Ambiguity: A Useful Component of "Fuzziness" in Innovation

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Abstract. The early phases of new product development (NPD) processes are characterized by a high degree of uncertainty and ambiguity, a phenomenon commonly recognized as the *fuzzy front en*d of NPD. A clear understanding of the term *fuzziness* is lacking in NPD literature. This paper suggests that its components can be understood through earlier scholars' use of concepts such as ambiguity, equivocality, lack-of-clarity and uncertainty. It is argued that resolving ambiguity is associated with knowledge creation, and hence that it is possible to separate useless from useful ambiguity and thus purposefully exploit ambiguity in a targeted manner to create new knowledge in innovation.
This theoretical paper provides an account of how ambiguity—as a component of fuzziness—has a useful role in the knowledge-building process in NPD.

Keywords: Fuzzy front end, innovation, new product development, ambiguity, learning.

1 Introduction

1.1 The Fuzzy Front End

The *front end* is the starting point that sets the initial direction of the NPD process. Many researchers have emphasized the importance of the activities occurring there [2-9]. Successful management of a new product development (NPD) project involves running the project in a cost- and time-efficient manner while at the same time providing optimal conditions for developing innovative products. To achieve these objectives, a substantial amount of information about relevant technology, market conditions, business potential etc, is required as a basis for making critical decisions at the onset of the NPD project. However, the earliest stage of NPD is especially prone to manifesting considerable uncertainty and ambiguity, or *fuzziness*: a characteristic that does not fit well with an approach that requires accurate and stable up-front information. This phenomenon is commonly termed the *fuzzy front end* of NPD [4, 8-11]. A common argument for the importance of early-phase activities is that the cost and time of corrective actions and engineering changes are then low while fuzziness is high, while they are high at the late phases of the NPD project when fuzziness is low [4, 5, 9]. Empirical studies have in fact confirmed the importance of early-phase activities in the successful launching of NPD projects [12, 13]. Reid and de Brentani [9] have therefore argued that research should be directed toward achieving a better understanding of the fuzzy front end and of ways in which to manage it. Various studies have been made to this end [e.g. 4, 8, 10, 11, 14, 15, 16] , but striking feature of almost all of them is their failure to define exactly what *fuzziness* is. All of the accounts of fuzziness described above imply that it somehow involves a lack of accurate knowledge or gaps in knowledge. This paper will first discuss how fuzziness can be described in terms of a few components that differ by their nature. Following this discussion, the paper will focus specifically on one such component—ambiguity—and address the question:

- Is ambiguity—as a component of fuzziness—entirely negative for the NPD process, or can ambiguity be useful?

[1] This paper is based on, and develops further, work in Eric Brun's doctoral thesis [1].

2 Literature review

2.1 Elements of fuzziness

Fuzziness can mean many things. A precise, consensus definition of the term is lacking in NPD literature, but it is often used to describe the problems one experiences in NPD projects in defining critical elements such as product concepts, markets, and processes [e.g. 4, 8-10, 14]. Some terms that have been used to describe the characteristics of fuzziness are *uncertainty* [8, 9, 16], *ambiguity* [17], *chaos* [7], and *complexity* [6]. The term *fuzzy* is hence used in a non-specific sense to label situations where one experiences a lack of accurate information or accurate knowledge. As we shall see, there have been many contributions to define and distinguish between terms that characterize such situations.

2.2 Distinctions between Equivocality, Uncertainty and Ambiguity

A suitable starting point is perhaps the term *equivocality*, which is commonly used to denote the presence of two or more interpretations for the same piece of information [18, 19]. In *The Social Psychology of Organizing*, Weick asserts that the need for reducing equivocality is the basic reason for organizing. Organizing, as he defines it, is "a consenually validated grammar for reducing equivocality by means of interlocked behaviors" [19]. In their contributions on organizational information requirements, Daft and Lengel [18, 20] distinguish between *equivocality* and *uncertainty*. They draw on Galbraith's [21] definition of uncertainty, which is "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization" [20]. This approach assumes that the organization operates in an environment where you can get clear answers to your various questions. When that is indeed the case, uncertainty can be reduced simply by acquiring new, well-defined data. But a far different situation exists when the organization is confronted with *equivocality*, which Daft and Lengel consider as synonymous with *ambiguity* and define it in the following way: "Equivocality means ambiguity, the existing of multiple and conflicting interpretations about an organizational situation" [20]. The approach they recommend to reduce equivocality is to reconcile these differences of perspective rather than to simply gather more information. Their notion of these two very different remedies for uncertainty and equivocality accords with Galbraith's conception from 1977 that uncertainty can be reduced by processing sufficient amounts of information and Weick's conception from 1979 that equivocality can be reduced by *consensually validated grammar* and *interlocked behaviors.*

In his landmark work *Sensemaking in Organizations* [22], Weick introduces the term *ambiguity*, which he accords two meanings. On the one hand, he says that ambiguity can be understood as *equivocality*—i.e., the presence of two or more interpretations. (He also uses the term *confusion* to designate this meaning of ambiguity.) On the other hand, he claims ambiguity can be understood as *lack of clarity*, which he equates with *ignorance*, the cause of which is insufficient information. This implies that the word *ambiguity* itself is ambiguous in Weick's [22] definition. Weick himself acknowledges the problem with this ambiguous definition, as the two forms of ambiguity require two quite different remedies. He agrees with Daft & Lengel [20] in believing that equivocality is reduced by face-to-face interaction, while reducing uncertainty requires collecting more information.

March has mainly discussed ambiguity as an aspect of decision-making. In March & Simon's [23] work on bounded rationality, the theme of ambiguity lies implicit in their discussion of how organizations consider available alternatives under limited access to information. In his more recent and comprehensive overview, March [24] sharply distinguishes between ambiguity and uncertainty. He claims that *uncertainty*, in most theories of decision-making, refers to imprecision in estimates of future consequences conditional on present actions. The basic assumption behind these theories, he contends, is that there exists an objective, real world that is imperfectly understood but that can in principle be discovered if enough information is made available. *Ambiguity*, meanwhile, refers to a state where the basic assumptions behind the view of uncertainty are challenged. Provision of more information may not in fact improve our understanding, and the world may actually be socially constructed rather than objectively real, meaning that it must be invented and negotiated rather than discovered. March's [24] conceptions of ambiguity and uncertainty therefore pertain to two very different epistemological views of the world. His understanding of ambiguity though, is twofold, although not as distinctly split as Weick's [22] dual definition. March [24] asserts that "Ambiguity refers to features of decision making in which alternative states are hazily defined or in which they have multiple meanings, simultaneously opposing interpretations" [24]. I believe that when alternative states are said to be *hazily defined* as March [24] puts it, this would mean that the decision makers lack the appropriate frames of reference they need to assign precise meanings to these states. Whereas when alternative states have *multiple meanings/opposing interpretations*, the meanings differ because they are interpreted from different perspectives; in other words, we have a situation of equivocality.

In this paper, the proposals and arguments presented rest on a definition of *ambiguity* as *the existence of two or more interpretations of a single cue*, in other words, equal to equivocality.

Despite the differences in definitions of ambiguity that we encounter in literature, a similarity between the authors reviewed so far is that they focus on reducing ambiguity, seeing it as an impediment—something that should be minimized so one can move forward. Eisenberg [25] has challenged this view. In his seminal article *Ambiguity as Strategy in Organizational Communication* [25] he questions the assumption of the central importance of clarity in organizational communication. Clarity, he claims, arises through a combination of the source of a message, the message itself and the receiver of the message. It exists when an individual (the source) encodes an idea into a language, and the receiver understands the message as it was intended by the source. Ambiguity will therefore arise when this condition is not met, i.e. when the source and receiver form their interpretations based on different "interpretive contexts" [25], i.e. different perspectives. He argues that clarity is a valid measure of effectiveness only when the organization aspires to be clear, and that individuals may, on occasion, purposefully deviate from clarity—i.e., strategically use ambiguity—to accomplish their goals.

2.3 **Probability, Uncertainty and Ambiguity**

Another view of uncertainty, commonly held in management literature, originated with Frank Knight [26]. When discussing it as it relates to probability judgment, Knight identified three types of uncertainty:

- When the outcome of an event is not known, but the probability distribution is known.
- When the outcome of an event is not known, and the probability distribution is unknown but can be estimated statistically.
- When the outcome of an event is not known, and the probability is unknown because a distribution is non-existent and cannot be estimated because we are dealing with situations that are unique, so statistical estimation based on a large number of homogeneous instances cannot be attained. In this situation probability cannot be estimated and is not susceptible to measurement.

Knight [26] used the term *risk* to denote the two first categories, which refer to measurable uncertainty, and used the term *true uncertainty* to denote the third, immeasurable type of uncertainty. Knight's account of true uncertainty focuses on the probabilities of the outcomes of events. Note however, that Knight assumes that the events themselves are known. This assumption is in my opinion questionable; I do not believe there is always agreement on what the events are. I argue that it is in the understanding of the event itself that ambiguity first emerges, as illustrated in Figure 1:

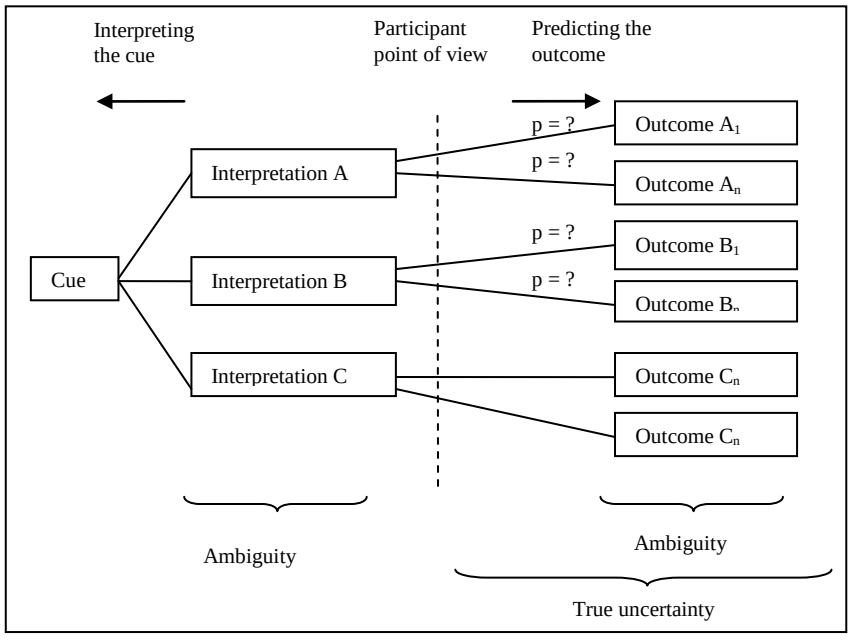

Fig. 1. Ambiguity and true uncertainty

I will illustrate with an example in the context of an NPD project. The process will typically be triggered by a cue, for example, a business opportunity that emerges. This cue will become subject to interpretation by the involved participants. Each interpretation will constitute an idea of what a sensible action may be to pursue the

business opportunity. An idea may for example be an idea of a product concept to pursue. When multiple participants are involved, multiple interpretations (i.e. ambiguity) may occur. In our example, this may mean that the involved participants each have different interpretations of what they see as a sensible product concept.
The participants will however also assume alternative outcomes of each action, and each outcome will also be a participant's interpretation. For example, if a certain product concept is agreed upon, there may still be different interpretations of what the market's response to that particular product concept may be. Hence these outcomes, too, may be ambiguous. Furthermore, the probabilities of the outcomes cannot be determined, i.e. there is a situation of true uncertainty. So in this situation, there is first an occurrence of ambiguity about the events resulting from multiple interpretations of the cue, followed by another occurrence of ambiguity about the outcomes of these events. When the participants try to predict these outcomes, true uncertainty arises. Situations like this are typical of NPD processes. Ambiguity in NPD is thus related to Knightian true uncertainty, first as a precursor to true uncertainty, and then as a component of true uncertainty.

2.4 **Thought Worlds – The Bases of Interpretations**

Weick [22] contends that sensemaking depends on *paradigms*, or vocabularies of work, which in occupational communities are rules and conventions, standard operating procedures, shared definitions of the environment, and an agreed-upon system of power and authority. These paradigms help organizational members form their interpretations and make sense of the cues they perceive.

Dougherty [27] argues that different functional departments in an organization will have their own separate *thought worlds*. In her account, a thought world "is a community of persons engaged in a certain domain of activity who have a shared understanding about that activity" [27] and "evolves an internally shared system of meaning . . . . based on common procedures, judgments, and methods" [27]. Individuals tend to interpret an aspect of the innovation process according to the thought world of their own department. Thus development priorities and tasks will be interpreted differently by organizational members from different departments. Dougherty contends that cross-functional communication and collaboration help unify these thought worlds and so reduce the divergence of interpretations; in other words, they reduce ambiguity. On a similar note, Daft and Lengel [20] argue that departments in organizations develop their own *frames of reference*, and that the differences in these departmental frames of reference give rise to ambiguity.

The terms we have just been encountering—*paradigms*, used by Weick [22], *thought worlds*, used by Dougherty [27], *frames of reference*, used by Daft and Lengel [20] and—as I will revert to—*horizon of understanding*, used in hermeneutics theory, all align as common terms for the bases from which interpretations develop. For the sake of simplicity I will mainly use Dougherty's term *thought world* in the further discussion. This thought world will involve a number of "taken-for-granted" assumptions shared by the individuals in a social group. Therefore that group's common *tacit knowledge* is closely associated with the group's thought world. The concept of tacit knowledge was first launched by Polanyi [28], and Nonaka [29] later tied the term specifically to knowledge development in innovation. Leonard and Sensiper [30, 31] also discuss the role of tacit knowledge in innovation. They claim that when a group of individuals address a common challenge, each individual "frames both the problem and its solution by applying a mental schemata and patterns that he or she understands best" [31]. Leonard [30] uses the term *specialization* to denote this kind of mental schema and specifically describes it as similar to Dougherty's [27] concept of *thought world*.

3 Ambiguity and Learning

Although there is little research specifically addressing the theme of ambiguity in NPD, previous research has addressed uncertainty and uncertainty reduction in NPD. For example, Eisenhardt and Tabrizi [32] argue that NPD projects benefit from iterations and tests because frequent iterations build understanding of the product, and extensive testing gives frequent evaluations of the current design, provides multiple options and a wider set of ideas and thereby accelerates understanding and re-conceptualization of the product. Their arguments for iteration and testing thus allude to a learning process involving new interpretations and new conceptualizations, which implies far more than the mere information gathering that would be required to reduce uncertainty. It is therefore relevant to explore the inner workings of such a learning process, where ambiguity reduction is associated with learning and development of thought worlds.

3.1 **Ambiguity Reduction and Hypothesis Testing**

Since ambiguity arises when a cue is assigned diverging interpretations, it is logical to direct our attention to theories of interpretation in order to enhance our understanding of ambiguity reduction. Hermeneutics constitutes one body of such theories. A central term in hermeneutics is the *hermeneutic circle*, and according to Føllesdal

[33] and Føllesdal and Walløe [34], the hermeneutic method can be seen as a special case of the hypothetical-deductive method. They consider the hermeneutic circle to be a circle of continual hypotheses-testing.

They distinguish between *understanding* (as something we arrive at) and *interpreting* (as the process used to arrive at an understanding). When we say that we *understand*, we have a satisfactory hypothesis about the phenomenon we're confronting. The hypothesis is then more or less explicit; we are aware that we are working with one, that we are testing it and may have to reject or modify it. When we understand, our hypothesis has been tested and has withstood rejection, and it becomes more implicit. It has then become part of our *horizon of understanding*, a term commonly used in hermeneutics to express the amount of opinions, notions, attitudes, or beliefs we have at any given point, which we may or may not be aware of. Føllesdal and Walløe consider the horizon of understanding to be the set of hypotheses, auxiliary hypotheses, or underlying assumptions we employ when interpreting something. An interpretation can thus be considered a hypothesis, and each loop of the circle represents a test of that hypothesis, resulting in either its rejection or strengthening. Brun and Sætre [35] have accordingly shown that participants in NPD processes actively make use of a hypothetical-deductive approach to reduce ambiguity, by testing the competing interpretations, leading to their confirmation or rejection.

According to postmodernist critique, the hermeneutic circle cannot reach final closure—that is, it cannot reach agreement on the definitive meaning of a cue—so the hermeneutic circle is often described as an ever upward-moving spiral. The spiral does not end, which accords with Popper's [36, 37] argument that a hypothesis can never be fully verified; it can merely be refuted or corroborated as a result of withstanding refutation. The upwards move on the spiral represents a move towards reduced ambiguity through test, rejection, and refinement of competing interpretations—or, in other words, towards increased understanding with more refined and strengthened hypotheses. This also implies that our horizon of understanding develops with the upward movement on the spiral.

3.2 **Ambiguity Reduction and Experiential Learning**

I have argued earlier that ambiguity is one category of fuzziness, fuzziness being a lack of accurate knowledge. But if presence of ambiguity is a form of lack of knowledge, then I would argue that reducing ambiguity implies a move towards gaining knowledge, i.e. resolving ambiguity is associated with knowledge creation. I believe this argument accords with the Hypothetical-deductive logic just described, which is essentially how knowledge is developed through scientific practice. That process is strikingly similar to the cycle by which knowledge develops through experiential learning as described by Kolb [38] and illustrated in Figure 2.

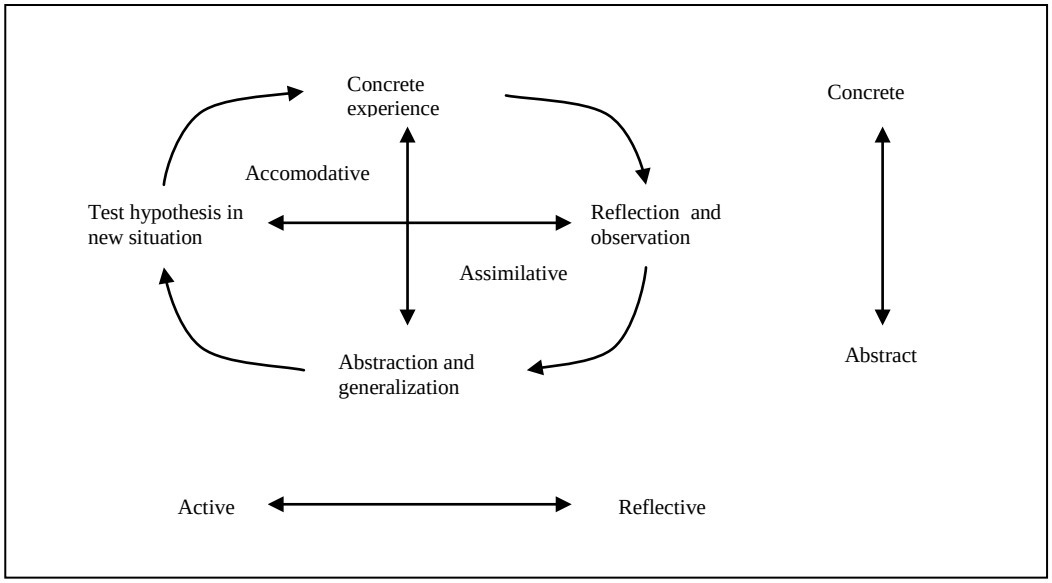

Fig. 2. Kolb's model of experiential learning

In the *observation* phase on the right-hand side of the model, an individual senses a cue. In the *abstraction and generalization* phase, he or she will interpret the cue and form an interpretation, i.e. generate a hypothesis. This *hypothesis* is then *tested* in phase on the left-hand side of the model, and then *experience* a result of the test. The individual will then *reflect* on the outcome of the test, i.e. decide whether the hypothesis is confirmed, or must be

rejected. If the latter, then the individual forms a new hypothesis, i.e. re-interprets the cue, possibly in alignment with the interpretation of another individual, if this second individual's interpretation was confirmed by the same process. The amount of competing interpretations—i.e. ambiguity—has then been reduced through this learning process.

3.3 **Ambiguity Development and Knowledge Creation in Innovation**

Dougherty and her colleagues argue that sensemaking in innovative organizations leads to renewal of knowledge frames [39]. Their argument implies that thought worlds are not static entities, they develop over time. This argument accords with the logic of both the Hypothetical-deductive model and Kolb's model of experiential learning, wherein a community's total amount of hypotheses is continuously enhanced and refined, leading to development of new knowledge.

The notion of growing thought worlds is also demonstrated in Nonaka's [29] model of knowledge creation in innovation, illustrated in Figure 5. He describes four phases through which knowledge develops; Externalization, Combination, Internalization and Socialization.

1) In the Externalization phase, individuals turn their tacit knowledge into explicit knowledge.
2) In the Combination phase, individuals share and combine elements of their explicated knowledge and thereby create new explicit knowledge.
3) In the Internalization phase, the newly developed explicit knowledge is internalized in the team members and thus adds to their tacit knowledge.
4) In the Socialization phase, this added tacit knowledge is shared within the larger group as individuals share experiences "and thereby create a common tacit knowledge such as *shared mental models*" [40].

Through Socialization, tacit knowledge thus grows from an individual level to a larger pool of common tacit knowledge shared by a community. The same growth occurs for explicit knowledge through the process of Combination.

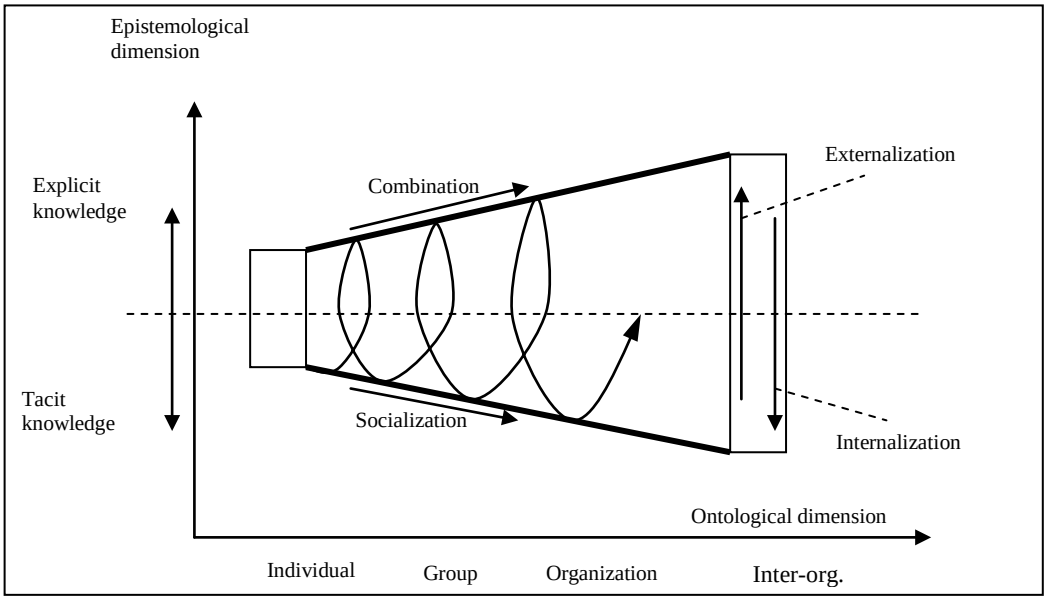

Fig. 3. Spiral of organizational knowledge creation. Adapted from Nonaka [29]

In Figure 3, the thick solid line going upwards towards the right as represents the growth of explicit knowledge as new product concepts are developed, refined and agreed upon throughout the organization and its immediate environment. The thick solid line going downwards towards the right represents the growth in common tacit knowledge and hence development of a common thought world throughout the organization and its immediate environment.

Whether such a pool of common understanding is denoted as a paradigm , thought world or frame of reference, or *shared mental model* as used by Nonaka and Takeuchi [40], it is clear that this pool is not static.

As new tacit knowledge develops and is shared the pool of common understanding and shared assumptions changes as a result of innovation activity.

When the individuals in an NPD team sense a cue, such as a product idea, they will form different interpretations of this cue based on their differences in tacit knowledge, and ambiguity thus arises. When these different interpretations are explicated in the Externalization phase [29], the ambiguity is brought to awareness. These different and explicated interpretations represent ideas that are shared between the team members in the Combination phase [29] and act as raw material for innovation. When these ideas are combined ambiguity increases. Then, when ideas are selected ambiguity is reduced, and the selected ideas (i.e. selected interpretations) are further developed. According to Nonaka and Takeuchi [40] it is in the Combination phase that product concepts are developed as the individuals of an NPD team exchange and combine knowledge. Development of a product concept is thus associated with an initial increase and a following reduction of ambiguity and growth of knowledge. When the 4 phases in Nonaka's [29] knowledge development model are repeated in cycles, ambiguity thus oscillates between growth and reduction throughout the innovation process, in accordance with Brun and colleagues' [41] model of how ambiguity develops throughout the NPD process.

4 Distinguishing between Useful and Useless Ambiguity

From the preceding discussion we can see how reduction of ambiguity is related to learning and knowledge creation. Ambiguity in NPD is thus useful when it has potential to contribute to the knowledge-building that a company seeks with its innovation effort. In this respect, it is useful to consider Brun and colleagues' [42] model for classifying ambiguity in NPD, presented in Table 1.

Table 1. A Model for Classification of Ambiguity in NPD [42]

		Subjects of ambiguity.			
		Product	**Market**	**Process**	**Organization resources**
Sources of ambi-guity:	**Multi-plicity**	Ambiguity arising from multiple interpretations of product issues.	Ambiguity arising from multiple interpretations of market issues.	Ambiguity arising from multiple interpretations of issues related to the work process.	Ambiguity arising from multiple interpretations of issues related to the organization's resources
	Novelty	Ambiguity arising from changing interpretations of the product	Ambiguity arising from changing interpretations of market issues.	Ambiguity arising from changing interpretations of the work process.	Ambiguity arising from changing interpretations of issues related to the organization's resources.
	Validity of info	Ambiguity arising from low validity of information about the product.	Ambiguity arising from low validity of information about the market.	Ambiguity arising from low validity of information about the work process	Ambiguity arising from low validity of information about the organization's resources.
	Relia-bility of info	Ambiguity arising from low reliability of information about the product.	Ambiguity arising from low reliability of information about the market.	Ambiguity arising from low reliability of information about the work process.	Ambiguity arising from low reliability of information about the organization's resources.

The columns in the table, i.e. the subjects of ambiguity, indicate what there is ambiguity *about*, i.e. issues about the Product, Market, Process and Organizational Resources. In any company, the purpose of an NPD project is to launch a new product in an appropriate market. One seeks to build knowledge about the product and the market and arrive at a description and understanding of what that product and what that market is. Ambiguity about the product and the market contributes to that knowledge-building process and should therefore be tolerated. For another subject of ambiguity—Process—the context of the NPD project will determine whether ambiguity related to that subject is useful. Companies in less regulated industries, as well as those developing service products, may well want to develop their NPD process along with the product. Ambiguity about the NPD process will then be a part of the innovation-related knowledge-building process and can therefore be useful. This will however not be so in a company in a highly regulated industry, requiring adherence to a well-defined NPD process. Here, the innovation-related knowledge-building is primarily associated with the subjects Product

and Market. Ambiguity about the subject Process will not add to this knowledge-building and is therefore not useful.

In companies conducting NPD largely under their own control, ambiguity about Organizational Resources is unlikely to be a welcome ingredient in the knowledge-building process of their NPD projects. However, in contexts where companies are exploring and developing new collaboration patterns together as part of a common NPD project, ambiguity about Organizational Resources will indeed contribute to innovation-related knowledge-building and should hence be tolerated.

The rows in Table 1 also identify four sources of ambiguity (i.e. what gave rise to the ambiguity); Multiplicity, Novelty, Validity and Reliability. Ambiguity from the first two sources—Multiplicity and Novelty—is essential for innovation, so care should be taken throughout the project to not reduce ambiguity to the extent it jeopardizes innovation. Ambiguity can however also arise from two other sources, low validity or low reliability. As in scientific experiments, low validity and low reliability do not contribute to build knowledge; on the contrary, they contribute to error and low trustworthiness. Ambiguity caused by these sources in NPD projects should therefore consistently be reduced by using valid and reliable information sources.

As a second criterion to distinguish between useful ambiguity and useless ambiguity, I therefore contend that ambiguity is only useful when it has potential to contribute to the knowledge development that is related to the purpose of a company's innovation effort.

5 Conclusion.

In this paper, I have addressed the question of what fuzziness is, and discussed the difference between the fuzziness components of uncertainty and ambiguity, and focused specifically on the concept of ambiguity. I have discussed how reduction of ambiguity is associated with learning, and how ambiguity—developing in a cyclical manner of increasing and decreasing— is an integral part of knowledge development in innovation. Ambiguity is thus a component of fuzziness that can be useful. However, ambiguity is only useful for NPD when it contributes to build the new knowledge one is seeking in the particular project. The subjects one seeks to build knowledge about depend on the context of the NPD project. Ambiguity related to these subjects is useful and should be tolerated whereas ambiguity not contributing to build this knowledge should not be tolerated.

This paper contributes to theory by providing a theoretical argument of how ambiguity, as a component of fuzziness, can be useful in innovation. This contribution can also be useful to practitioners. When confronted with situations that they experience as fuzzy in their innovation projects, they may be better able to identify what component is contributing to this fuzziness and thereby be better able to select the right means to reduce the fuzziness. If the component they are facing is ambiguity, then understanding it's role in the knowledge-building they are attempting to achieve can help them to purposefully exploit ambiguity to the benefit of their innovation projects.

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