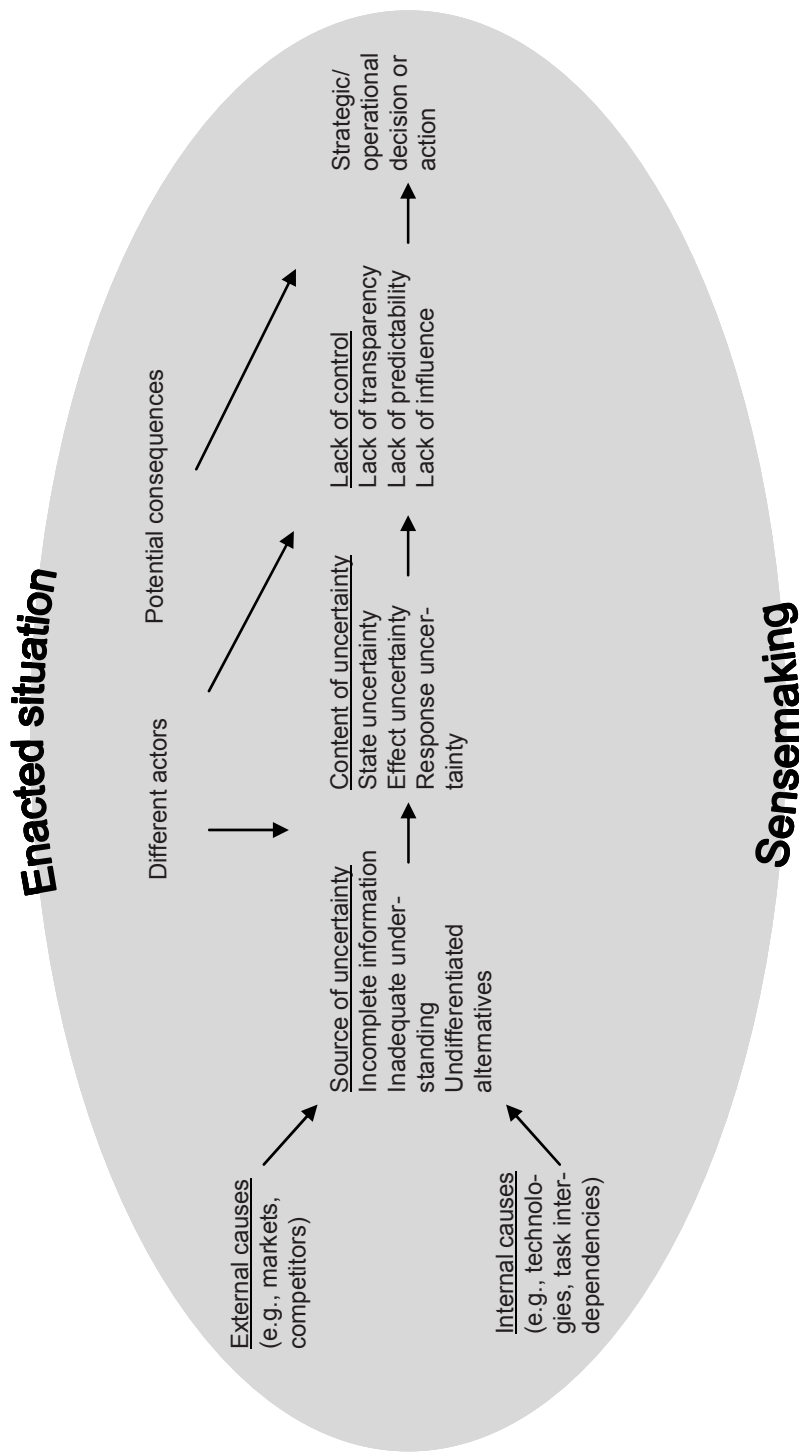


Figure 2.1. Framework for uncertainty analysis

any effect, or any response in the organization or in the environment. Two very different examples are presented below for how different contents of uncertainty have been defined in organizational research (see Examples 2.1 and 2.2).

Example 2.1. Operationalizing uncertainty in hospital emergency units in terms of state uncertainty (Argote 1982)

In her study on how emergency units in hospitals coordinate their actions in the face of different levels of uncertainty, Argote focused on what she termed input uncertainty. “Input uncertainty stems from the external environment with which the various units are in continuous contact, yet it has an immediate impact on the tasks that the units perform” (Argote 1982, p. 422). For the purpose of her study, she only looked at input uncertainty with respect to expected number of patients in various medical conditions. This definition is directly linked to the notion of state uncertainty. Input uncertainty was considered higher with more and equally likely patient conditions and lower with fewer conditions and/or conditions with varying probabilities. In order to measure input uncertainty, nurses in the units studied were asked to estimate the volume of patients in each of ten conditions representative of the range of patient conditions encountered in emergency units. The lower the variance across estimates within an emergency unit for the different conditions was – that is, the more similar the expected occurrence of the various patient conditions was – the higher the input uncertainty was considered to be.

Example 2.2. Changes in product lines of film studios in response to state, effect, and response uncertainty (Miller and Shamsie 1999)

In the study by Miller and Shamsie, hypotheses were tested regarding adaptations in range of film genres undertaken by major film studios in response to different kinds of uncertainties. For this purpose, the three contents of uncertainties suggested by Milliken were operationalized. State uncertainty was defined only in view of environmental states regarding the robustness of demand and competitive volatility in the industry. It was measured by the percentage of annual household spending devoted to movie attendance and by annual changes in market share for all film studios. Effect uncertainty was defined in terms of lack of organizational skills needed for understanding and adapting to environmental demands and lack of control over film distribution. It was measured by reverse indicators, namely academy awards won and ownership/leasing of theatres per film studio. Finally, response uncertainty was understood in terms of risks perceived by managers in making a decision, both regarding costs and their own reputation. It was measured by average production cost per film and tenure of production head.

2.1.2 Sources of Uncertainty

Within the general decision-making framework employed here, uncertainty can arise due to incomplete information, inadequate understanding of available information, and undifferentiated, that is equally attractive or unattractive, alternatives (Lipshitz and Strauss 1997). The latter may also be related to uncertainties regarding the goals to be achieved by making a certain decision. While incomplete information is a factor that can be determined objectively, both undifferentiated alternatives and inadequate understanding are sources of uncertainty that imply an interaction between characteristics of the decision to be taken, the environment in which the decision is embedded, and the decision-maker him- or herself (Sitkin and Pablo 1992). Because of these differences, sometimes only incomplete information is defined as uncertainty, whereas the other two elements are subsumed under a separate category ambiguity.

The attractiveness of alternatives is linked to the goals, values, needs, and attitudes of the decision-maker, as well as the expected utilities for the organization in whose interest the decision-maker is supposed to act. Inadequate understanding may be a consequence of too little, but also of too much, information. Moreover, it may be caused by information that is difficult to interpret because several, potentially even conflicting, meanings exist (Weick 1979; Leifer and Mills 1996). The decision-maker's competence for handling large amounts of ambiguous information will strongly influence the degree of uncertainty experienced in those cases. Given the importance of decision-makers themselves as defining factor for uncertainties, it has been frequently argued that measures of uncertainty should focus on the uncertainty as perceived by decision-makers instead of on objective accounts of uncertainty in the decision-making situation (see Example 2.3 for a prominent study that took this approach). We will return to this important point later.

Example 2.3. Exploring contingencies between uncertainty and organizational design (Lawrence and Lorsch 1967)

In their seminal study on contingencies between uncertainty and organizational design, Lawrence and Lorsch measured uncertainty by means of top executives' perception of clarity of information, uncertainty of causal relationships, and time span of definite feedback, thereby touching upon two of the mentioned sources of uncertainty, that is incomplete information and inadequate understanding of available information. The three questions asked to measure the three components of uncertainty were the following (Lawrence and Lorsch 1967, p. 248ff):

a) Please circle the point on the scale provided which most nearly describes the degree to which present job requirements in each functional department are clearly stated or known in your company for:

Research	Job requirements	1 2 3 4 5 6 7	Job requirements
Manufacturing	are very clear in		are not at all clear
Marketing	most instances		in most instances

b) Please circle the point on the scale provided which most nearly describes the degree of difficulty each functional department has in accomplishing its assigned job, given the limitation of the technical and economic resources which are available to it.

Degree of difficulty in:

<i>Developing</i> a product which can be manufactured and sold profitably	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
<i>Manufacturing</i> economically a product which can be designed and sold.	Little difficulty			Extremely difficult			
<i>Selling</i> a product which can be developed and manufactured economically.							

c) Please check the alternative which most nearly describes the typical length of time involved before feedback is available to each functional area concerning the success of its job performance.

Research Department	(1) one day
Manufacturing Department	(2) one week
Marketing Department	(3) one month
	(4) six months
	(5) one year
	(6) three years or more

2.1.3 Causes of Uncertainty

Beyond determining the different sources of uncertainty, that is incomplete information, inadequate understanding of information, and undifferentiated alternatives, one can study their *causes*. One might be interested in personal causes of uncertainty, for instance, why a person is more or less able to handle ambiguous information due to different cognitive abilities or personality characteristics like control orientation or emotional stability. Especially different risk preferences and thereby different attitudes to uncertainty, have received much attention in the literature (*e.g.*, MacCrimmon and Wehrung 1990; Sitkin and Pablo 1992). However, as the focus of this book is on organizational requirements for managing uncertainties, we will discuss these personal causes mostly in passing in the following chapters.

Situational causes can be found in the external environment of the organization, *e.g.*, suppliers not providing information on anticipated late deliveries, or in the organization's internal processes, *e.g.*, unforeseen complications in heart surgery. In academic literature, environmental uncertainties have been treated much more prominently (*e.g.*, Bourgeois 1985; Eisenhardt and Martin 2000; Kreiser and Marino 2002). Ever since the shift from viewing organizations as closed systems acting more or less independently of their environment to acknowledging their nature as

open systems co-existing with and depending on their environment, environmental uncertainties have been a core concern (Thompson 1967). Pfeffer and Salancik's (1978) eminent conceptualization of organizations' dependence on their environment focuses on the dependence on resources from external partners with varying degrees of power as the core cause of uncertainties. In their view, uncertainty – defined as “the degree to which future states of the world cannot be anticipated and accurately predicted” (p. 67) – is only problematic when “it involves an element of critical organizational interdependence” (p. 68). In resource dependence theory, only those uncertainties need to be managed that arise due to the criticality of a particular resource for the organization's survival, the scarcity of that resource, and the level of competition between organizations for that resource. These characteristics of the environment are crucial in determining the influence an organization can exert to obtain necessary resources and the different strategies available to control resource access. Uncertainty therefore is understood in terms of lack of control, and not as lack of information as such. The consequences of this distinction will be taken up again later in this chapter.

Internal uncertainties have been described less succinctly, usually listing different functions and operations in the organization that can cause variability and unpredictability of work tasks. Therefore, internal uncertainties are often summarized under the term task uncertainty (Van de Ven *et al.* 1976). In Perrow's (1967) prominent analytic framework for comparing organizations, variability and lack of knowledge concerning raw materials and technology are mentioned as key factors. Slocum and Sims (1980) distinguish between task uncertainty, related to lack of knowledge about how to produce the desired outcome, and workflow uncertainty, which concerns lack of information about inputs and outputs for a particular work station. In the literature on sociotechnical design, internal (but potentially also external) uncertainties are frequently termed variances, defined as “any unprogrammed event”, and particularly important ones, which critically affect outcomes, are termed key variances (Cherns 1976, p. 787). Examples given are often lists of various possible events in an organization, such as insufficient quality of raw materials or machine failures.

A related concept frequently discussed in the sociotechnical literature is that of task interdependence (Thompson 1967; Van de Ven *et al.* 1976). Individual tasks are linked through technical and organizational design in ways both creating uncertainties and allowing for particular ways of handling uncertainties. Usually three types of task interdependence are distinguished:

Pooled interdependence is present when system performance is an additive function of individual performance. The performance of other members of the system may affect the work of the individual members, but only indirectly through parallel contributions to a superordinate goal. Coordination in this case is usually achieved via centrally determined work programmes which every individual has to follow independently and which assure that subtasks serve the superordinate goal. An example would be a service organization, such as an insurance company, where individual employees are responsible for all the concerns of a particular group of customers.

Sequential interdependence is a unidirectional workflow arrangement, where individual performance depends on the proper fulfilment of prior subtasks. Syn-

chronization is needed based on centrally determined programmes and plans that spell out the exact content and temporal requirements of subtask fulfilment. The classic example of this kind of interdependence is the assembly line.

Reciprocal interdependence implies that information and results of work activities have to be exchanged between team members continuously. Coordination is mainly achieved via direct communication, be it in the form of personal directives, or multilateral flow of communication between the individuals involved in self-regulated task performance. Project teams of any kind are examples of this type of interdependence.

Each type of task interdependence involves particular causes of uncertainty for the individual actors. For instance, in a situation of pooled interdependence, uncertainty is mainly created by inappropriate programmes used to coordinate individual tasks, as well as by problems in the fulfilment of individual tasks such as machine breakdown. Sequential interdependence implies that uncertainties are handed down along the process and, if not handled adequately, create a series of problems throughout the process. Reciprocal interdependence involves multiple parallel sources of uncertainties, such as misunderstandings about task requirements, changes in individual plans for task fulfilment, or inadequate consideration of interfaces in project specifications. In Example 2.4, the operationalization of uncertainty used in a study on different ways of handling task interdependencies is described.

Example 2.4. Testing contingencies between task uncertainty, task interdependence and coordination modes (Van de Ven *et al.* 1976)

Hypotheses regarding the relationships between task uncertainty, task interdependence, and coordination modes were tested by means of questionnaire data collected in a large state employment security agency. Task uncertainty defined as the “difficulty and variability of the work that is undertaken by an organizational unit” (Van de Ven *et al.* 1976, p. 333) was measured by eight items measuring perceived uncertainty (*e.g.*, During the course of your work, how often do you come across specific but difficult problems that you don’t know how to solve, and you have to take some time to think through by yourself or with others, before you can take any action? How much variety in cases, claims, clients, or things do you generally encounter in your normal working day?) and by a standardized classification of tasks. This classification was based on lists provided by each respondent of all tasks performed on a normal day and the percent of time spent on each task. The tasks were classified by the researchers according to difficulty and variability and individual scores were calculated for the predominant task performed by each respondent. The individual scores were then averaged per organizational unit and correlated with the perceived uncertainty scores as a validity check.

Additional uncertainties, irrespective of the particular form of interdependence, may be created if the individuals involved in the different work arrangements are

not provided with the adequate means to manage task interdependencies (Crowston 1997; Tushman and Nadler 1978). For instance, in pooled interdependence this might imply that there are insufficient opportunities to adapt central work programmes to changing circumstances. In reciprocally interdependent team work, problems may arise when mutual adjustment is impeded by lack of direct communication. This particular issue has been studied extensively in distributed project teams where much of the communication has to happen via electronic means (*e.g.*, Hinds and Mortensen 2005; Kraut *et al.* 1999).

2.1.4 Organizational Actors Affected by Uncertainty

Two types of actors can be distinguished in the literature on handling uncertainties in organizations: high-level executives in their role as strategic decision-makers and operative personnel making decisions in the course of day-to-day work processes. The basic definitions of uncertainty are usually similar, their operational meaning is, however, very different for these different actors. Pfeffer and Salancik (1978) and Wall and colleagues (2002) for instance, both describe uncertainty as lack of knowledge and lack of understanding of cause and effect relationships. However, Pfeffer and Salancik further specify uncertainty in terms of coping with critical organizational interdependence on a strategic level, while Wall and colleagues define what they call operational uncertainty further in terms of “lack of knowledge about production requirements, of when problems will be met, and how best to deal with them” (Wall *et al.* 2002, p.159)

In order to understand how uncertainties affect decision-making in organizations, one can easily imagine that several kinds of actors should be considered: Is it top management having to make decisions such as which company to buy, which products and markets to develop, or which strategic alliances to build? Is it middle management having to mediate between strategic decisions and operations, for instance, by setting up production facilities in a way that allows for faster changes between products? Is it shopfloor personnel having to handle variations in production schedules, machine breakdown, and customer demands? Is it people in line functions, in core business units, or people in staff functions? Relevant sources and effects of uncertainties will differ substantially depending on the group of actors and types of decisions and actions required.

There are only few studies which have systematically addressed different groups of actors in relation to the management of uncertainty. One classic example is again the study by Lawrence and Lorsch (1967), which had the explicit aim of comparing contingencies between uncertainty and organizational design for different departments in organizations, specifically R&D, marketing, and manufacturing. However, the actual measure of perceived uncertainty in these different departments was derived from the account of the top executive in each company alone (see Example 2.3).

2.1.5 Potential Consequences of Uncertainty

A final perspective concerns the potential consequences of uncertainty. Thompson (1967) has described task uncertainty as the inability to act deterministically. With

that same focus on action, Lipshitz and Strauss (1997, p. 150) defined uncertainty as “a sense of doubt that blocks or delays action”. In Pfeffer and Salancik’s (1978) resource dependence theory, only those uncertainties are considered relevant that affect critical organizational relationships. The focus on consequences of uncertainties may help to identify those uncertainties that have to be managed most urgently. This perspective can thereby act as a useful filter for defining and subsequently analyzing uncertainties in an organization.

Lipshitz and Strauss (1997) also point out that doubts experienced in decision-making depend on the chosen decision-making model, which in turn highlights certain consequences and disregards others. For instance, applying an expected utility model focuses attention on doubts regarding possible alternatives, their outcomes, and the attractiveness of these outcomes in relation to certain goals. Considered consequences therefore are directly linked to capitalizing on positive outcomes, *e.g.*, raising revenue by buying a particular firm. A role compliance model, on the other hand, implies handling doubts about situational requirements in light of an assigned role. Possible consequences of fulfilling or not fulfilling that role are crucial considerations, *e.g.*, will I still be considered a proactive manager if I abstain from changing the firm’s production portfolio? The uncertainties selected for analysis and management vary accordingly. This again points to the importance of distinguishing objective and subjective approaches to measuring uncertainty, which will be discussed further in a later section of this chapter.

2.2 Defining Uncertainty within a Control Framework

In line with the suggestion that one should choose definitions of uncertainty that fit the nature of the organization and the nature of the question studied, different perspectives on uncertainty have been presented that should be taken into consideration when making this choice. Starting from the perspective of an individual decision-maker having to choose between different alternatives in view of achieving particular goals that themselves may not be fully clear, three contents of uncertainty were distinguished: uncertainties concerning states, effects, and responses. Subsequently, three sources of uncertainties were discussed: incomplete information, inadequate understanding of available, but ambiguous information, and undifferentiated alternatives. Looking into situational causes of uncertainties, environmental and internal uncertainties were distinguished and resource dependence was discussed as a prominent contributor to environmental uncertainties. Additionally, task interdependencies were discussed as an important cause of internal uncertainties. Finally, it was pointed out that uncertainties may impinge on different kinds of actors and have different kinds of consequences for these actors.

From the examples provided along with the discussion on different definitions of uncertainty, it can easily be seen that many different ways of defining uncertainties are possible, leaving the choice to the researcher or practitioner. As this book ultimately wants to help decision-makers in organizations in not merely analyzing, but also shaping the ways they manage uncertainties, Pfeffer and Salancik’s conceptualization of uncertainty in terms of lack of control is suggested as the basic

framework. That is, uncertainties should always be studied from the perspective of control over decisions and the different actions required for the achievement of organizational objectives. "The fact that we expect all organizations to seek the same state – self-control – does not mean that we expect all of them to attain it in the same way, with identical design, structures, or behavior. It is essential that we find universals, but equally essential to find patterns in variations" (Thompson 1967, p. 161).

In the broadest sense, control is usually described as exercising influence or power in order to reach certain goals, often also with the implication of influence or power over other people. From a system theory perspective, control entails more specifically regulation via feedback (*e.g.*, Green and Welsh 1988). In order for influence to be exerted effectively, there has to be sufficient predictability and understanding or transparency of the situation (Brehmer 1992; Sutton and Kahn 1987), that is: little uncertainty. Turning this argument around, uncertainty reduces effective control because it reduces transparency and predictability. Additionally, there may even be uncertainty as to which means of influence there are and what effects they have on what outcomes, which is implied in the notion of response uncertainty introduced earlier. While lack of transparency and predictability can be fully described in terms of uncertainty, lack of influence is predominantly determined by other factors, such as the distribution of power within and across organizations and the competence level of the actors. However, as transparency and predictability are necessary prerequisites for using existing means of influence, the degree and types of influence available in a particular situation are directly affected by uncertainty. Influence also involves the active handling of uncertainties, for instance, by reducing uncertainties or shifting uncertainties to less powerful others (Marris 1996; Pfeffer and Salancik 1978). Therefore, uncertainty and influence are reciprocally related to each other. Consequently, influence is included in the definitional framework even though it cannot be fully specified by the factors contained in the framework.

In Figure 2.1, the different facets to be considered when defining uncertainties for a particular purpose are presented. The arrows in Figure 2.1 are not to be taken as signalling cause-effect or antecedent-consequence relationships, but they indicate rather a possible ordering of facets in a particular analysis in line with "mapping sentences" used in facet theory (*e.g.*, Guttman and Greenbaum 1998, Shye 1998). For instance, an analysis may concern externally caused inadequate understanding regarding response options for employees in a sales department. A concrete example within such an analysis could be customers who have the habit of vaguely announcing the possibility of orders, which each time leaves the sales agents wondering whether or not they should raise their forecast. The facets of sense-making and enactment have not been discussed so far because they concern the issue of employing objective versus subjective accounts of uncertainty when identifying and managing uncertainties. This will be covered in the next section.

2.3 Identifying Uncertainties in Organizations

The framework presented in Figure 2.1 is meant to guide, but not determine uncertainty analysis. The overall aim of the analytic framework is to help decision-makers in organizations to sketch an uncertainty landscape that supports informed decisions on managing these uncertainties so as to achieve desired outcomes. Depending on the type of organization and the particular problems to be dealt with in that organization, different elements of the framework will be of more or less importance. The examples in the previous section illustrated how the particular focus of an analysis will determine the facets of uncertainty to be studied. Before another more complete example of the application of the framework is given, the fundamental question of objective versus subjective approaches to identifying uncertainties is discussed.

2.3.1 Objective versus Subjective Accounts of Uncertainty

In the literature on assessing and managing uncertainties, two prominent debates can be found: (1) the significance of objective versus subjective accounts of uncertainty; (2) whether organizations and the decision-makers within them merely react and adapt to environmental uncertainties or actively shape their environments as well (Jauch and Kraft 1986).

Regarding the first debate, the focus on decision-makers in organizations and their having to face uncertainties has fuelled arguments against objective accounts of uncertainty, in favour of perceptions of uncertainty by the actors themselves as adequate measures. Some of the facets included in Figure 2.1 in fact, imply measurement of perceptions, such as inadequate understanding of information, which can only be assessed for a particular actor. Contributing factors for inadequate understanding, such as ambiguous information, again need to be identified with reference to the actors affected. Many landmark studies on contingencies between uncertainty and organization design therefore, only used perceptual measures of uncertainty (see Example 2.3). Also, perceptual accounts of uncertainty have been used to further the understanding of the concept of uncertainty itself. Duncan (1972), for instance, used the two dimensions “simple-complex” (related to the number of factors to be taken into account in a decision) and “static-dynamic” (related to the stability of the factors over time) to study decision-making in organizations, and found that the static-dynamic dimension was more important for the experienced level of uncertainty.

However, other authors have argued that both objective and subjective accounts of uncertainty need to be assessed and that in fact, the co-alignment of perceptions and objective realities is crucial for good performance (Bourgeois 1985). The validity of this finding can be questioned in light of the second debate.

This second debate delves into basic beliefs by researchers and practitioners alike about the relationship between organizations and their environment. One of Pfeffer and Salancik’s (1978) main intentions in developing resource dependence theory was to show both organizations’ links with their environments and how they can actively shape these links. In doing so, organizations do not react to or act upon given realities, but they enact their environments through processes of selec-

tive attention and interpretation. Or as Weick (1979, p. 130) puts it "Enactment is the only process where the organism directly engages an external environment. All processes subsequent to enactment work on edited raw materials [...]." Therefore, "the question of what the environment is, is meaningless without regard to the focal organization which enacts it, or more precisely, the individuals who enact it in planning the activities of the organization" (Pfeffer and Salancik 1978, p. 73). Enacting situations is highly intertwined with processes of sensemaking (Weick 1995), that is, literally making sense out of things happening through placing them in a particular framework and deriving their meaning from that. Environments are socially constructed on the basis of actors' subjective theories and preconceptions which are used to make sense of any ambiguous information. Any meaning that is derived from this sensemaking process subsequently shapes actors' behaviour. It is through the cyclical sensemaking and enactment processes that actors can either improve their own conditions or, in contrast, can become the authors of their own problems (Weick 1979). Self-fulfilling prophecies are an extreme case of sensemaking, because starting from specific assumptions about the world, people act in ways that will make these assumptions come true. "People create and find what they expect to find" (Weick 1995, p. 35).

Sensemaking is particularly powerful under conditions of high uncertainty when incomplete or ambiguous information requires assumption-based reasoning and interpretation in order to develop a basis for action (Lipshitz and Strauss 1997). Weick points out that uncertainty stemming from incomplete information should be clearly distinguished from ambiguity based on several possible meanings of information. Ignorance and confusion are not the same thing and require different sorts of action, as Daft has studied (Daft and Macintosh 1981; Daft and Lengel 1984): To remove ignorance, more information is needed; to reduce confusion, richer information is needed that provides more cues for sensemaking, for instance, rather a face-to-face conversation than an electronic message.

Questioning the objective and deterministic nature of uncertainties even further, Weitz and Shenhav 2000, p. 246) have argued that notions of uncertainty in the internal and external organizational environment are socially constructed by professionals dealing with management of organizations in order to legitimate the rise of management as such and "to justify [...] managerial and organizational methods of control". They tested their claim with respect to the rise of scientific management at the end of the 19th and beginning of the 20th century using data on the discourse on technical and organizational uncertainty in two prominent American mechanical engineering journals and linking it to membership numbers in the American Society of Mechanical Engineers and to labour unrest. Given that discourse on technical uncertainty, society membership, and labour unrest all added significantly to explaining the amount of organizational uncertainty discourse, Weitz and Shenhav postulated that engineers used their success in handling technical uncertainties to expand their professional domain to include the reduction and elimination of organizational uncertainties as well. The pervasiveness of assembly lines to this present day and the substantial efforts by many companies to shape their environments accordingly provide powerful support for this claim. Barley and Kunda (1992) argued more generally that just how uncertainties are understood and which form of uncertainty management is chosen depends on the prominence of normative versus

rational ideologies; that is, ideologies that build on normative control such as culture, versus ideologies that build on rational control, such as Taylor's scientific management. The prevalence of these ideologies is, in turn, influenced by changes in labour relations and expansions/contractions of the economy. Prospering of normative ideologies seems to coincide with economically difficult times and little labour unrest, while rational ideologies tend to parallel economic expansion and confrontational labour relations.

Uncertainty analysis should, at best, include both perception-based measures and objective indicators. The combination of both approaches helps to account for individual and collective processes of enactment and sensemaking, while at the same time allowing the identification of and compensation for selective processes of information uptake and interpretation.

2.3.2 Uncertainty Analysis: An Example from Railway Operations

The framework presented in Figure 2.1 was used to analyze the uncertainties contained in a particular safety-relevant task in a railway company, which had been related to several incidents and accidents in the recent past (see Figure 2.3 for a summary of the analysis). The task concerns moving a train from a track used only for shunting onto an occupied track from which it is to depart as a passenger train (see *required decision/action* in Figure 2.3). This operation is carried out by the train driver without the assistance of shunters and is guided by dwarf signals. Usually, signals for the train to move onto a track are given when the track sector concerned is free. A special situation, which increases the risk of this operation, is moving the train onto a track sector that is still occupied by another train. This is sometimes done when traffic is particularly dense, for instance, when a train is still on the track but is to depart at the same time as or very soon after the shunted train is supposed to get there (see *external cause* in Figure 2.3).

The task requires cooperation of two actors; the train driver – who also acts as shunting supervisor because no shunter is on the train with him or her – and the signaller (see *actors* in Figure 2.3). The shunting supervisor's responsibility is to determine and lead shunting movements, which includes determining the track to be used, informing all persons affected by the planned train movement, checking several operational requirements (*e.g.*, release of brakes), and requesting a go signal for the chosen track. Also, the shunting supervisor is to be informed by the signaller if there are unexpected obstacles on the chosen track, for example another train on the same track sector. Shunting operations are signalled by means of dwarf signals. These can take on several states, with not all of them having singular meanings (see *internal cause* in Figure 2.3). In particular, one signal state frequently used for shunting in stations “go with caution” implies three possible meanings: expect an obstacle, expect a stop signal at the next sector, or there is no further dwarf signal (see Figure 2.2). Depending on the meaning assigned to the signal by the train driver, for instance, based on his or her expectations linked to prior experience with the particular situation, he or she will drive with the maximum speed allowed of 40 km/h or drive more slowly, in order to be able to stop quickly (see *sources of uncertainty* in Figure 2.3). From their instruments, signalers are not able to ascertain the actual speed of the shunted train; they only have an

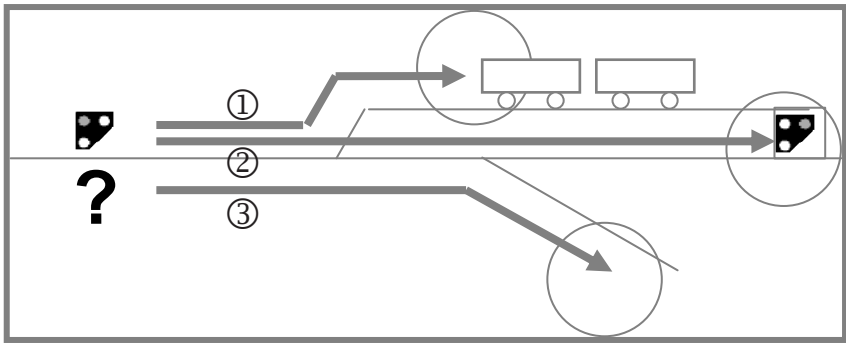


Figure 2.2. The three possible meanings of the dwarf signal “Go with caution”

indication of the train moving across the different track sectors (see *sources of uncertainty* in Figure 2.3). Therefore, they cannot predict the exact arrival time of the shunted train on the occupied track and cannot plan more specifically as to whether the departing train on that track will be gone by the time the shunted train gets there (see *content of uncertainty* and *lack of control* in Figure 2.3).

The standard operating procedures have recently been changed regarding the role of shunting supervisors. For unaccompanied trains the signaller used to be the shunting supervisor; with the new rules the train driver is assigned this role. Several incidents have happened where, among other issues, it was obvious that this new role assignment had not been implemented, but rather signaller and train driver still behaved in accordance with the old role distribution (see *enacted situation* in Figure 2.3). This implied that the train driver did not select the track he or she was to move to. Also, the train driver was not told explicitly that the track to move to was occupied (see *sources of uncertainty* in Figure 2.3). Instead, the signallers' implicit assumption was that the train drivers would be ready to meet an obstacle because this is one of the meanings of the employed dwarf signal state “go with caution”. Also, the maximum speed of 40 km/h should only be used when the track the train is moving to can be seen by the train driver, which was not the case in the incidents analyzed. The train drivers, on the other hand, took the dwarf signal “go with caution” in combination with the absent communication from the signallers concerning obstacles to mean that they were about to move to a free track (see *sensemaking* in Figure 2.3). They therefore chose the maximum speed of 40 km/h, leading in a few cases to critical situations or even a collision with the train already on the track (see *potential consequences* in Figure 2.3). Overall, the handling of this situation by signaller and train driver involved high state and high response uncertainty (see *contents of uncertainty* in Figure 2.3) and led to a lack of transparency and predictability for the train driver and a lack of predictability and influence for the signaller (see *lack of control* in Figure 2.3).

The analysis shows that either an enforcement of the new role assignment or at least more direct communication between signaller and train driver would be required to reduce the uncertainty for the train driver. As the signaller's work load is often too high to expect him or her to spend extra cognitive resources and time

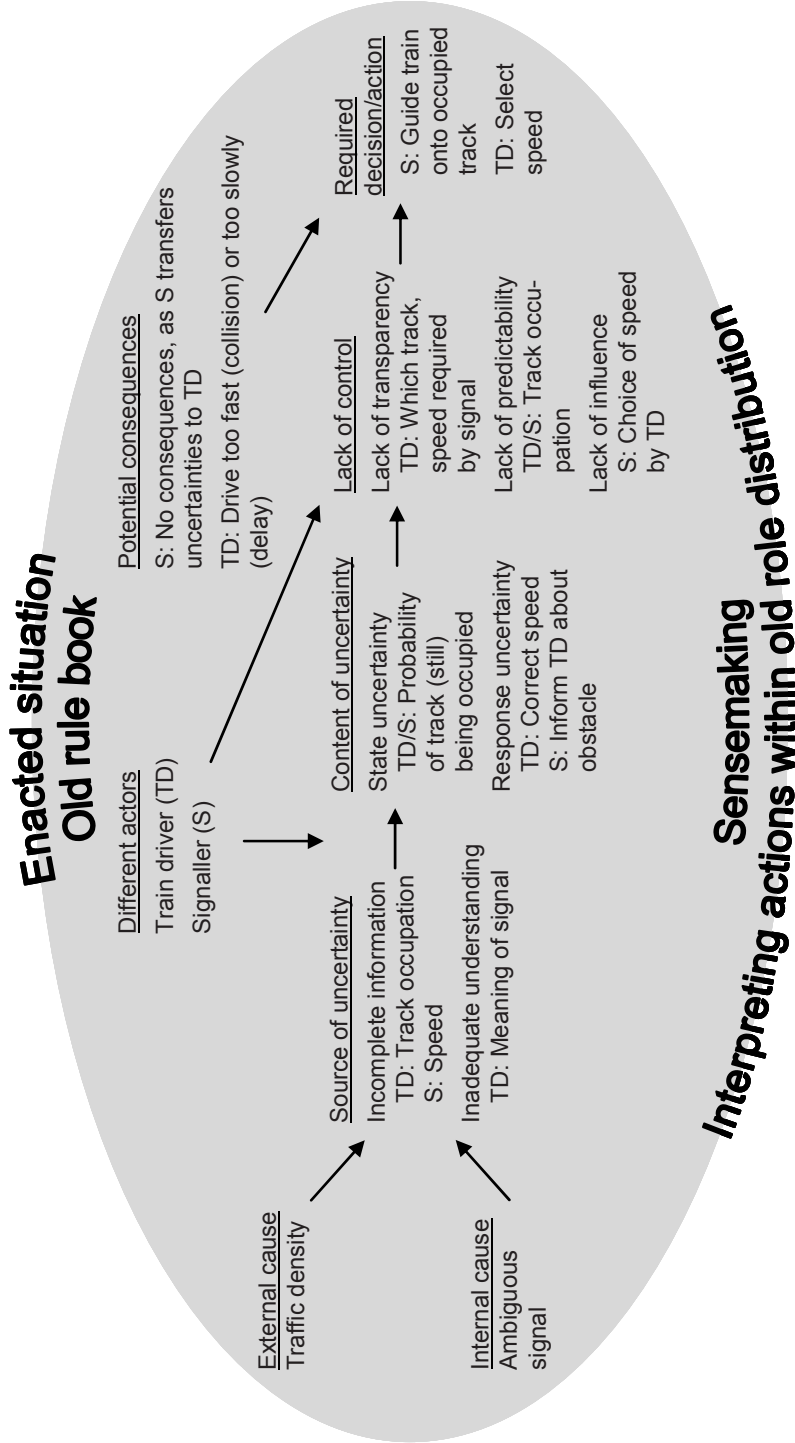


Figure 2.3. Analysis of uncertainties involved in shunting a train onto an occupied track

on communication, another option would be to generally lower the speed the train is allowed to move at upon receiving the dwarf signal and so not reducing uncertainty, but reducing potential negative consequences of the uncertainty. As using occupied tracks is often related to particularly high traffic density and time pressure, this decision could be counterproductive because it might create even more time pressure. These brief considerations already illustrate that the design of a presumably straight-forward operational task may involve strategic decision-making as well, in this case, decisions on production capacity and interaction between traffic control and train control. A more detailed analysis of different options for managing uncertainties better for this task and the concrete steps taken by the railway company to handle this situation will be described at the end of the next chapter.

2.4 Chapter Summary

In this chapter different perspectives on defining uncertainties have been presented and integrated into an analytical framework. Starting from the basic definition of uncertainty as lack of information required to perform a task, three variations of this lack of information were discussed: incomplete information, inadequate understanding of existing information, and undifferentiated response alternatives. These different kinds of lack of information may concern the organization's and the environment's current or future state, cause-effect relationships, or available responses. Causes for uncertainties may lie within the organization, for instance, they could be related to technologies and materials used and the interdependencies between tasks, or they may be external to the organization, such as changing customer demands or emerging competitors. One main effect of uncertainty is lack of control, be it through lacking prerequisites for control in terms of transparency and predictability of the situation or through lack of clarity regarding possible means of influencing the situation. Finally, uncertainty may affect different actors and may have different consequences. In drawing up uncertainty landscapes for organizations, these different facets of uncertainty should be analyzed, leading potentially also to the exclusion of some facets which are not relevant for a particular organization or for a particular type of situation or decision analyzed. In the analysis, both objective characteristics of the organization and its environment and subjective enactments of the situation by different actors, including the sense-making processes involved, should be described. In an example from a railway company concerning a particular safety-relevant task the suggested framework for uncertainty analysis was illustrated.

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