Decision Analysis with Personal Distinctions

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Abstract

The clarity of distinctions is a cornerstone of decision analysis. The "classical clarity test" is a gedanken experiment which requires that distinctions have an unambiguous, physically determinable specification. This clarity underlies many fundamental concepts, including probabilistic modeling, clairvoyance and the value of clairvoyance, and the operations used to evaluate decision models. Although the classical clarity test provides these powerful benefits, it imposes a large cost by limiting the expressiveness of distinctions to those that are physically determinable.

In many decision situations, the most useful distinctions are preferences, feelings, and impressions that are not physically determinable, and thus do not satisfy the classical clarity test. When they are nonetheless unambiguous to an individual, we call them *personal distinctions*. We show how the decision maker can appropriately use her personal distinctions, which include her preferences and beliefs, to represent her perspective of her decision problem. When the decision maker's personal distinctions are also unambiguous to other decision participants, we call them *shared distinctions*. Not surprisingly, unambiguous physically determinable distinctions are a special case of shared distinctions. Finally, we extend the decision analytical framework so that we can include all the decision maker's personal distinctions in her decision model.

1. Introduction

Distinctions are basic constructs in a decision model and must be defined precisely. Because of this, Spetzler & Stael von Holstein defined the "classical clarity test," a gedanken experiment that requires that distinctions have an unambiguous, physically determinable specification [Spetzler & Stael von Holstein 1975, Howard 1992]. The test is a key part of the decision analytic methodology because it is the basis for procedures that facilitate a distinction's precise definition prior to probability encoding. The clarity test has improved the discipline's efficiency and effectiveness by reducing confusion among decision participant(s) [Howard 1990, Howard 1988].

However, the classical clarity test requirement may also limit the discipline's efficiency and effectiveness because it prohibits many useful and meaningful distinctions from being included in a decision model. For instance, many distinctions that a decision maker[1] considers when evaluating her therapeutic alternatives do not pass the classical clarity test. Examples of such distinctions, obtained from our discussions with people evaluating therapy for AIDS, include: *quality* time with our 5-year old daughter; the *taste* of wine; a doctor that I *respect*; and *pain*, *suffering*, or *discomfort* (*feeling* as I do now, *feeling* as I did when I had lip cancer therapy, *feeling* as I did when I was recovering from surgery). All fail the classical clarity test and are therefore excluded in a decision model. We address this discrepancy between decision analytical requirements for clarity and modeling needs for expressiveness.

Can we model distinctions that do not pass the classical clarity test? If so, can we remain consistent within decision theory and analysis? How are distinctions that do not pass the classical clarity test related to decision analytic concepts—such as the value of perfect information—and procedures—such as the operations used to evaluate a decision model? This paper answers these questions by formalizing the use of distinctions that are not physically determinable.

[1]For readability, we arbitrarily refer to the decision maker and another individual, in general, respectively as female

The remainder of this paper is organized as follows. Section 2 provides more formal definitions. Section 3 presents an example that we use to facilitate our discussion and to support our thesis. Section 4 defines and relates key concepts that are fundamental to understanding our new view of distinctions for decision modeling and view of beliefs and preferences. Section 5 provides the infrastructure that allows us to model the decision maker's unambiguous distinctions that are not physically determinable. Section 6 shows, through examples, how we can use personal distinctions to characterize consequences and to learn about other distinctions. Section 7 summarizes our findings.

2. Distinctions and the Classical Clarity Test

A **distinction** is a feature which can be used to separate possible worlds into two or more categories, exactly one of which must come about. Example distinctions about a room are its temperature, size, color, aroma, and ambiance.

Distinctions play a crucial role in decision modeling and analysis. When adopting the decision axioms [Savage 1972]—in particular, the problem description, orderability, and continuity axioms—the decision maker uses distinctions to characterize her decision problem. The decision maker must: insure that the consequences that follow courses of action under consideration are well-defined, meaning that she must introduce unambiguous distinctions as necessary to sufficiently differentiate and order the consequences; provide meaningful preference probabilities; and provide meaningful probabilities that reflect her background state of information.

Therefore, decision analysis requires that distinctions pass the classical clarity test. The

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and male.

classical clarity test, as presented in the earliest publication that we can locate, is provided below:

> The quantity should be clearly defined. A good test of this quality is to ask whether a clairvoyant could reveal the value of the quantity by specifying a single number without requesting clarification [Spetzler & Stael von Holstein 1975].

A more recent publication of the test follows:

> A distinction meets the clarity test if a clairvoyant with the power to know any physically definable event or number in the future or the past could say which degree of the distinction occurred without any use of judgment [Howard 1992].

The essence of the gedanken experiment is that distinctions used in decision analysis must be unambiguously specified and physically determinable.

Although the test's description varies slightly among authors [Kirkwood 1997, Howard 1992, Clemen 1990, Howard 1990, McNamee & Celona 1990, Holtzman 1989, Howard 1988, von Winterfeldt & Edwards 1986, Spetzler & Stael von Holstein 1975], the requirements it imposes upon distinctions remain the same. We now define these requirements and examine their decision analytic role.

We define *unambiguous* as follows: a distinction is unambiguous to its author if, no matter what the outcome of an experiment might be, he can identify observations that will make him certain about whether the distinction is true. For example, suppose the decision maker is interested in the distinction “room size.” If she is presented a room that measures 15 m x 10 m x 80 m and if she can say, with certainty, that the room size is big, medium, or small, then she is unambiguous in her specification.

Though desirable, it may be difficult if not impractical or impossible to define a distinction so that it is absolutely unambiguous, simply because the distinction may have infinite variations.

For instance, take the distinction room size. What exactly is a room? We might define a room to be an area separated by walls from other similar parts of the structure in which it is located. But what is a wall? We might define a wall to be a vertical structure used to divide an area. The specification can continue indefinitely.

Fortunately, it is usually unnecessary for the decision maker to remove absolutely all ambiguity. Rather, it is usually adequate when she has defined the distinction sufficiently in detail with respect to the particular context of the decision at hand.

Now we define *physically determinable*, the second requirement of distinctions. A distinction that is specified in terms of characteristics of phenomena that can be shared by different observers, consistently described, and precisely measured in mathematical language is physically determinable. Physically determinable distinctions include the language of mathematics. An example of a physically determinable distinction is a room's size specified in metric units.

To represent important aspects of decision situations, we need to include unambiguous distinctions that are not physically determinable, in violation of the classical clarity test. We examine such distinctions in the next two sections.

3. Discrepancy

To understand the discrepancy between decision analytical clarity requirements and modeling needs, we examine a decision problem that exhibits characteristics similar to evaluating therapeutic alternatives for personal treatment, but is more manageable and for which most people have some expertise: evaluating shoes for personal use. What distinctions might one consider? Some considerations are comfort; appearance; odor resistance; durability; size;

width; forefoot and instep measurement; arch and heel design; shock absorbency features; breathing and moisture accommodations; welt construction; shank specification; and insole, outsole, lining, and upper material; color; and/or style [Allen 1916, Black Edwin 1996, Black Elizabeth 1996].

Some of these distinctions concern gestalt properties, or, are gestalt distinctions. In our particular example, a shoe's comfort is a characteristic that can be known only by wearing the shoe rather than by analyzing all its isolated parts, which include size; width; forefoot and instep measurement; arch and heel design; shock absorbency features; breathing and moisture accommodations; welt construction; shank specification; and insole, outsole, lining, and upper material. Similarly, a shoe's appearance is a characteristic that can only be known by examining the whole shoe rather than all its isolated parts.

Which of these distinctions pass the classical clarity test and which are of primary interest to the decision maker? Distinctions that pertain to the shoe's parts are physically determinable and pass the classical clarity test. But gestalt distinctions are usually associated with personal judgment and perception that go beyond physical determinants and, therefore, do not pass the classical clarity test. If the decision maker is primarily interested in the shoe's parts, then we do not conflict with the classical clarity test. However, if the decision maker is primarily interested in the shoe's gestalt property(ies), such as comfort or appearance, then we conflict with the classical clarity test.

This leads to a second observation: some of these distinctions might be considered objective and others subjective. By objective, we mean that the distinction pertains to an object, phenomenon, or condition, and is independent of individual thought. Physically determinable distinctions are objective distinctions. By subjective, we mean that the distinction pertains to an object, phenomenon, or condition, but belongs to the perceiving subject, is influenced by the perceiving subject's personal interpretations, feelings, or prejudices, and therefore, can be assessed only by the perceiving subject. For example, the shoe's forefoot and instep measurements are objective distinctions; the shoe's comfort and appearance are subjective distinctions.

We elaborate on the discrepancy between clarity requirements and modeling needs. The classical clarity test excludes gestalt or subjective distinctions from usage in a decision model. Not until the decision maker has sufficiently characterized her consequences in physically determinable terms, is she able to introduce her subjective preferences and beliefs.

Thus, to meet modeling needs, we employ various ad hoc approaches that often reduce the discipline's efficiency and effectiveness. We may, for example, insist that the decision maker specify only physically determinable distinctions, even if these distinctions are only of secondary interest. This means that even when the decision maker is primarily interested in a gestalt distinction, then she cannot use the distinction in her model. Alternatively, we can proceed to model the gestalt distinction and simply footnote or ignore the classical clarity test violation. Or, we may require that the decision maker suppress any uncertainty that she has concerning gestalt distinctions and instead focus on point estimates.

Each of these approaches in their current form is unsatisfactory, as each requires either the decision maker or modeler to make an unacceptable sacrifice to accommodate the other's agenda. Moreover, we do not possess clear guidelines about the proper use of the various approaches, their implications, and their relation to the decision analytic framework.

4. Personal Distinctions for Decision Modeling

This section introduces concepts that lead to a new view of distinctions for decision modeling, enabling us to reconcile clarity requirements with modeling needs and to achieve a unified view of beliefs and preferences in a decision model.

4.1 Personal Distinctions

Our belief that certain distinctions pass the classical clarity test implies that we believe distinctions can be both unambiguous and physically determinable. But can distinctions be unambiguous without being physically determinable? We maintain they can and define a *personal distinction* to be a distinction that is unambiguous to an individual.

For example, in the shoe evaluation problem, suppose the decision maker is really interested only in the shoe's comfort. Suppose she claims that she knows what she means when she says a shoe is or is not comfortable. Suppose she also claims that, after trying on a pair of shoes, she can identify whether the pair of shoes is or is not comfortable. We do not know what she means by comfortable nor do we know what she means by not comfortable. We can do things to challenge and sharpen her claim, such as give her several dozen pairs of shoes to assess in terms of comfort. But even after that exercise, we still may not know any better what she means by comfortable, although she may. Ultimately, comfort is her personal distinction when she is convinced that she knows what she means by comfortable.

4.2 Shared Distinctions

We already know that a decision model's distinctions' unambiguous specification by the decision maker is important. But it also matters to which other people these distinctions are also unambiguous to, for much of decision analysis' power comes when a decision maker's distinctions are unambiguous to, or shared with, other decision participants.

We define a *shared distinction* as follows: a personal distinction for two or more individuals is shared if, no matter what the outcome of an experiment will be, they will agree about whether the distinction is true. A personal distinction may or may not be shared among the decision maker and other decision participants.

To get a better feel for distinctions that may and may not be shared, let's examine the aforementioned distinctions about shoes. A shoe's size, width, forefoot and instep measurement may be shared between many individuals; a shoe's style and appearance may be shared within a community of individuals with the same background or training; and a shoe's comfort is unlikely to be a shared distinction.

There are many common shared distinctions that might not be physically determinable. For example, the color of an object might not be physically determinable under adverse lighting or to a color blind observer. Chinese characters are certainly shared distinctions, but most people in the United States cannot distinguish them. There are a variety of medical distinctions, such as heart murmur, whose characteristics are recognized only by trained physicians.

Can we validate that a personal distinction is shared between individuals, such as the decision maker and other decision participants? As in the case of ensuring that a distinction is unambiguous to an individual, we cannot and are limited in our ability to do so. Furthermore, we may not even know what the distinction means. To challenge or help sharpen their claim, we can again do things such as to expose all the involved individuals to a variety of experiments that test their assessments about the distinction. And even after that exercise, we may again not know any better what the distinction means. Ultimately, it is sufficient when they are convinced that they share the distinction.

4.3 Physically Determinable Distinctions

Earlier, we asked why the classical clarity test requires that a distinction must be physically determinable. What physically determinability does ensure is that a distinction can be shared. This follows directly from the definition of a physically determinable distinction. Thus, if a decision maker's personal distinction is physically determinable, then the distinction can potentially be shared with other decision participants. We present this relation as follows: *If a distinction is physically determinable, then it is a shared distinction.*

A shoe's size, width, and forefoot and instep measurement are examples of physically determinable distinctions. A shoe's comfort and appearance are physically determinable only if one considers the physical parts that comprise these distinctions to be equivalent to the distinctions themselves.

4.4 A New View of Distinctions for Decision Modeling

If a decision maker characterizes her decision problem with her personal distinctions, then should she be allowed to include all the distinctions, including those that are not physically determinable, in her corresponding decision model? We maintain she should, if the decision model is to reflect the decision maker's perspective of her decision problem. For instance, if the decision maker is evaluating shoes for personal use, is concerned about a shoe's comfort, and claims she knows what she means by comfort, we maintain that she should include comfort in her decision model.

Thus, we arrive at our new view of distinctions for decision modeling: any distinction that is unambiguous to an individual is a personal distinction, and any of the decision maker's personal distinctions can be included in her decision model. This view is motivated by the thesis that many useful distinctions are not physically determinable but nonetheless unambiguous and actually knowable to the decision maker.

We contrast this new view with the classical view that does not regard the personal aspect of distinctions. Instead, the classical view begins with and limits itself to physically determinable distinctions.

We draw an analogy of our new and the classical view of distinctions to two views of probability [Savage 1972, von Winterfeldt & Edwards 1986]. One view regards probability as a subjective measure of uncertainty and a reflection of an individual's belief about distinctions and her background state of information. The other view regards probability as an objective measure of uncertainty, where the measure is obtained by accumulating evidence over repeated trials or through symmetrical characteristics of an object, such as the six symmetrical sides of an ideal die.

We now have two views of distinctions for decision modeling. Our new view regards a distinction as a subjective artifact that originates and resides with an individual, reflecting her perspective of the world and her background state of information. This is in contrast to the classical view that regards a distinction as an objective artifact defined by the object or nature.

4.5 A New View of Preferences

The above concepts allow us to achieve a unified and coherent view of the decision maker’s preferences and beliefs in a decision model as personal distinctions. Specifically, beliefs (what the decision maker knows) can be viewed as either shared or non-shared distinctions and preferences (what the decision maker wants) can be viewed as non-shared distinctions.

Traditionally, the decision maker's preferences are defined in terms of physically determinable attributes through an objectives hierarchy [Keeney 1992].

5. Decision Analytic Implications

We now present the infrastructure that allows us to include not only physically determinable distinctions but *all* the decision maker's personal distinctions in her decision model. We accomplish this by extending the decision analytic framework, reviewing decision analytical procedures, and identifying where we have additional flexibility when a distinction is shared.

5.1 Personal Clairvoyants

We introduce the concept of a personal clairvoyant corresponding to the concept of personal distinctions. A *personal clairvoyant* can resolve any and all distinctions that are unambiguous to a particular individual, and it can resolve only that particular individual's personal distinctions.

We compare a personal clairvoyant's capabilities and purpose with the classical clairvoyant's. A personal clairvoyant can resolve all of a particular individual's personal distinctions, including those that are physically determinable, whereas the classical clairvoyant can only resolve distinctions that are both unambiguously specified and physically determinable, without particular regard for whose distinctions they are. All personal clairvoyants, like the classical clairvoyant, are mythical constructs used to facilitate a distinction's unambiguous specification, communication, and the concept of perfect information (or clairvoyance).

5.2 The Extended Clarity Test

We extend the classical clarity test to the following: A decision analytical requirement of each distinction in a decision model to which probabilities are to be assigned is that its resolution can be determined by the decision maker's mythical personal clairvoyant who knows the past, current, and future value of all of the decision maker's personal distinctions. The essence of this extended clarity test is that a distinction used in a decision maker's model must be unambiguous to the decision maker but need not be physically determinable.

5.3 Influence Diagrams

An influence diagram is a graphical structure for representing decision problems [Howard & Matheson 1981, Shachter 1986]. The diagram, which we refer to as the classical representation, employs rectangles (decision nodes) to denote alternatives under consideration, ovals (chance nodes) to denote a set of mutually exclusive and collectively exhaustive distinctions, one which will come about, and arrows to denote probabilistic dependencies and information flow.

To express and represent whether a distinction is shared, we extend the influence diagram representation. We differentiate non-shared from shared distinctions by using an oval with a dashed outline (dash-oval) and a standard oval with a solid outline (solid-oval) to respectively denote the two distinction types.

Arrows between decision and chance nodes retain the meanings of those under the classical representation, regardless of whether the distinction is shared or non-shared. We enumerate the eight possible relationships between alternatives and distinctions that follow from distinguishing shared and non-shared distinctions and provide an example of each relationship in Figure 1. The first four relationships are identical to the four in the classical representation, except that the solid-oval denotes any shared distinction and not only physically determinable ones. The fifth through seventh relationships are analogous to the first three, except that distinctions are non-shared rather than shared. The last relationship indicates the possibility of relevance between a shared and non-shared distinction.

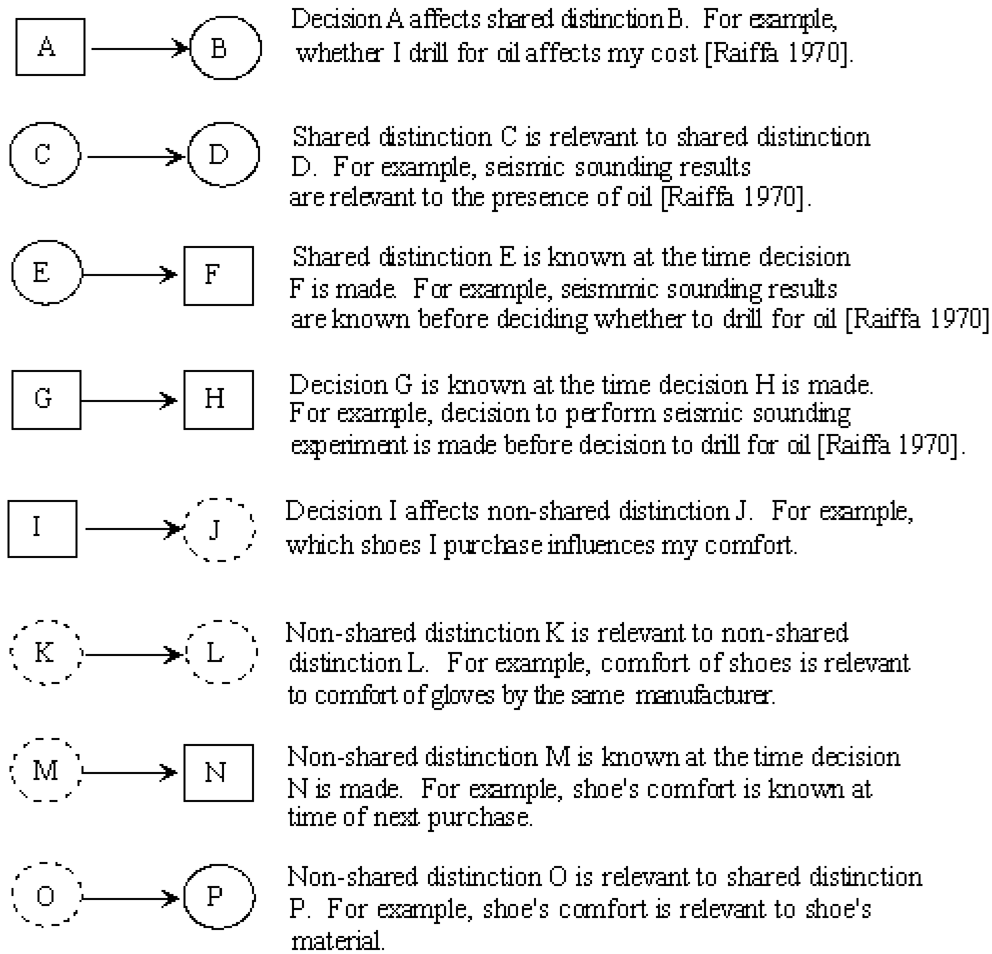

Figure 1. Relationships between alternatives and distinctions in extended influence diagram notation. There are eight possible relationships.

In the extended representation, we employ a diamond to depict the value node, the node that represents the distinction whose certain equivalent is to be optimized. Furthermore, in the extended representation, we use a diamond with a solid outline (solid-diamond) if the distinction is shared and a diamond with a dashed outline (dash-diamond) otherwise. For instance, if the decision maker wants to minimize her cost, a shared distinction, then the value node is denoted by a solid-diamond. If the decision maker wants to maximize her satisfaction, a non-shared distinction, then the value node is denoted by a dash-diamond.

To illustrate the extended influence diagram representation for a decision problem, suppose that the decision maker's ultimate considerations when purchasing a pair of shoes are its comfort and cost. Shoes are either comfortable or not comfortable to her. Shoes will cost her more than, less than, or exactly $50. In addition, she believes that a shoe's cost is relevant to its comfort. Should she or should she not buy the shoes that she is examining? We refer to this problem as the Shoe Purchase Problem.

In this problem, the decision maker is uncertain about a shoe’s comfort but knows its cost and must decide whether to buy it. Represented in the influence diagram in Figure 2, the problem illustrates how shared and non-shared distinctions are depicted. In addition, it illustrates relevance between a shared and non-shared distinction and shows that both distinction types can contribute to the decision maker's satisfaction.

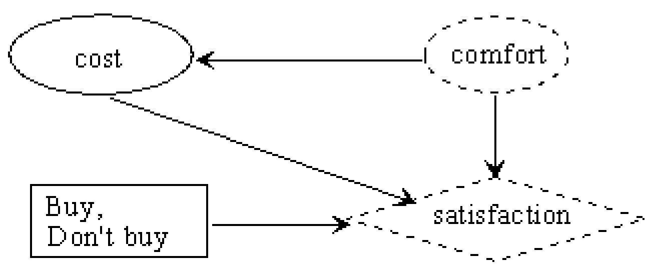

Figure 2. The extended influence diagram representation for the Shoe Purchase Problem. This representation employs a solid-oval to denote a shared distinction, a dash-oval to denote a non-shared distinction, and a dash- (or solid-) diamond to denote a value node.

5.4 Probability Encoding

If the decision maker's distinction is shared with other decision participant(s), then others besides the decision maker can provide a probability for the distinction. Otherwise, if the distinction is non-shared, only the decision maker can provide a probability for the distinction or any distinction conditioned on it. Otherwise, a probability provided by someone other than the decision maker would be unreliable.

The task of providing a probability for a non-shared distinction is no different than the task of providing a probability for a physically determinable distinction. In both cases, the individual who provides the probability draws upon her background state of information and experiences. For example, in arriving at her probability that it will rain tomorrow, the decision maker might draw upon the weatherman's forecast, what this evening's sunset looks like, and whether her bones ache. Similarly, in arriving at her probability that a particular pair of shoes will be comfortable, she might draw upon other people's recommendation, where the shoes are manufactured, and how comfortable her current pair of shoes are.

5.5 Evaluating a Decision Model

Given that a decision maker accepts the decision axioms, has formulated her decision model, and has provided probabilities for her distinctions, we can evaluate the model. The transformations used in the extended influence diagram representation are the same for shared and non-shared distinctions and identical to those used in the classical representation. Specifically, the influence diagram is evaluated by applying a combination of the following transformations: chance node removal, decision node removal, and arc reversals [Howard and Matheson 1981, Olmsted 1983, Shachter 1986].

5.6 Resolving Distinctions

If the decision maker's distinction is shared with other decision participant(s), then others besides the decision maker can obtain the evidence or information that resolve the distinction. Otherwise, only the decision maker can perform this task. For instance, the decision maker or someone else can determine a shoe's manufacturer, a shared distinction, whereas only the decision maker can determine her shoes' comfort, a non-shared distinction.

Under the classical framework, it is not necessary to qualify who can resolve the different distinctions types, as only physically determinable distinctions are permitted in a decision model. By definition, physically determinable distinctions are shared distinctions. It follows that the information for resolving physically determinable distinctions can be shared. Thus, the decision maker can always delegate the information gathering and distinction resolution task to another individual.

5.7 Value of Information

The concepts of perfect and imperfect information [Clemen 1991, Howard 1966, Howard 1967, Howard 1988] apply to all types of personal distinctions. Recall that perfect information is information that allows the decision maker to know a key distinction's resolution, and imperfect information is information that allows the decision maker to know the resolution of a distinction relevant to the key distinction, thereby enabling her to learn something about it. We illustrate these concepts through the oil wildcatter's decision problem [Raiffa 1970], a problem that involves physically determinable distinctions, and show how the concepts likewise apply to distinctions that are not physically determinable.

In the wildcatter's decision problem, the wildcatter is trying to decide whether or not to drill for oil. She would like to know whether or not there is oil in the ground. Though she lacks a way of knowing whether there is oil in the ground before drilling, she can take seismic soundings, an experiment that produces useful but imperfect predictions about the presence of oil. Figures 3a-3c shows the influence diagrams for these three scenarios.

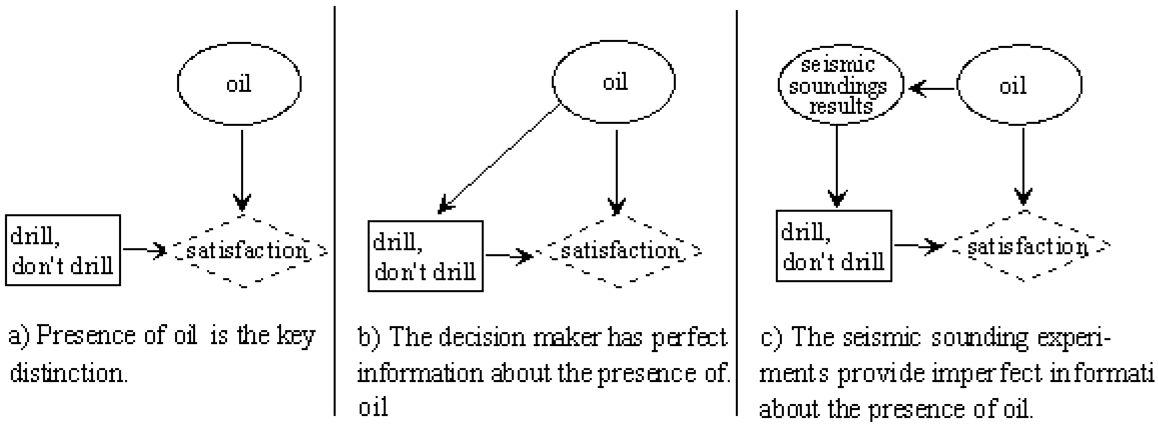

Figure 3. The wildcatter's problem.

Now we modify the Shoe Purchase Problem by supposing that the decision maker is trying to decide whether she should purchase shoes shown in a mail-order catalogue. The catalogue provides plenty of information about the shoe, including cost and details such as the shoe's moisture resistancy and shock absorbency features. However, despite all this information, the decision maker remains uncertain and concerned about the shoe’s comfort, her ultimate interest. For any model that she selects, she can specify its size and width, but her selection must be final. We refer to this example as the Mail-Order Shoe Purchase Problem.

Let us momentarily focus on the key distinction, comfort. The decision maker would like to know the shoe’s comfort before she decides whether or not to order. However, she cannot try the shoes and therefore cannot know their comfort prior to her decision. But she believes that the shoe's sales record is a useful indicator of how comfortable she will find the shoes. Figure 4 shows the influence diagram for these three scenarios. Notice that the diagrams assume the same form as in the oil wildcatter's problem.

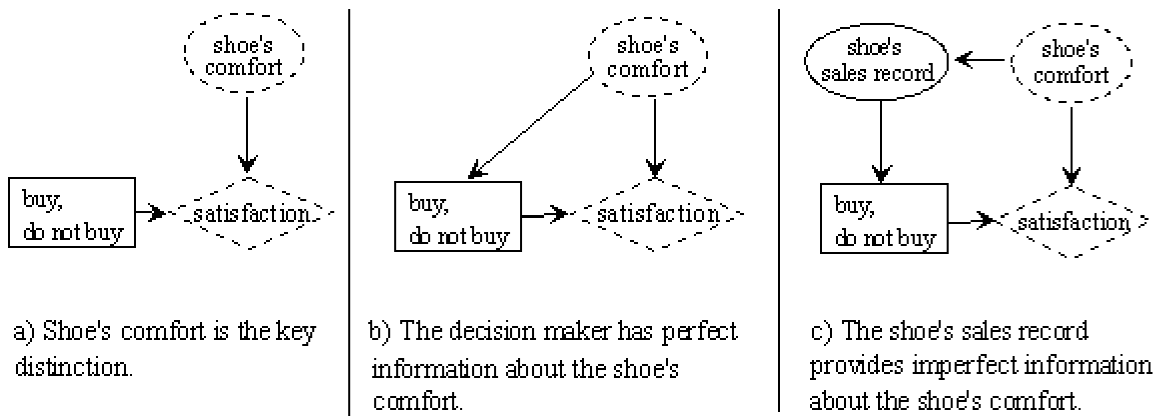

Figure 4. The Mail-Order Shoe Purchase Problem.

We used information about a relevant physically determinable distinction to serve as an example of imperfect information. We could have just as easily used information about a relevant not-physically determinable distinction. For example, the decision maker may be able to obtain imperfect information about the mail-order shoes comfort by assessing the comfort of a local pair of shoes that are produced by the same manufacturer.

If the decision maker has specified the maximum amount that she is willing to pay for each consequence, then we can transform the decision problem into an equivalent one with consequences consisting of only monetary attributes. In addition, if the decision maker has constant risk aversion [Raiffa 1970, Keeney & Raiffa 1993], then we can easily calculate the value of perfect information, the most that a decision maker should pay to observe a distinction before making a decision, by finding the difference between the expected values of the decision problem with perfect information and the decision problem without any information about the key distinction. In the above examples, this is the difference between the scenarios reflected in b and a of the respective figures.

6 Examples

In this section, we provide additional examples that contrast what the extended and classical frameworks allow. We illustrate that the decision maker can now use her personal distinctions that are non-physically determinable in addition to those that are physically determinable to characterize her consequences, thereby enabling her to be certain in her evaluation and preference ordering of them, thus satisfying the orderability axiom. We also illustrate how the decision maker can use such distinctions to learn about other distinctions in her decision model.

Our first example is the Mail-Order Shoe Purchase Problem. We show the influence diagram for this problem in Figure 5. The characteristic to note here is that we can now use comfort, one of the decision maker's key concerns, to characterize some of her consequences. In the classical framework, we would have been restricted to specifying the physically determinable distinctions that are relevant to comfort which, in our example, would include those distinctions represented by nodes directly preceding comfort. This restriction is problematic because the consequences would be characterized with so many attributes that it might be difficult for the decision maker to order them. More importantly, the consequences would be characterized with distinctions that are not the decision maker's key concerns.

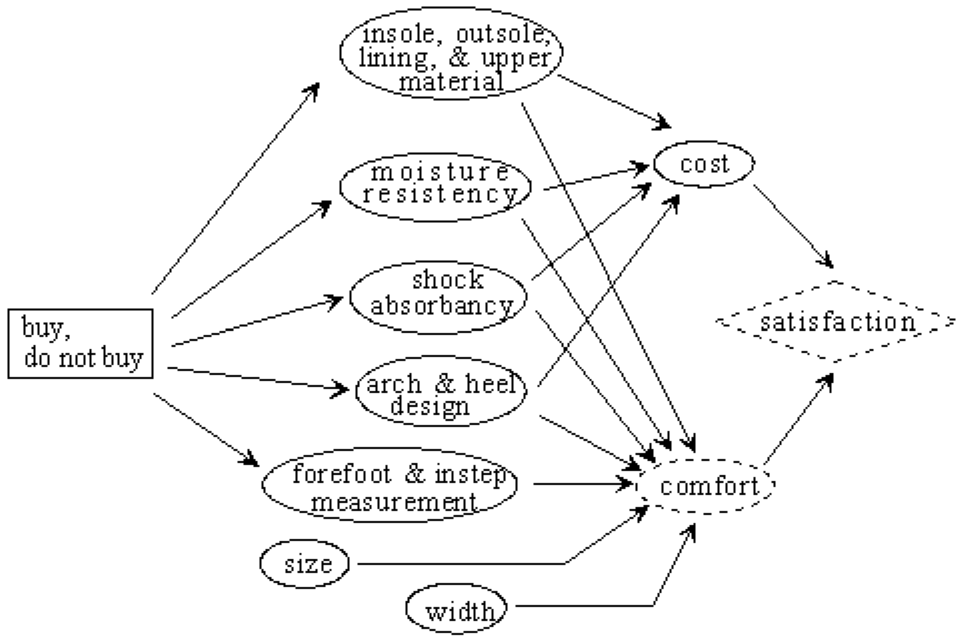

Figure 5. The decision maker can use "comfort," a non-physically determinable distinction, to characterize some of her consequences in the Mail-Order Shoe Purchase Problem.

In our second example, the decision maker is having difficulty deciding whether or not she should adopt a baby. She is concerned that she may love the adopted baby less than she loves her own biological child. She is also concerned that the adopted baby's biological mother may reclaim the baby. Figure 6 shows this problem's influence diagram.

We use "reclaim baby" and "love for adopted baby," distinctions that respectively are and are not physically determinable, to characterize her consequences. If she characterizes her consequences with only "reclaim baby," she is unable to order her consequences because they are insufficiently characterized. By also characterizing her consequences with "love for adopted baby," she is finally able to order her consequences in her decision problem.

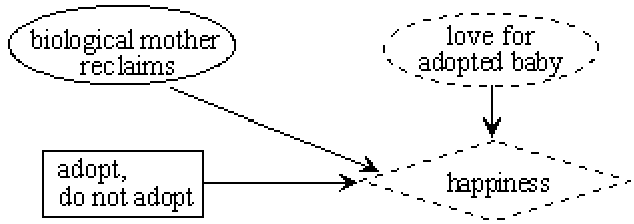

Figure 6. The decision maker can use "love for adopted baby," a non-physically determinable distinction, to characterize her consequences.

In our third example, the decision maker is trying to decide whether to buy retailer A's stock. She is interested in A's stock "price," a physically determinable distinction that she believes is relevant to her "satisfaction with the retailer's employees," a non-physically determinable distinction. She reasons that if she is satisfied with the retailer's employees, that the retailer will attract many similarly satisfied customers and its profits and stock price will rise. If she is dissatisfied, the retailer will lose her and many other dissatisfied customers and its profit and stock price will fall. Figure 7 shows this problem's influence diagram.

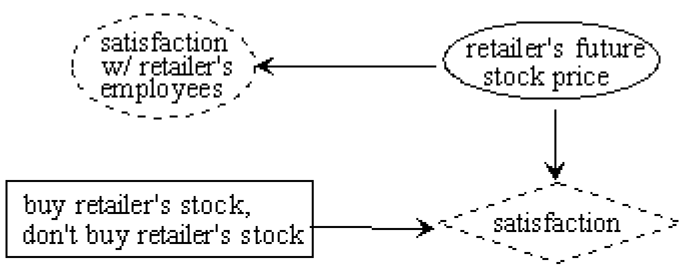

Figure 7. The decision maker can use "satisfaction with retailer's employees," a non-physically determinable distinction, for forecasting a stock's future.

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In our last example, the decision maker is interested in hiring a babysitter so that she can go out next week. The decision maker would like to interview a potential babysitter and assess her intelligence, reliability, respectfulness, and trustworthiness—distinctions that are not physically determinable. The decision maker believes that her first impression of the babysitter, also a non-physically determinable distinction, is relevant to these qualities. However, the decision maker wants the potential babysitter to have these qualities only because of their relevance to things that she is really concerned and cares about. The decision maker believes an intelligent babysitter is more likely to know what action to take in the event that the kids have an accident or there is an emergency, such as fire, as she cares that her kids are safe and physically well. She believes a reliable babysitter is more likely to follow instructions and hence, her kids will be fed and clean when she returns from her outing. She believes that a babysitter who is respectful of other people's property is more likely to leave her house in order. Finally, she believes that a trustworthy babysitter is not likely to steal from her household. Figure 8 shows this problem's influence diagram.

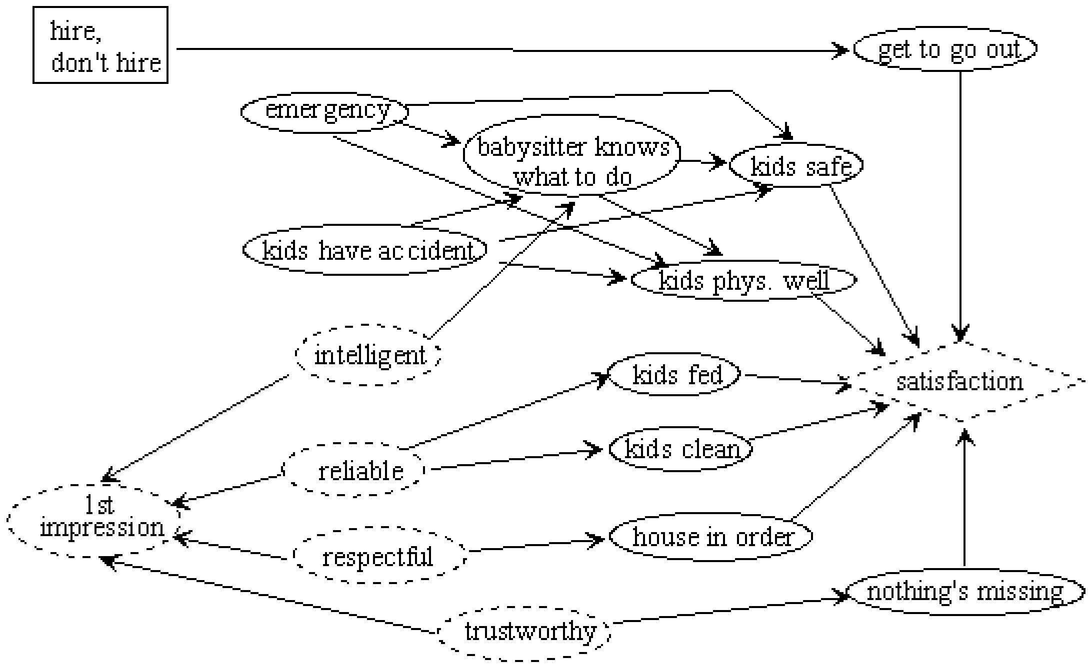

Figure 8. The decision maker can use non-physically determinable distinctions, such as "reliable," for learning about distinctions that she really cares about, such as "kids safe."

We conclude this section by summarizing its key points. Simply put, the extended framework allows us to use non-physically determinable distinctions, as well as physically determinable ones, for characterizing consequences and for learning about other distinctions. This is in contrast to the classical framework that allows us to use only physically determinable distinctions. In addition, distinctions that are not physically determinable, as well as distinctions that are physically determinable, can be directly relevant to any personal distinction and not only to the decision maker's preference. This result follows from the first key point and translates to the following: non-physically determinable distinctions can appear anywhere in a decision model and not just peripheral to the value node.

7 Conclusion

This paper develops the concept of a personal distinction that leads to a new view of distinctions for decision modeling and a unified view of beliefs and preferences in a decision model. This concept serves as a basis for developing the extended framework, thereby enabling us to reconcile decision analytical clarity requirements with modeling needs.

The extended framework consists of extensions and qualifications to the classical framework so that we can properly use all the decision maker's personal distinctions and not just those that are physically determinable. Thus, the extended framework encompasses and offers additional capabilities beyond the classical framework.

The decision maker no longer has to compromise her perspective of decision problems or choice of distinctions—if any are gestalt, subjective, or non-physically determinable—just to fulfill the classical clarity test. A decision maker must present distinctions that are unambiguous to her, but not necessarily unambiguous to anyone else nor physically determinable. In terms of the shoe problems presented in this paper, if she wishes to use comfort to characterize her problem, she can do so now as long as comfort is unambiguous to her. Similarly, in terms of medical problems, if she wishes to use feelings to characterize her problem, she can do so now as long as feelings are unambiguous to her.

We can now model distinctions such as these by using the extended framework rather than make exceptions to the classical framework, thereby remaining consistent within the decision theoretical and analytical framework. The result is that we can build more meaningful models and the decision maker can realize more benefit from a decision analysis.

We have shown how our results can be used for characterizing consequences and for learning about other distinctions in a decision model. Our results can be used for other purposes, such as for modeling a decision maker's time and risk preference. By applying our results, we expect to gain new insights, especially in domains such as medicine where decision participants often identify key distinctions that are not physically determinable.

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