

## LITERATURE SURVEY AND CHILDREN'S PERCEPTION ON RISK

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*Risk perception differs between people. There are studies presenting the different risk perception according to their character. The aim of this paper is to give a short literature review on risk and also to present papers which consider the hypothesis: 'is there any correlation between risk perception by children and mathematical thinking?'*

### 1 Background

Risk is a topic of much interest nowadays. The 'sociology of risk' deals with how some individuals react and make decisions in our society. Obviously, adults and children risk in many different ways in their everyday life, according to the way they perceive risk. It not easy to understand how adults risk and the way they perceive risk. If we want to find any correlation between adult's risk taking and their past experiences, we have to consider how children risk. Children risk easily as they do not have any prior information in risky situations and also they do not have generally any disappointing experiences of risk taking.

Risk decisions presuppose mathematical thinking because on risk decisions, we use mathematics for ordering, counting or estimating the different outcomes. For example, Wachbroitt (1990), characterises risk as the probability of 'harm'. Although it is very difficult to estimate the extent to which mathematical thinking relates to risk perception, the definition of risk as the probability of 'harm' implies that a good mathematical understanding of probabilities may also play an important role in our everyday risk decisions.

Parents want their children to succeed, take 'reasonable' risk and be able to make the right decisions. Some suggest that the schooling system must encourage early mathematical thinking development while others blame lack of teacher knowledge in applied mathematics. So, a positive attitude towards mathematics thinking and teaching makes learning of probabilities very important from kindergartens.

Our aim in this paper is to present a literature review on the different definitions of risk and also a discussion from published papers about:

1. 'the relation between risk perception by children and their mathematical thinking in early years' and
2. 'the relation between risk perception by children and probability thinking'.

### 2 The definition of a Risk Process

According to Buhlmann (1996) risk should not be characterised by "what it is" but by "the properties which it has" and may be described by a functional random pair  $(Pt, St)$  where,

$P_t$  = premium earned in the time interval  $(0,t]$ , independent of chance,

$S_t$  = sum of claim amount incurred in  $(0,t]$ , stochastic,

and where the difference  $P_t - S_t$  is essential in analysing the risk.

But, Duckworth (1998), in a recent paper about risk, suggests that society or natural sources impose risk on the subjects. So, one side generates the risk and the other is put at risk. The decision of a subject exposed to risk might be expressed by the equations

Expected utility = known benefit – expected loss

*Expected loss = probability x consequential loss*

In 1997, Oekerman, wrote that :

“recent discoveries within a number of scientific disciplines, collectively referred to as the science of complexity, are creating a major shift in how human beings understand the complex, adaptive systems that make up the world. A complex adaptive system consists of networks of large numbers of agents that interact with each other and with their environment according to a set of rules. This set of rules contains two subsystems: a dominant, or legitimate, subsystem that encompasses the system's primary task, and a recessive, or shadow, subsystem that operates outside of the system's primary task, providing the arena for play, exploration of new behaviors, and creativity. The shadow subsystem also seeks to undermine or modify the dominant subsystem through change. These two subsystems coexist in dynamic tension, and when the system is operating in the narrow zone between order and chaos, called a phase transition, or the edge of chaos, "it is operating at its highest level of functioning. Here is where the system creates space for novelty, where the greatest information processing takes place, where risks are taken and new behavior is tried out”.

### 3 What is risk?

Wachbroitt (1990) characterises risk as the probability or the expectation value of ‘harm’. So there are ‘thin’ (physical harms) and ‘thick’ (social harms, i.e. economic losses, social disruption etc) where harm and risk descriptions cannot be neutral.

According to Adams (1996) "risk is defined as the product of the probability and utility of some future events. The future is uncertain and inescapably subjective; it does not exist except in the minds of people attempting to anticipate it. Our anticipations are formed by projecting past experience into the future". Risk is an interactive phenomenon that exists in many forms and as Lord Kelvin said "anything that exists, exists in some quantity and therefore can be measured". *Adams* also suggests that we have to distinguish between “objective risk – the sort of thing ‘*the experts*’ know about – and ‘*perceived risk*’- the lay person’s often very different anticipation of future events”, and he poses three questions.

- Can risk be managed?
- How far (or low) is reasonably practicable?
- Do we have enough accidents?

Adams concludes that the propensity of people to take a risk has to do with their perception of risks, the rewards, their accidents and their balancing behaviour. He also considers four combinations of risk and culture, where any individual might belong in one of the following categories: individualists, hierarchs, egalitarians, and fatalists. According to Adams these categories represent four distinctive world views and are the basis of four different rationalities.

*Individualists* “are enterprising ‘self-made’ people, relatively free from control by others and who strive to exert control over their environment and people in it.”

*Hierarchs* “inhabit a world with strong group boundaries and binding prescriptions, with everyone knowing his or her place.”

*Egalitarians* “have strong group loyalties but little respect for externally imposed rules. Group decisions are arrived at democratically and leaders rule by force of personality and persuasion.”

*Fatalists* have “minimal control over their own lives. They belong to no groups responsible for the decisions that rule their lives. They are resigned to their fate and they see no point in attempting to change it.”

#### 4 Risk perception

This concept appeared for first time in early 1960’s. In a psychometric study by Sjoberg (1999), where people were asked to rate the risk of a large number of activities, little information was provided on the way people perceive the risk, because there are other factors which affect risk perception, such as media effects. In this study Sjoberg shows that the demand for risk mitigation has to do with the seriousness of consequences and not the risk per se. He also suggests that “that interest in a risk was a relatively powerful predictor of demand for risk mitigation, clearly more so than perceived risk. The risk perceiver seems to be willing to pursue risk themes in a positive mood perhaps because such an active attitude creates a feeling of empowerment and heightened self esteem”.

Krebs et al (1997) consider that “the job of scientists is to estimate risk, with sociologists, psychologists and economists playing a part in evaluating risk (including public perception)”. Moreover they say that in the estimation of risk we can either approach it by using statistical inference from observations or by building predictive models. In their analysis of the sociology of risk they state that ‘cultural theory’ could explain why some individuals tend to perceive some events as riskier than others and they describe individuals as fatalists (f), hierarchs (h), individualists (I) and egalitarians (e), in the same way as did Adams before. They also consider the grouping of people as technocrats (where risk assessment is through science,

technology etc) and as cultural relativists (where valid information depends on their point of view). They also conclude that, there are individual differences in the perception of risk and scientific evidence for risk estimation is often incomplete because uncertain or unexpected social and psychological factors influence the way people perceive risks.

O’Riordan et al (1997) believe that although cultural theory may help in the classification of the degree of the social regulation and social contact (fatalists and hierarchs have high degree of social regulation, while hierarchs and egalitarians have high degree of social contact). In their analysis, most of the variance of risk perception was explained by psychometric route of dread, lack of knowledge, harm to future generations, etc., rather than the cultural route. They generally believe that our cultural level has less impact on our risk perception comparatively to our psychometric route (fear for the future generations, etc). They conclude that cultural theory is very difficult to put into practical use and social solidarity is mobile and overlapping. Moreover, a "civic" extension to science needs to be invoked, where the risks cannot easily be categorized into the *two-value frame of reference* and especially where there is no reasonable likelihood of reliable proof, possibly due to the chaotic character of the issues under examination. They simply mean that risk perception, has also a chaotic behavior.

Neville-Rolfe (1997) describes the difficulties that influence the decision making process because peoples’ perceptions of risk are affected by "how much they understand the risk, how much control they have over it, and whether there is a particular risk to children or future generations".

According to Kempton (1998) ‘risk can be defined as the chance (probability) of the occurrence of a particular adverse event or hazard’ and he points out that a risk-free society is unattainable since, a) risk involves more than simple life-events; b) time changes the validity of an event, and c) the risk (probability) changes as the population grows.

Jorion (1997) discusses types of financial risk and says that risk is measured as the dispersion of possible outcomes where a flatter distribution indicates greater risk where the tighter distribution shows lower risk. In modeling time-varying risk, he uses a moving average method.

Tom Spradlin, in his Internet report ‘A Lexicon of Decision Making’, suggests that decision-makers think about risk as the possibility of an undesirable result.

Bedford (2001), considers risk as a hazard with uncertain negative consequences and suggests that risk analysis tries to answer the following questions. What can happen? How likely is to happen? Given that it occurs, what are the consequences?.

## 5 Risk decision

There are many factors that contribute to the growing difficulty in making the 'right' decisions. Amongst these factors the most important according to Adams(1996), Buhlmann (1996), Oekermann(1996), Simon (1986) are:

- complexity of the environment and the different choices,
- sensitivity of decisions to changes,
- different perspectives,
- multiple objectives,
- the uncertainty of key variables in the decision process.

Simon (1986) refers to decision-making as an important aspect of life and writes "The time dimension is especially troublesome in decision making. Economics has long used the notion of time discounting and interest rates to compare present with future consequences of decisions, but research on actual decision making shows that people frequently are inconsistent in their choices between present and future. Although time discounting is a powerful idea, it requires fixing appropriate discount rates for individual, and especially social, decisions. Additional problems arise because human tastes and priorities change over time. Classical subjective expected utility theory assumes a fixed, consistent utility function, which does not easily accommodate changes in taste".

According to Adams (1996) "the propensity to take risks is widely assumed to vary with circumstances and individuals, there is no way of testing this assumption by direct measurement" and risk could be seen as objective and perceived.

Of course one of the basic problems in risk assessment, is the inadequate information we have when decisions must be made, because decisions cannot wait (National Research Council, 1983).

Richards et al (1999) explain how to use models in a decision-making system where they identify the sources of uncertainty in a model and the presence of a hierarchy. They suggest that although there are four types of uncertainty (temporal, structural, metrical, and transitional) with a set of associated parameters that define their role, the proposed models should minimize the degree of complexity. Monte-Carlo analysis techniques and other approaches (classical methods, multivariate methods, time-series methods) can be applied after the identification of critical variables. In their conclusion they state that "providing data because you can easily obtain it for non-critical values tends to obfuscate the analysis and the uncertainties involved".

Bedford (2001) suggests that 'decision analysis seems to be the logical extension to risk analysis' and increasingly risk analysts are applying decision theory techniques. He also discusses the application of decision trees in risk analysis where the decision model should help decision makers to form and rationalize their beliefs.

Moreover, "high consequence/low probability events and costs require a sophisticated approach" that risk analysis has to use.

## 6 Preschool children and risk perception

There is little literature concerning risk and its perception by children. Smith, (1998), in his book, uses the playground as a reference point for a phenomenological examination of risk in children's lives and the development of a pedagogy of risk. He examines how consideration of risk as challenge and adventure leads to questions concerning adults' relationship to children and enabling children to take risks in a relatively safe way. According to Schlottmann (2001), children accept risk more easily than adults do. Kopfstein and Donald (1973) (cited in Jeffrey 1973) suggest that the way children accept risk depends more on their character, especially on the way they perceive any loss and how ready they are to accept the loss. They found in their study that boys are less anxious than girls are where risk is involved. Many investigators were concerned about children's behavior and the way they understand probabilities and perceive the risk. In 1957, Messiac and Jolley (cited in Reese & Lipsitt 1970) studied the behavior of children aged 3-8 years on double-choice experiments. They found that all children preferred the outcome with the greater probability. They showed that preschool children (3-4 years) were able to distinguish between 60:40 and 50:50 in a probability matching experiment. Derks & Paclisann in 1967 (cited in Reese & Lipsitt 1970) found that preschool children in a probability learning experiment favor the 'recent effects' and also prefer the maximizing effect. According to Goodwin (1969) (cited in Reese & Lipsitt 1970), children aged 3-5 years have not any prior information on different educational subjects and they prefer the better rewarding choice, so it may be difficult to develop and test probability learning strategies for that age.

In other experiments with fractions and probabilities, Arcedolo et al (1989), found that children tend to look at the numerator, without considering the denominator in fractions, so they cannot calculate probabilities well.

Recent researchers tried to take account of children's intuition to explain their behavior on probabilities and risk. This intuitive way of thinking does not need any arithmetic at all but children intuitively have a better understanding of the expected value (Schlottmann, 2001). Moreover, children care more about the 'win-lose' process than 'how big is the reward' in the winning process.

In a recent study (Pange et al, 2002) about the development of children's decision-making abilities and the effects of age and gender differences on their use of probability, gain, and risky alternatives, a small group of pre-school children was studied. According to this study the children were able to play games with risk taking (in this game, they played with beans, candies etc, and they either were winning more or losing beans, candies etc). Children in this game, were able to use their prior information as much as they could. These findings agreed with those of Schlottmann (2001), where children improved their answers on probabilities when they had a

reward for every right answer. Moreover, the children in this study showed a preference on recent effects and an intuitive way of predicting the outcomes of a random experiment as other researchers had already demonstrated (Schlottmann, 2001). This analysis showed also that older boys and girls favoured choices that would reduce their exposure to large losses, while younger girls and boys preferred choices that afforded opportunities for large gains. Moreover, in that study it was found that children who could risk, had a good intuitive way of counting probabilities and also a mathematical thinking.

## 7 Discussion

Although it becomes quite clear from the studies mentioned before, that consideration of risk is somehow related to mathematical thinking, until now, we did not find any papers which clearly described the relationship between risk taking and mathematical thinking. Promoting mathematical thinking in early childhood may help children to risk, make choices and decisions and deal with uncertainty. But could we say that children cannot consider the risk because they cannot predict their actions as they have not sufficient data to make predictions? Could the school system be sometimes responsible for the way children will behave later in their lives and take risks? A schooling system that accepts loss more easily and promotes mathematical thinking may help children not to be anxious when they are faced with risks. Rodriguez (1997) in analysis writes: "it seems that until we revise schooling to treat people as individuals in context and not as pawns or agents of a system, disparate treatment will continue and effective educational reform may be beyond our grasp".

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