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Dragons, black swans and decisions

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ABSTRACT

Since Nassim Taleb coined black swan as an event that occurred as a complete surprise for everybody, the metaphor of the black swan has been applied to a much wider variety of events. Black swan events now comprise events that are a surprise for some but not for others, events that have a low likelihood, events that were not believed to be possible but still proved to be possible, events that were dismissed as being too improbable to worry about but happened anyway. For a decision maker the black swan problem is choosing where to put effort to prevent, or mitigate events for which there are warnings, or for which the possibility has been put forward. Does the fact that there are thousands of books written about fire breathing dragons warrant the development of an Anti-Dragon Defense Shield? The black swan may have been a surprise for Willem de Vlamingh in 1697, it was not a surprise for the inhabitants of Australia, for which the appearance of tall white humans was their "black swan event". In this paper we explore the options available to decision makers when confronted with the various sorts of swan (or dragon) events.

1. Introduction

The use of a metaphor can be a powerful method of conveying a message and clarifying meaning. It is therefore no surprise that metaphors are also used to convey scientific concepts. Rutherford's (1911) model of the atom as being similar to a solar system made the idea that matter is predominantly empty space much more clear than all the equations that described the passage of particles through supposedly dense materials. In safety science the domino metaphor by Heinrich (1941) conveyed the message of the causal chain (Gulijk et al., 2009). The Swiss cheese metaphor by Reason (1990) conveyed the message of lines of defense and the role of imperfections. This model led to a gamut of derived metaphors in what could be called a cheesology (Ale et al., 2010). Recent models in safety science include that of the black swan and that of the dragon.

A Black Swan event was the term that Nassim Taleb coined for events that came as a complete surprise (Taleb, 2010). Before Willem de Vlamingh encountered a bevy of black swans in Australia in 1697 all known swans were white. That was all swans known in the northern hemisphere of the world. This was about 200 years before Darwin (1859) published his "Origin of Species". At that time the current belief was that the world has been created perfectly and therefore unchanging. Australia just did not exist. For people in the Northern Hemisphere world, the idea of a black swan just had never occurred to them. Encountering a black swan was the pure Black Swan event.

Taleb devotes a large portion of his book and of his further publications to random events, probability distribution curves and discussions about rare events. He attempts to explain the difficulties people have in understanding the difference between the improbable and the impossible; and in estimating probabilities in general. This watered down the pure definition of the black swan event to that of an event of which the probability was underestimated, or of which the possibility was dismissed because the probability was thought to be too low to consider.

The main example on which Taleb's reasoning is founded is that of the financial crisis of 2007. It can be argued that this crisis was not unexpected at all, or should not have been because it was completely predictable (Frieden, 2011). Banks and states "create" money by selling loans. In fact they allow people to spend the money now that they are supposed to earn in the future (http-7). The latter is a stark assumption. Selling mortgages and other loans to people who cannot pay the loan back creates a hole in the finances somewhere. As long as people continue to believe that the hole will be filled by somebody, that hole can remain. But it is like a game of black peter. Sooner or later somebody, or some bank, will be confronted with having this debt and not being able to refinance it, at which time the bank falls over. This in turn

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uncovers the holes in the balances of other banks and of states, which then also will fall over unless they are rescued by states, i.e. the taxpayer. The financial crisis therefore was entirely predictable and not a pure Black Swan event at all.

As a result of Taleb's analyses and descriptions a library of literature and discussions has emerged, that might be termed “cygnology”. In these discussions more and more sorts of events have been designated as belonging to the genus swan (Aven, 2015). In the remainder of the paper which focuses on several knowledge-related factors that permeate the fuzzy and dynamic boundary between policy, politics and science, we will try to unpick this “cygnology” and analyze the importance of the difference between the various genera for making well-reasoned decisions in real life.

2. “Cygnology”

“Cygnology” plays an important role in the current discussions about risk management. The discussion is being held in words and the definition of words seems to be central in the discourse. Many words are used in ordinary speech and in writings with only loose definition. This should not be a problem. However, scientists and especially philosophers use small differences in the meaning of words as a basis for further reasoning. Therefore precise definition of terms is one of the instruments and goals of science and philosophy (Plato, 1997). These discussions are especially difficult across languages. As an example in the English language “safety” and “security” have a different meaning. In Dutch these meanings are covered by only one word: “veiligheid”. In order to make the distinction possible the word “security” has found its way into the Dutch vocabulary. However there is ample resistance against this way of “anglicizing” the Dutch language. This problem occurs in many languages and traditions. In the context of this paper a few terms need to be defined more precisely.

2.1. Chance

Probability, chance, odds and likelihood are primary examples where precise definition can be important. In the “normal” use of language these words are used as synonyms. In mathematics they have precise and distinct definitions.

Unfortunately, these exact definitions present decision makers and those who philosophize about risk with some serious problems. Probability is defined as the number of a particular outcome (often called success) divided by the total number of tries, if the number of tries is infinite. In the real world the number of tries cannot be infinite. If the particular outcome is an accident, if one looks carefully enough, no accident is really the same, nor are the circumstances.

What confounds the issue even further is that more often than not, the “probability” is really a frequency. It is the number of occurrences in a certain timeframe, usually a year. Even if events do not occur every year, the cumulative number over a longer period can rise to a number above 1, which violates the mathematical rule about probability that it is a number between 0 and 1 by definition. When a frequency is nonzero the relevant question is no longer whether the event can happen, but when it will happen, making the probability equal to 1, thus fulfilling Murphy's law.

Probability also has gained extended meaning beyond the mathematical definition. It can also mean the subjective estimate of a chance given the information available to the assessor (Aven and Reniers, 2013). Risk and probability can even be defined as a social construct (Johnson and Covello, 1987).

Finally all definitions by means other than mathematical formulae tend to be imprecise and often circular, such as the definition that probability is the likelihood, or chance (http-1, 2019).

For decision makers the philosophy around terminology may not be exciting, but it is important to know whether any number or wordy expression about chance is a probability, a frequency or whether that has any meaning at all. For this paper probability is independent of the time frame. It is the chance (!) that something will happen ever. Frequency is the number of events per year, or per experiment, or per try.

2.2. Improbable or impossible

Another set of notions that play an important role in “cygnology” are those of improbability and impossibility. In decision making surprises often stem from confusing the improbable with the impossible.

An improbable event is usually understood to be an event of which the probability is low. Low in this respect is not really defined. Just as a small elephant is a large animal, what constitutes a low probability depends on the judgement of the beholder and is often contextual. A probability of 1 in 6 may be low if it pertains to the chance of heads coming up in the throw of a coin, it is high if it where the chance of an airplane not completing its journey. When the numbers get really small and the costs of making the improbable impossible are high, it is tempting to decide that a 1 in a million per year event “will not happen to us” and decision makers often cherish this illusion (Hand, 2014). This is despite the observation of an observed probability of 1 in 5 million for an airplane not to arrive (http-8), airplanes do crash. The 1 in 5 million is per flight and there are approximately 37 million flights per year (http-9). Therefore the impossible 1 in a million results in on average 9 crashes per year. In 2018 more than 500 people lost their lives in these “impossible” accidents.

On the other hand some analogies cause the impossible to be deemed probable. The demonstrated possibility of a nuclear mushroom explosion played a significant role in the discussion about the safety of nuclear power plants, even though in such a plant a mushroom explosion is physically impossible. To represent the perceived epistemic uncertainty – “you never know whether the scientists are wrong” – the probability of such an event was set at 10^{-9}. With the increasing safety of nuclear power plant design and operation this one catastrophic but impossible event started to dominate the results of quantified risk analyses. This led Kaplan and Garrick (1981) to redefine risk as R = f (s,p,c), with p probability, c consequence and s scenario, their message being that there should be a plausible scenario by which the event could materialize in order to make it part of the total risk.

3. Knowledge

Another parameter that is important in “cygnology” and distinguishes one type of swan from another is the level of knowledge. The United States Secretary of Defense Donald Rumsfeld made an idea famous that was first created by Luft and Ingham (1955) as the Johari window. In its original form the Johari window looks like the diagram depicted in Fig. 1. It was meant to classify the relationship between the individual (self) and the people around him/her. The meaning of the quadrants changed over time with the way the Johari window was applied and even morphed into a risk matrix (http 12) where the left top corner was “good” and the right bottom corner was “bad”.

3.1. Known and unknown

In this Johari diagram, the relationship between peoples' conscious knowledge and the hidden knowledge, or between peoples’ knowledge and knowledge in general, was divided up into four quadrants: the things people know they know: the known knowns; the things people know they do not know: the known unknowns; the things people do not know that they know, or more generally the things that people do not know that it is known somewhere in the world: the unknown knowns and finally the things that people do not know that it is unknown; the unknown unknowns.

Of these four quadrants the known knowns seem to be the easiest to deal with. However people's knowledge may be deceiving. Memories

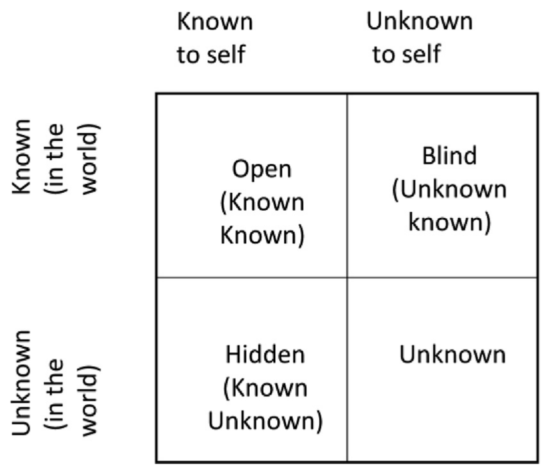

Fig. 1. The Johari window.

can evolve over time (Loftus et al., 1992). People can have the idea that they know all there is to know about a subject. Columbus thought that the earth was a globe and that he therefore could sail west to arrive at India. He was almost right. As it happens the Americas were in the way, which did not prevent him from calling the native Americans Indians.

The known unknowns used to be called hidden. In the original Johari window this meant information that was known to self but hidden for the others. This was deemed to be a bad thing for people who worked in teams, but in the modern era keeping private information such as details about one's bank-account may be a good thing for oneself. For other parties that may be a bad thing. These parties would like to know and that has become the dominant meaning of this quadrant: information that we know we do not know and would like or need to know. One could try and resolve the problem by further investigations to make the unknown known. However when time or money runs out one could decide not to. It is also possible that people just do not want to know. This is especially true when the message is uncomfortable, in which case one rather ignores the message that "the emperor" has no clothes (Anderson, 1837), than confront the situation or admit that there is a problem. We will discuss later how a decision maker can take advantage of sustained ignorance. Then there are things that are known to be unknown, but have to remain unknown. The future temperature rise of the earth is an example. There is no way of doing a controlled experiment to determine the temperature rise depending on the concentration of greenhouse gasses in the atmosphere. There is only one earth so we have to be resigned to the situation that having an estimate is the maximum achievable.

A special case is the case of pseudo randomness. If it were possible to measure exactly all the variables and parameters that determine where gunshot bullets would hit, they could be made to pass through the same hole. In practice this is too difficult and hence a certain spread needs to be accepted. Similarly it is not possible to know whether a butterfly flapping its wings will cause a hurricane, nor is it possible after the hurricane to find this butterfly if it did. Finally there are the fundamental unknowns. Although it is known that the probability of a 6 coming up in the casting of a die is 1/6, there is no way of knowing what the result of the next throw will be. Neither is it possible to know whether Schrödinger's cat is alive or dead as long as his box is closed. These uncertainties cannot be reduced.

The unknown knowns comprise the things we used to know but have forgotten, more importantly the things we do not know but others do and most importantly the things others have tried to bring to our attention but we dismissed them. In this realm resides the infamous memo that surfaces after the accident, which contains the warning that the accident is imminent. Also the miscommunications between managers and technicians constitute unknown knowns, such as the behaviour of the "O" ring seals of the booster rockets of the Challenger under low ambient temperatures (Rogers, 1989). Many of the unknown knowns can be resolved by asking around or research. If William de Vlamingh would have asked an Australian, the black swan would not have been such a surprise. He did not know Australia and its Australians existed and by finding out he became famous.

The unknown unknowns are the most problematic and the most discussed. These are the real black swans. There is no way to know such an unknown. Although one can argue that we should be prepared for a surprise, there is not really a method to do this. The essence of a surprise is that it is a surprise. The existence of the phenomenon called "synchronous lateral footfall" is an example of such a surprise. It had been long known that people and especially platoons of soldiers should not march in step over bridges. However that random people would synchronize their step due to small lateral vibrations of a bridge and as a consequence could let the bridge collapse was only found out after the millennium bridge in London needed to be closed due to heavy vibrations ((http-13; Strogatz et al., 2005; Taylor, 2019). There are however many instances where surprises are claimed where they should not have been a surprise at all. In many cases the possibility of the event was dismissed. Some examples are given above. One reason can be the low probability in the mistaken belief that improbable and impossible are synonymous. Beyond design-basis accidents such as the accident in Fukushima (http-11) are examples. Another is the difficulty in assessing the probability of large consequence low probability events, making estimates uncertain leading to the mistaken belief that uncertain is synonymous with wrong. Yet another is the hesitation to admit to potentially catastrophic consequences where denial is much less expensive than facing the problem. In the Netherlands it took a major flood in 1953 to make the authorities take the warnings of experts that the dikes were not strong enough seriously (Veen, 1955). It took two fatal crashes before it was recognized that there was a problem with the MCAS system in the Boeing 737 Max. A special class of surprise are accidents that are the result of not taking known safety precautions. Prescribed safety precautions are there to prevent an event. Not taking them makes an event unavoidable. This claim of surprise is akin to claiming that throwing heads with a coin came as a surprise (unless one assumed the coin was tampered with and had tails only). Confucius already remarked "When you know a thing, to hold that you know it; and when you do not know a thing, to allow that you do not know it; —this is knowledge".

3.2. Uncertainty

The black swan metaphor led to the realization that risks may be underestimated because the risk assessor is not aware of knowledge that is available elsewhere. This led authors to replace the triplet of Kaplan and Garrick by $R = f(K, p, c)$, where K is knowledge (Aven, 2012).

It should be noted that pure aleatory uncertainty can be integrated in the estimate of probability when the probability distribution is known. Long before Taleb it was an established fact that in real life, many probability distributions have a much larger portion of the probability mass away from the center, than would be predicted by the familiar Gauss distribution. The difference in probability of a 4-sigma event between a normal distribution and a Cauchy distribution is two orders of magnitude (Davies, 2002). Distributions with so-called fat tails can be observed for instance in the distribution of the location of crashed aircraft relative to the intended flight path. Many of these distributions are power law distributions. If it is assumed a priori that the probability distribution of the outcomes of an activity is normal, the occurrence of an event may be more of a "surprise" when the real distribution follows a power law. Because of its relatively fast decline, the normal distribution makes it more inviting to declare the improbable impossible. Nevertheless the extremes are not as unlikely as they might appear. Average chemical plants do not explode on average, nor do average airplanes fall from the sky or average cars collide. But then, the world is not an average. The world on the average of the universe should not exist, but it does. Now that in many areas of technology the probability of failure is low but the consequences of failure could be catastrophic, it is no longer sufficient to look at predefined abnormalities. Unfortunately looking at success, or why a system keeps working is not sufficient either. Having airplanes diverted to small airfields was considered normal, just as having pilots and co-pilots with large differences in experience, air traffic controllers with limited command of the English language and taking off with limited visibility. Nevertheless they combined in 1977 at Tenerife in the largest airline accident to date. Yet these factors were all considered as contributing to speedy and successful operation of an airline. It was the unlucky combination of success factors that created the disaster.

Rather than modelling either success or failure, systems can also be modelled in their entirety. The model will show emergent behavior just as reality does. The model results can be observed and unwanted behavior can be detected. This would be hindsight after the calculation, but before the unwanted behavior emerges in reality. The causes can then be explored which can be the combination of factors that are considered a bit extreme but accepted as normal. The result of modelling all behavior is conceptually depicted in Fig. 2. Average behavior is the most expected behavior. What is unsafe will reveal itself.

This approach already has been employed in the Causal Model for Air Transport Safety (Ale et al., 2006) and in a causal model for chemical plant safety (Ale et al., 2014; Gulijk et al., 2014).

Appearances of “black swans” have become quite frequent in business since the publication of Taleb's book, a phenomenon that didn't exist beforehand. One useful example in the Canadian agribusiness is the characterization of China's ban on canola oil after the unexpected arrest of Ms. Meng Wanzhou at Vancouver airport in 2018. However, according to White (2019), a more careful analysis, and in particular a statement by Mr. Neil Townsend of FarmLink Marketing who at a conference pointedly stopped short of calling it a “black swan” event. As White points out that while nobody others than those involved could have predicted the arrest of the Chinese business woman, what was not unpredictable was the idea that a geopolitical event somewhere would easily pop up and disrupt Canada's export markets. White questioned “is that a black swan after the last 10 years of crises and political squabbles?”

Later in the paper we will address the question whether it is right to assume that outliers in a distribution should lead to the conclusion that the distribution has fatter tails than expected or that the outliers indeed are outliers and do not belong to the population that is described by the distribution.

Unfortunately the advice of Taleb not to make systems too large to fail, cannot be followed for many technological systems such as the flood protection of a nation, or hydropower dams chemical production sites and the transport of hazardous materials. A failure of these systems have in common that the failure rate is small but the consequences catastrophic. Many of these systems have been in existence for a long time and there is not much opportunity to reduce the size. Because of the low probability of accidents the data base for assessing the probability of failure remains small making the estimates uncertain resulting in the confusion of improbability and impossibility, which is only broken from time to time by an event.

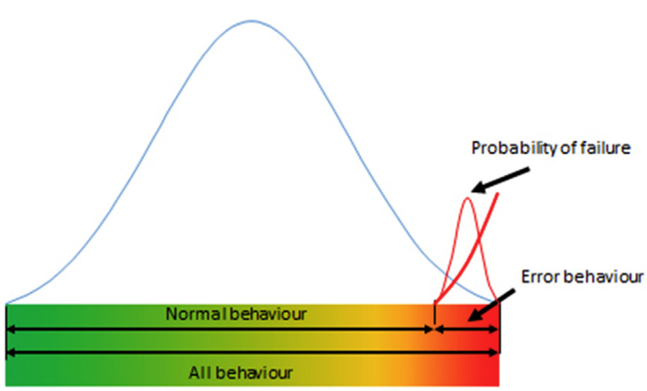

Fig. 2. Model simulations show potential failure conditions.

3.3. Ignorance

The advantages of ignorance were already described in the beginning of the previous century (Keedy, 1908). Ignorance is bliss seems especially to hold for managers of larger companies, who increasingly call accidents and incidents, black swan events. Ignorance also supports the claim that causes of accidents, incidents and events are identified in hindsight, looking to accident causation as a linear process, that the world is really too complicated to model accident causation in a fault tree (Dekker, 2006) and therefore nobody is to blame, except may be the operator who made the final mistake.

The sub-prime-mortgage crisis is described as being the result of an unknown: Although the risk of home owners defaulting on the mortgage was known, it was completely underestimated by the unknown that they could all default simultaneously (http-2-2019). However, what such a description fails to recognize is that a basic safety barrier in the mortgage market was broken deliberately: one should not sell mortgages to people of which it is certain that they cannot pay their loan back and thus defaulting is unavoidable. Because it was deliberate it should have been known and there is actually no reason to assume that it was not (http-3, 2019). Denial and the black swan metaphor however were extremely helpful for bank managers to avoid jail sentences.

Safety barriers and safety systems that are built into technical systems are there for a reason. It is therefore asking for trouble when they are removed especially when nobody remembers what they were for and never seemed to be challenged. One could claim that it is hindsight to conclude that a safety valve should not have been welded shut, that bolts should have been tightened using a torque wrench, that a new catalyst should have been tested by an adiabatic heating test (OVV, 2015) and that bellows should be supported (http-4, 2019), but this was all known in advance when the system and the procedures were designed and for a reason. That the current CEO does not know that, is neither a reason to deviate from the design, nor should it be an excuse. Nevertheless black swans are on the move as they appear to be a convenient escape for those who do not want to spend money on safety before the event or to be blamed after.

4. Dragons

It is not always easy to decide what is possible and what is impossible. Jules Verne described how to get to the moon by firing a large bullet from an enormous gun. Although the bullet had the size of what later was a lunar orbiter, this method was impossible. London & New York Herge (1953) used a rocket that looked like a German V2 rocket. Still not possible, but only 16 years later people actually landed on the moon. The impossible proved to be possible after all. Decision makers face the problem whether scenario's that, prima facie seem impossible, are merely improbable; and whether the probability may increase over time, or is already underestimated. In terms of swans the analogy may be a fire breathing dragon. There are whole libraries of books written about dragons and movies made. Since the literature about dragons goes back at least a few millennia there are many species such as those with three and those with five toes. And most of them can breathe fire. If they exist their effect could be devastating and sooner or later they will appear. The question whether an Anti-Dragon Defense Shield is worth investigating may with our current understanding of dragonhood sound ridiculous, but there are many other stories of mass destruction by floods, asteroids, weapons and other natural and manmade disasters that have been described in fiction, where deemed fantasy and later proved to be even less improbable than dragons.

4.1. Dragon Kings

A special breed of dragons is the Dragon King. This term was introduced by Sornette (2009) to mean the existence of transient organization of phenomena that can emerge into extreme events. These extreme events lead to so-called meaningful outliers. These are events or data points that coexist with series of similar events that are distributed according to a regular distribution such as a power law. Sornette argues that rather than assuming that these outliers are the associated with distributions with fatter tails than follow from the bulk of the events, these outliers have special meaning. This is not a new argument. It has long been standard laboratory practice that outliers in a series of measurements used to establish the value of a particular entity, should be investigated and probably discarded, because there is something wrong with the measurement (ASTM, 2016). In (Sornette, 2002) further analytical techniques are developed to discern these meaningful outliers from the remainder of the set of events and it is argued that these outliers can be used to detect whether a mechanism of self-organization is present in the progression of events. In Sornette et al. (1996) it is argued that further analysis of these events may be used to also detect future onsets of catastrophes or extreme events and even possibly prevent the ultimate catastrophe. The behavior of such systems in which there is transient organization leading to extremes can also be observed in certain chemical processes that show limit cycles (Aris and Amundsen, 1958; Ale, 1980) as well as in earthquakes (Van Gelder, 1999). As example it is shown that crisis on the financial markets follow a similar pattern as the infamous pork-belly cycle, the difference being that these are not caused by under and overproduction of the same product but by sudden Lemming-type behavior towards a variety of commodities such as tulip-bulbs, Russian Railroads, dot-com shares, sub-prime mortgages and financial derivatives. The communality in these crises being human greed and putting short time profits above long term stability and safety, just as can be observed in the precursors of many large scale industrial accidents (Le Coze, 2015; Hopkins, 2015).

From the above it follows that crises often can be predicted when it is not assumed that they are just random events in the fat tail of a distribution and the pathology of earlier crises is analyzed. From there counter measures potentially can be designed. The unknown of the Black Swan thus is first converted into an unknown known: there must be something out there that causes these events. Then it is converted into a known. The cause may lie in the thermodynamics of the reaction (Ale et al., 2018) or in human traits such as greed or may be in both. In these cases, crises and disasters are predictable extreme behaviors which fall outside the regular distribution of events but are inherent to the dynamics of the systems at hand. They make the financial crisis of 2007 eminently predictable. They also make it possible to design counter measures, such as providing sufficient cooling if a run-away reaction is possible or regulate the trade in volatile commodities. One could even modify Taleb's advice to keep low-tech solutions available, such as pen and paper for making notes as back-up when the integrated high-tech system of the cloud fails due to a power outage. As such the development of anti-dragon measures is much less ridiculous or illusory as one might initially assume.

5. Decision making

How to make decisions under conditions of uncertainty has been the subject of countless books and papers for decades (Raiffa, 1968; Smithson, 1988; Hirshleifer and Riley, 1992; Etner et al., 2009). Despite all of this effort, an algorithmic or formulaic way to make most real-life decisions under conditions of uncertainty remains elusive as illustrated by the case of health and safety regulation in the United Kingdom for instance (UK HSE, 2001). As it has now become virtually impossible to read everything that ever has been written on the subject itself, it presents a situation of unknown knowns. In this blissful ignorance there are a number of observations that can be made.

Although the known knowns may look unproblematic, there are still some issues to consider. First of all there is the problem that the general understanding may in fact be erroneous. It is the general understanding that the general understanding that the earth was stationary was contradicted at first by a single person Galileo with the words. “Eppur, si muove”, but according to Boller Paul and George (1990) he never said that. On the other hand the myth that sunlight could start a fire was claimed to be false on 1920s Lambert & Butler English Cigarette cards, while it is in fact true. Which raises the Fire Breathing Dragon question: given the abundance of books and movies about them, should an anti-dragon-defense-shield be developed. That such a question is not trivial is proven by the question whether the –later proven to be false–allegation of the existence of weapons of mass destruction warranted the start of a war, which prompted Rumsfeld's discussion on knowledge. On the other hand climate change has been given the dragon treatment for decades by some in positions of power and influence.

In a situation of known unknowns it remains a good strategy to try and reduce the extent of ignorance or uncertainty by further research. However this may be time consuming and also may be expensive. Most decisions have a constraint in time. A decision not made in time usually also constitutes a decision, which is to let events take their course uninfluenced. If there is a constraint in money or other means one has to decide on this uncertainty, in both cases one needs to be prepared to accept that one could get into a situation where after an – usually adverse – event somebody will say that you could have known. A good secondary strategy therefor is to try and identify those facts, or those pieces of information that would change the decision and try to resolve those issues with priority.

The situation of unknown knowns is more problematic. Fortunately, seeking whether there is actually information out there that one is not aware of can be supported by the internet, although there are caveats there too. Not everything that has been written is valid and a significant part of the information gathered before 1990 is not on the internet. For accidents and disasters history books can be eye openers (Nash Jay, 1976). It remains an undeniable fact that the Australians knew about black swans and that in the absence of the knowledge that Australia existed there was no way for William the Vlamingh to know. However in the majority of accidents one could have known if one had followed procedures, read the instructions, listened to an operator who tried to convey a message (http-5, 2019) or searched the literature, whether on the internet or in a library. After the event the knowns usually surface in the post-accident inquests in the form of memo's, emails and notes. Therefore it is a good strategy to have an organized way of dealing with unorganized incoming information so that weak signals are not missed (Guillaume, 2011).

Weak signals can also come as warnings given by field workers and other persons who are close to the activity at hand but far from where the decisions are made. (Hopkins, 2011).

The unknown unknowns are perceived to be the most frightening. But there is nothing that can be done about them because it is unknown that they are unknown. It never occurred to William de Vlamingh nor to anybody in the northern hemisphere at the time that swans could be anything other than white. Until July 1940, when the Tacoma Narrows Bridge collapsed, it never occurred to engineers that the effect of the wind could make a bridge flutter and collapse. These are the real Black Swans. Strangely enough the bridge problem proved to be an unknown known to the architects who designed the Erasmus Bridge in Rotterdam, which had to be closed shortly after the opening in 1996, to take remedial action against the same effect (http-6, 2019).

Unfortunately, it is also impossible a priori to know whether an event is of type black swan or of type dragon. A black swan event is typified by being dismissed as impossible or even not imagined at all but yet it happened. A dragon event is typified by being imagined but dismissed as impossible and the event has not happened yet. But as Sornette et al (1996), Sornette (2002, 2009) shows sometimes they happen anyway. In the absence of knowledge, the application of any decision theory, whether normative or based on utility or value fails. However as has been described above the level and content of knowledge is often negated, understated or undervalued in the pursuit of some pre-existing goal. This, among others, attaches more utility to present profitability than to future damages. One of the results is the persistent tendency to ignore warnings of future disasters especially when taking them seriously would invoke considerable expenses (Merchant, 1986; Thunberg, 2019).

6. Discussion and conclusion

The evolution of the genus of "Black Swan" has led to a number of undesirable side-effects. The first is that an event that is the result of putting a protective mechanism, which under circumstances will be the last line of defense, out of commission is no longer seen as a direct cause that should have been known in advance, but as an explanation in hindsight and falling in the black swan family. The second is that ignorance can be used as an excuse for failed management supervision. The unknown known (the organization is so big I cannot know what all the operators are doing) and the known unknown (I cannot read all the incoming warnings) can be used to make the operator culpable and give management a "get out of jail free" card. These two mechanisms combine in the denial of the potential for catastrophic events, which takes away the need to organize contingency and disaster plans. Being sent to the realm of myths and dragons has been the fate of many disaster scenarios. Unfortunately fantasy may become reality, as the examples of dragon-king events has shown. A serious accident in a nuclear power plant was the subject of a movie released on March 16, 1979 and only 12 days later the Three Mile Island event occurred. The mechanisms that lead to financial crises and how to detect them had been analyzed already in 1996 and called Dragon-Kings, long before the Black Swan metaphor entered the realm or risk governance. Therefor decision makers should be aware whether their choices are based on facts, reason, belief or disbelief and that new signals may arise that should change their course of action. Finally we should be aware that nothing will prepare us for the "Big White Men" event, because its possibility never will occur to us until after the fact.

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